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Economic Insights

Volume 10, Issue 4

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Economic Insights

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Economic Insights features nontechnical articles on monetary policy, banking, and national, regional, and international economics, all written for a wide audience.

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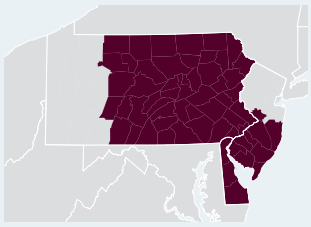

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Ecomonic Insights Is Going Digital in 2026

This year marks the last in which the Philadelphia Fed will print this quarterly journal. Instead, *Economic Insights* will relaunch in 2026 as a dynamic, all-digital source for our cutting-edge research. Visit http://www.philadelphiafed.org/economicinsights next year to see the new *Economic Insights*.

Harvesting Historical Data with LLMs

Large language models enable researchers to analyze historical records at scale.

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The views expressed in this article are not necessarily those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

Large language models (LLMs) are transformative tools. They are flexible, scalable, and capable of reading and writing text (and often other forms of information). They can appear to understand and respond to prompts and even converse with humans. And they give researchers a new way to digitize previously hard-to-access data at scale.

Compared with traditional data-collection methods, LLMs offer several advantages. LLMs often produce reasonably high-quality transcriptions without the need for specialized computer code, making digitization faster and more cost-effective than manual methods. They also work well in conjunction with other tools—for example, by cleaning up the messy results of text recognition software or structuring output from other models into a tabular form. Because LLMs can interact with researchers using regular language, researchers can focus on what they do best: interpreting and analyzing data rather than developing specialized, single-use tools. LLMs are also scalable, efficiently digitizing large corpuses of data. In short, LLMs can help researchers answer important, timely, and interesting questions

without having to spend a fortune on data collection.[1]

There are few commonly accepted best practices about when and how to use LLMs to produce high-quality data from historical source materials. This lack of consensus can be problematic because these data are often entirely novel, so researchers may not have access to other data or statistics for comparison. What's more, the appearance and formatting of source material can be highly variable. In such settings, researchers must use manual methods (such as hand annotation) to evaluate the output for quality. But manual methods do not scale well, and even hand-entered data are not error free.

To digitize the data in variable document formats at scale, researchers can turn to older computer-vision-based machine learning (ML) methods.[2] However, such methods require a substantial technical background, which serves as a barrier and limits their use. Researchers using any automated means to digitize data (whether older ML methods or LLMs) must extensively validate their data production pipeline and evaluate the final data output. *Validation* improves the performance of the data pipeline, which helps to calibrate the model. *Evaluation* ensures that the final data output is accurate, and that it is likely to retain that accuracy when the researcher digitizes new data the pipeline has not yet seen. Highly customized ML models can perform extremely well for data digitization but do not generalize well. (That is, small changes in input format or image quality can greatly degrade performance.) And they typically require a lot of training data, which makes it difficult to use ML to validate and evaluate.

But it's relatively easy for researchers to validate data with LLMs. All they need is plain language prompts and simple statistics. What's more, LLMs tend to be more resilient to variable input formats, and even when they are not resilient, they are relatively easy to adapt. As with any automated method, it is vital that we rigorously evaluate LLM outputs to ensure that the data are of high enough quality to be used for analysis. However, because LLMs are constructed to perform well across a wide range of tasks, finding the ideal set of prompts is generally a simpler task than optimizing older computer vision models.[3]

The Federal Reserve Bank of Philadelphia's Center for the REstoration of Economic Data (CREED) is actively engaged in using LLMs to digitize historical data of economic interest. As such, its researchers are developing best practices for using LLMs to produce high-quality data from historical source materials. This article describes the best practices we and our coauthors have developed for two recent Philadelphia Fed projects.

Historical Vehicle Registrations

Although much has been written about the development of the automobile industry, substantially less is known about what contributed to American consumers' widespread adoption of cars. And yet, patterns of automobile penetration from the 1920s persist in the modern era. For example, counties with more vehicles in 1920 still had substantially more vehicles in 1960.[4] Even more starkly, in the early 1920s Chicago had roughly 40 percent of cars per capita as did Los Angeles, and this relationship is roughly the same today (about 50 percent).[5] Given the persistence of historical patterns and how they interact with urban form and accessibility, it's worth our while to document these patterns and understand the causes and consequences of early automobility. Doing so enables our understanding of current patterns of urban and suburban life, the role transportation plays in consumer expenditures, and how societies adopt new and transformative technologies.

One promising way to study the rise of the automobile is through historical vehicle registration data. Nearly all states required motor vehicle registration by 1920, and many of these states published county- or city-level total counts of the number of vehicles. These data were typically released annually, which is a higher frequency than many other data sources. This means that they are useful not only for studying automobility in the early 20th century but also for examining broader phenomena such as early 20th century industrialization and the Great Depression.

Building a Pipeline for Vehicle Registration Data

Vehicle registration tables came in a broad variety of formats and from a wide array of government agencies and publishers. The agencies releasing the data often had differing goals, such as recording vehicles, collecting fees, and improving access to roads or farms. These differing objec-

TABLE 1

Historical Data Aren't Useful for High-Level Research Until They Have Been Digitized

Original 1923 Michigan vehicle data

COUNTIES.	Passenger Cars.	Commercial Cars.	Motor Cycles.	Trailers.
Alcona	733	39	3	2
Alger	1,121	108	10	4
Allegan	7,631	909	32	48
Alpena	2,671	234	8	27
Antrim	1,575	95	5	16
Arenac	1,175	105	.....	1
Baraga	697	45	1	.....
Barry	4,493	372	14	31
Bay	9,085	1,044	48	32
Benzie	1,014	150	1	5
Berrien	12,847	2,308	74	57
Branch	5,389	424	16	48
Calhoun	15,483	1,366	139	82
Cass	3,776	354	10	12
Charlevoix	2,387	242	15	4
Cheboygan	1,565	158	3	4
Chippewa	2,341	217	9	7
Clare	934	82	4	7
Clinton	5,165	470	10	82
Crawford	660	58	.....	12

Data Source: Table A1 in Bäcker-Peral et al. (2025)

TABLE 2

Optical Character Recognition Software Can Digitize Raw Data, but the Results Are Flawed

Amazon Textract incorrectly splits rows and merges values.

Textract-extracted 1923 Michigan vehicle data

COUNTIES.	Passenger Cars.	Commer- cial Cars.	Motor Cycles.	Trailers.
		39	3	2
Alcona	733	108	10	4
Alger	1121		32	48
Allegan	7631	909 234	8	27
Alpena	2671 1575	95	5	16
Antrim		105		1
Arenac	1175	45	1	
Baraga	697	372	14	31
Barry	4493	1044	48	32
Bay	9085 1014	150	1	5
Benzie				
		2308	74	57
Berricn	12847	424	16	48
Branch	5389	1366	139	82
Calhoun	15483	354	10	12
Cass	3776	242	15	4
Charlevoix	2387			
		158	3	4
Cheboygan	1565	217	9	7
Chippewa	2341	82	4	7
Clare	934	470	10	82
Clinton	5165 660	58		12
Crawford				

Data Source: Table A1 in Bäcker-Peral et al. (2025)

Note: Catastrophic failures in red.

tives led to inconsistent data fields.[6] And some of these data fields, such as fees collected for registrations, are tangential to the primary use case for these data. Collectively, these factors explain the poor performance of most prior methods. Notably, optical character recognition (OCR) software often misaligns table rows and columns. We term such misalignment "catastrophic failure" because when rows or columns are misaligned, the output data is much less accurate.

At the start of our pipeline, we scoured library indexes and websites for leads on historical registration data. We then evaluated the utility of these leads. This step was the most labor intensive, and it is hard to automate (at least for now). Our challenge was to find a cost-effective method for converting these source documents into harmonized, accurate data ready for analysis.[7]

We then created a "gold standard" data set that we confirmed is very accurate through extensive manual checking. We randomly split this gold standard data into a validation (or development) subset we used to improve prompts and an evaluation (or holdout) subset we used only to assess performance.

In the next part of our pipeline, we instructed the LLM to detect the general layout and identify key layout features (such as column headers, rows, and years) for every table in our data set (Table 1). After detecting and defining the layout, we called the LLM to extract the data and appropriately assign the data to their rows and columns (that is, county and vehicle type). During the extract call, we prompted the LLM to harmonize the data by correcting and validating county names and vehicle types, and by ensuring that the column and row alignment appear reasonable. It's here that LLMs really shine. Prior methods tend to generate many catastrophic failures (Table 2). By the end of the validation process, the LLM-produced data had no catastrophic failures (Table 3). To reach this high degree of performance, we alternated between adjusting the prompt in response to observed errors and comparing the output from the updated prompt with new subsets of the validation data. We also combined the outputs of several LLMs.[8]

Finally, we evaluated the final LLM-generated data by conducting a cell-to-cell comparison with the evaluation subset of the gold standard data.[9] We found that the LLM-generated data and the evaluation data are statistically indistinguishable, which indicates that any errors that persist in the data are unlikely to bias our analysis.

Deeds and Restrictive Covenants

Property deeds contain a wealth of information, but extracting these data presents major challenges. The documents may be either typed or handwritten, and preserved as transcriptions or as (potentially low-quality) photographs of the originals. Furthermore, deeds are only loosely structured; key information can appear almost anywhere on the page. And relevant deeds are often buried among thousands of similar but irrelevant documents.

Despite these challenges, property deeds are valuable for studying a wide range of economic, legal, and historical questions. Researchers have used them to study family genealogies, examine environmental

changes, understand what happens when someone dies without a will, analyze patterns of land ownership concentration, track how buildings and land use change over time, and trace how unclear property ownership affects neighborhood development and wealth accumulation.[10] (This work has been done either at substantial expense or with a limited sample.) These research areas provide crucial insights into how real estate markets function. And because real estate represents a major portion of household wealth and economic activity, these patterns help explain broader trends in inflation, employment, and financial stability.

One notable area of research examines how land-use restrictions have shaped housing access, affordability, and quality.[11] Both before and after the introduction of modern zoning laws, property owners used private agreements or "covenants" to control how the underlying land could be used–for both current and subsequent owners.[12] These covenants, written directly into property deeds, might specify building height limits, minimum structure setback, and exterior materials; they might also exclude certain groups of individuals or businesses from ownership or occupancy. To understand the long-term impact of these restrictions on today's housing patterns, researchers need to identify and extract the restrictive language from thousands of individual deeds and then map each property geographically–a massive data-extraction challenge.

Modern versions of property transfer data–which might be found on a municipal open data portal–contain some of the information necessary to facilitate all research mentioned above. However, such databases typically include only select information from the last 15 to 25 years. For example, in Philadelphia, property transfer data from 1999 onward are publicly available as tabular data but track only price, address, and buyer and seller names. These data omit coverage of earlier time periods and the covenants, restrictions, and contextual details necessary for many forms of research.

TABLE 3

An LLM Does a Very Good Job of Making These Data Useable

Although not entirely free of numerical transcription errors, the LLM has preserved overall table integrity.

LLM-structured 1923 Michigan vehicle data

COUNTIES	Passenger Cars	Commercial Cars	Motor Cycles	Trailers
Alcona	733	39	3	2
Alger	1121	108	10	4
Allegan	7631	909	32	48
Alpena	2671	234	8	27
Antrim	1575	95	7	16
Arenac	1175	105		1
Baraga	697	59	1	
Barry	4493	372	14	31
Bay	9085	1044	33	32
Benzie	1014	150	1	5
Berricn	12847	2308	74	57
Branch	5389	424	10	48
Calhoun	15483	1366	139	82
Cass	3776	334	10	12
Charlevoix	2587	242	15	4
Cheboygan	1565	178	3	4
Chippewa	2341	217	9	7
Clare	934	82	4	7
Clinton	5165	470	10	82
Crawford	660	58		12

Data Source: Table A1 in Bäcker-Peral et al. (2025)

Building a Pipeline for Philadelphia Deeds

Researchers at the Philadelphia Fed are studying the impact of a specific form of restrictive covenant on the Philadelphia property market, with a focus on deeds recorded between 1910 and 1965.[13] Our challenge was to find–within a corpus of 4.7 million scanned deed images–documents containing specific restrictive language and then extract key information from each document, including the property address, buyer and seller information, covenant terms, and financial details. These scanned images are highly variable in format and often of very low quality. Indeed, even a human would find them difficult to read. That said, we found that pairing frontier LLMs with proven technologies such as OCR and full-text search allowed us to accurately and efficiently extract these data at scale.

LLMs help us avoid the expense and limitations of building custom ML models. Although custom models could theoretically perform better for this specific task, they require deep technical expertise, thousands of hand-labeled training examples, substantial computing resources, and months of development time. Even worse, these specialized models are brittle: Small changes in document format or new research questions often require building entirely new models from scratch and at a cost that can rival the initial investment.

LLMs offer more flexibility. Tuning performance or even adapting to new problems can be as simple as changing the text instructions (prompts)

given to the LLM. However, they're not perfect. Running LLMs on millions of documents would be prohibitively expensive, and LLMs don't always match the performance of highly specialized ML models. Our solution combines the best of both worlds.

First, we used off-the-shelf OCR software to convert images into searchable text. OCR quality will be highly variable given the poor condition of many historical documents. Even clearly legible text can be mangled. For example, when searching for property transfers without a will, "intestate" might become "inte3tate" (creating a false negative) or "interstate" might be read as "intestate" (a false positive). We could ask an LLM to read each page directly, but processing all 4.7 million images would cost approximately $24,000.

Instead, we used OpenSearch—a search engine that powers everything from e-commerce sites to NASA's public databases—to cast a broad but manageable net. OpenSearch allows fuzzy matching, finding phrases such as "shall not be sold" even when OCR software introduces character errors or extra words. This fuzzy matching reduced our corpus from 4.7 million to about 160,000 documents that can be cost-effectively processed by LLMs to identify true positives.

We also used OpenSearch to pinpoint the location of relevant phrases within documents, which allowed us to extract short text snippets rather than submitting entire pages to the LLM. This targeted approach is fast, cheap, and accurate. Using snippets resulted in 2.4 times fewer false positives than when using whole pages.

Throughout this process, we followed the ABC rule: "always be checking." We manually reviewed approximately 30,000 LLM classifications to measure accuracy and tested 100,000 low-probability documents using an LLM to ensure that we weren't missing relevant cases.[14] Our validation showed us that our approach captured almost 95 percent of relevant documents[15] at 15 cents per true positive, compared with an incremental cost of $55 per additional true positive found by processing everything.

Our work identified approximately 7,500 highly relevant deeds that we're now having professionally transcribed, which enables econometric research and targeted custom ML work.[16] LLMs made this focused approach possible. Traditional ML methods would have been costly, inflexible, and prone to error.

Lessons Learned

These case studies demonstrate the transformative potential of LLMs to improve historical data digitization and analysis. LLMs allow researchers to significantly reduce the time and effort required to extract valuable insights from historical documents, which enables a broader range of research.

In this article, we've demonstrated a few best practices for researchers who want to digitize historical data with LLMs. First, careful pipeline validation and evaluation of LLM-generated data are essential for obtaining trustworthy and high-quality data. Although LLMs can produce high-quality results, such output is not guaranteed; the output must be rigorously checked against known quantities or existing data to ensure its accuracy. To acquire a trustworthy evaluation set in novel historical use cases, researchers must still either manually transcribe some data or carefully check some portion of LLM-extracted data.

Second, LLMs work best in partnership with other technologies and when given highly targeted, narrow tasks. Unstructured data—such as property deeds—often contain information irrelevant to the task at hand. Although LLMs can handle unstructured data, they are most cost-effective and accurate when the task is highly focused. Existing technology, such as full-text search, can winnow the large amount of raw data into manageable and interpretable data, which LLMs can then use to generate a clean and well-structured data set.

Because LLMs can efficiently and rapidly find high-signal data, they can produce data sets that cover most of the signal in the original documents. If necessary, researchers can then conduct more targeted custom ML or manual work to cover the edge cases not accurately or sufficiently captured by the LLMs. However, researchers must still preprocess documents—by, for example, cropping pages or adjusting the gray scale—to contain costs and provide a more targeted corpus for the LLMs.

Finally, to ensure that LLMs perform well at producing accurate data, researchers must take a disciplined approach to prompt development. By validating new prompts on a growing corpus of high-quality validation data, researchers ensure that they are not overfitting existing data or obtaining hallucinated results.

LLMs can greatly increase the efficiency and scope of a data production pipeline. Philadelphia Fed researchers affiliated with CREED seek to produce economically relevant and interesting historical data using innovative technologies (such as LLMs) but while taking a careful, disciplined, and rigorous approach. EI

Notes

1 For example, economists are using LLMs to understand how zoning impacts housing market affordability. See Bartik et al. (2024).

2 Many approaches fall into this category. See Correia and Luck (2023) for one example.

3 However, LLMs' performance is unlikely to be "optimal" compared with models built to do just one task extremely well.

4 See Bäcker-Peral et al. (2025).

5 See *Report and Recommendations…* (1925), Illinois Secretary of State (2025), and State of California Department of Motor Vehicles (2025).

6 States varied in how they classified commercial or private, truck or car, and pneumatic or solid tire. Some states even registered tractors.

7 See Bäcker-Peral et al. (2025) for complete details.

8 Ensembling, or combining the output of several models, leverages the different strengths of individual LLMs and improves overall performance.

9 Because the pipeline does not otherwise use these data, we avoid the risk of overfitting, which happens when a model fits the data it has already seen very well but performs poorly on novel data.

10 See Hincken (2021), Stein and Carpenter (2022), and Storey (2018).

11 See Bartik et al. (2024) and Asquith et al. (2023).

12 See Korngold (2001), Santucci (2020), and Weiss (1987).

13 See complete details in Moulton et al. (2025).

14 We were able to do this review with just two people reviewing for a few days. We built simple tools to make this review quick and visually simple.

15 More exactly, this approach achieved 98 percent precision and 90–98 percent recall.

16 A single deed often applies to more than one property, so we have identified significantly more than 7,500 properties covered by the restrictions.

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Regional Spotlight

Introducing PIES

Our new Price and Inflation Expectations Survey measures Third District firms' expectations.

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To conduct sound monetary policy, policymakers must closely follow not only changes in inflation but also changes in the public's expectations of future inflation. These expectations impact behavior and economic decisions made by individuals and businesses. In this way, inflation expectations can become self-fulfilling and contribute to actual inflation outcomes.[1] Therefore, measuring inflation expectations is central to understanding how and when inflation may rise.

Several surveys ask households and economists about their inflation expectations, but until the last decade relatively few surveys have asked business leaders.[2] This was a notable gap, given the important role businesses play in setting prices and wages. When firms expect higher inflation, they often respond by raising prices, adjusting wages, and revising investment and hiring decisions.[3]

To address the relative lack of information on firms' inflation expectations, the Federal Reserve Bank of Philadelphia developed the quarterly Price and Inflation Expectations Survey (PIES) in 2015. Soon after, other Federal Reserve Banks started

similar surveys. This article provides an overview of PIES, discusses the motivation for the survey, examines the relationship between PIES results and realized U.S. inflation, and briefly compares PIES with inflation expectations surveys conducted by other regional Reserve Banks and private firms.

The Philadelphia Fed's PIES

Since the fourth quarter of 2015, PIES has asked business leaders in the Third District about their short- and long-run inflation expectations and price-setting behavior. The survey is conducted quarterly (in February, May, August, and November of each year) as a supplement to the Philadelphia Fed's Manufacturing (MBOS) and Nonmanufacturing (NBOS) Business Outlook Surveys. Results have been published for each firm type as part of the MBOS and NBOS results since 2015.

Beginning in the fourth quarter of 2025, PIES results are being released as a separate quarterly report. In addition to the results for manufacturing and nonmanufacturing firms currently published as part of, respectively, the MBOS and the NBOS, the new PIES release includes results for all firms, which aggregates responses for both firm types. The aggregated all-firms results provide a more complete view of overall business expectations.

*See **PIES Questions***

By collecting data on both firm-specific and economywide expectations, PIES provides a comprehensive view of how businesses perceive inflationary pressures and how they accordingly adjust their expectations. In the current environment, where the economy is only recently removed from postpandemic inflation and faces further upside risks to inflation due to rising tariffs, understanding firms' inflation expectations is arguably more important than ever.

Furthermore, by collecting data on both near-term and long-term expectations, PIES allows policymakers to gauge whether firms anticipate persistent inflationary pressures or a return to price stability over time—dynamics that are likely to influence monetary policy. Firms' near-term expectations are often shaped by immediate cost pressures and changing economic conditions. But firms' longer-term expectations may reflect beliefs about the Federal Reserve's credibility and commitment to maintaining price stability.

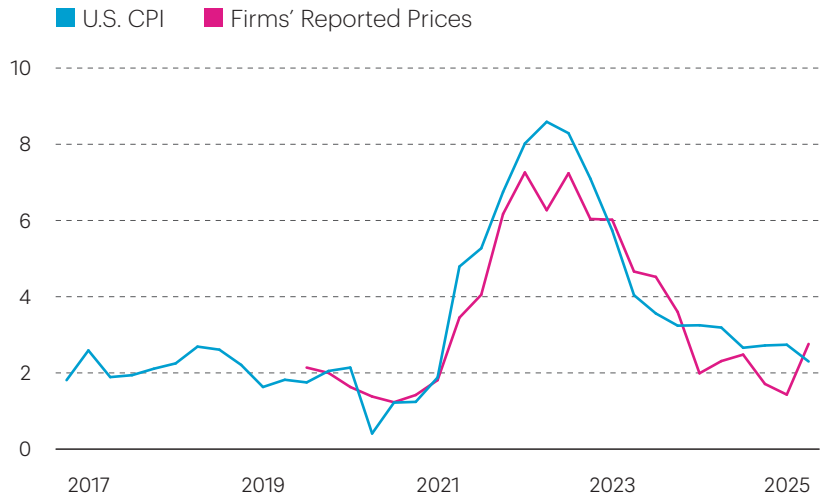
PIES' Past Prices Compared with Realized Inflation

With nearly 10 years of data and a sample that includes a period of rapidly changing inflation follow-

FIGURE 1

Firms' Reported Change in Own Prices Closely Tracked the CPI

Quarterly U.S. CPI; mean percentage of firms' reported change in own prices over the previous four quarters; 4q2016–2q2025



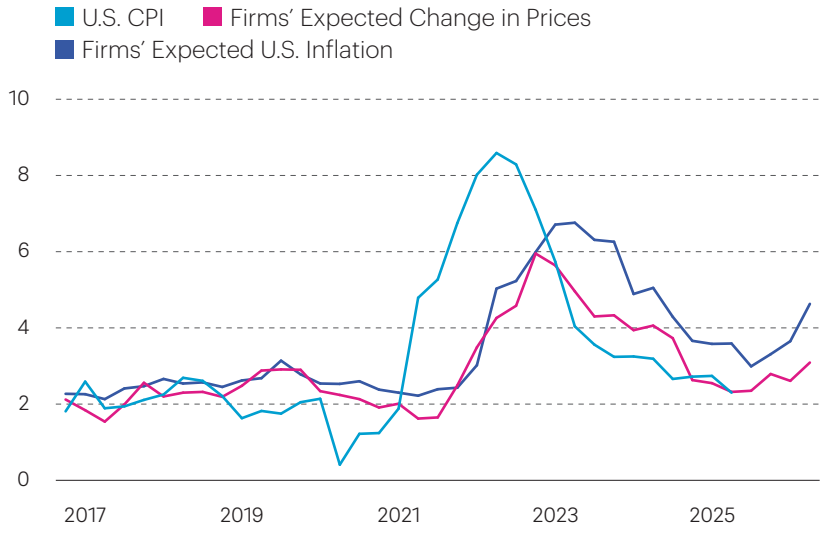
Data Sources: U.S. Bureau of Labor Statistics and Federal Reserve Bank of Philadelphia

Note: PIES data are the 10-percent trimmed mean of responses provided by firms. The CPI is published monthly by the BLS, but we have averaged the published series to a quarterly frequency for direct comparison with PIES.

FIGURE 2

Firms' Expectations Lagged Realized Inflation Prior to the Turning Point

Quarterly U.S. CPI; mean percentage of firms' expected change in own prices and U.S. inflation over the next four quarters; 4q2016–2q2026



Data Sources: U.S. Bureau of Labor Statistics and Federal Reserve Bank of Philadelphia

Note: PIES data are the 10-percent trimmed mean of responses provided by firms. PIES data are plotted four quarters ahead to reflect the period for which they are forecast. The CPI is published monthly by the BLS, but we have averaged the published series to a quarterly frequency for direct comparison with PIES.

FIGURE 3A

In Mid-2020, Firms Did Not Anticipate Price Shocks

Mean percentages of firms' expected change in own prices over the next four quarters and reported change in own prices over the previous four quarters

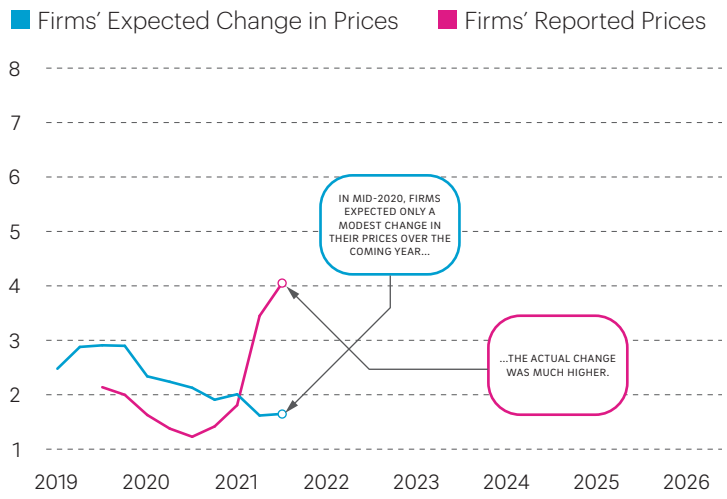


FIGURE 3B

By the Start of 2021, Firms Were Anticipating Larger Price Increases

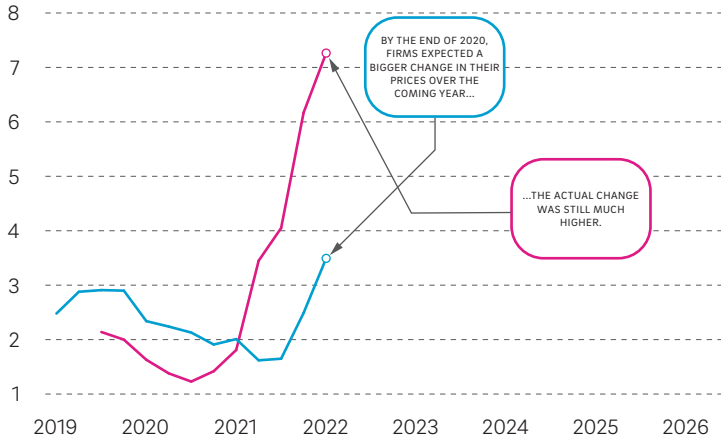


FIGURE 3C

Going into 2022, Firms Anticipated Smaller Price Hikes

Mean percentages of firms' expected change in own prices over the next four quarters and reported change in own prices over the previous four quarters

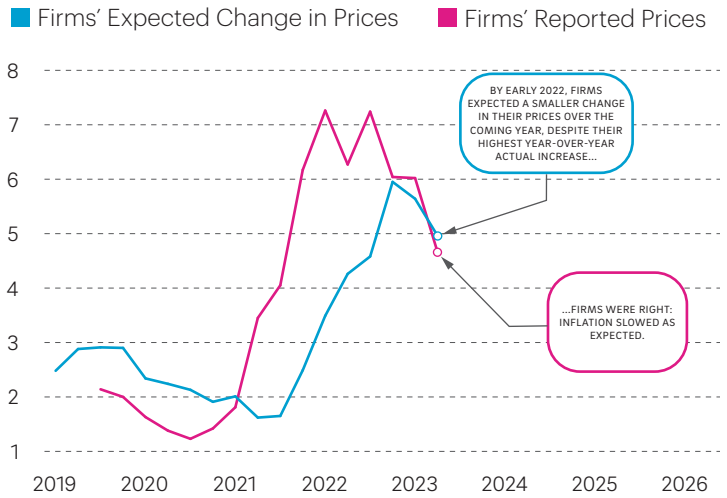
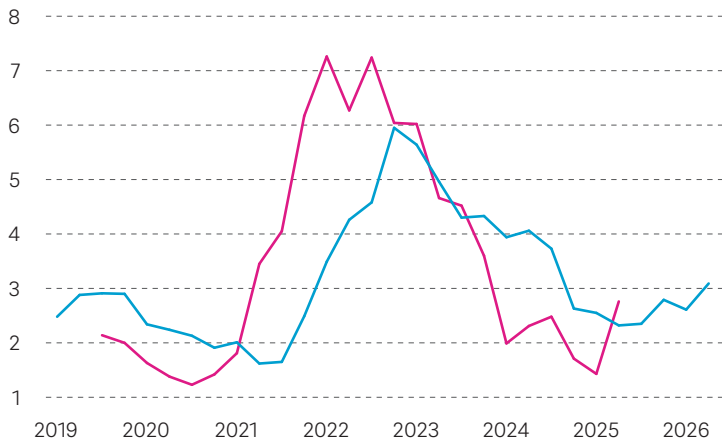


FIGURE 3D

However, Firms Mostly Overestimated Price Increases Until 2025



Data Source: Federal Reserve Bank of Philadelphia

Note: PIES data are the 10-percent trimmed mean of responses provided by firms. Firms' expected change in prices are plotted four quarters ahead to reflect the period for which they are forecast.

ing the pandemic, now is an opportune moment to take stock of how well PIES tracks and forecasts U.S. inflation. For all comparisons we use the Bureau of Labor Statistics' (BLS) headline Consumer Price Index (CPI) as our benchmark for realized U.S. inflation.[4]

Before comparing PIES' forecasts with the CPI, we compared the CPI with the average reported percentage change in firms' own prices over the previous four quarters. Although this retrospective question was added only in mid-2019, it allows for meaningful comparison through the volatile inflationary environment of 2021 to 2024.

We find that reported changes in firms' own prices closely mirrored the CPI throughout the inflationary period but peaked slightly lower than the CPI in 2022 (Figure 1). This alignment suggests that firms' reported price changes in PIES accurately reflect broader inflation dynamics, which lends credibility to responding firms' forecasts.

PIES' Future Prices Compared with Realized Inflation

Although individual firms and the aggregate U.S. economy experience similar changes in price growth, it is difficult to accurately predict *future* changes for either individual firms or the aggregate economy. This is especially true in times of economic and geopolitical uncertainty that lead to significant price instability.

Before the pandemic, firms' predictions of their own future price growth and future U.S. inflation generally tracked the realized CPI (Figure 2). The unprecedented nature of the pandemic and ensuing supply chain disruptions made forecasting future prices extremely difficult.

By mid-2020, many firms were experiencing weak overall price growth and did not anticipate the price shocks that lay ahead (Figure 3a). Having cut capacity earlier in the pandemic, firms may have been reluctant to ramp up production to meet surging demand. As a result, they continued to expect weaker price growth through mid-2021 even as the realized CPI and their own prices were accelerating due to revived demand and global supply bottlenecks.

By the end of 2020, firms expected higher prices, although their forecasts remained below the realized inflation rate (Figure 3b). Although firms anticipated continued price increases through 2022, their expectations were still lower than realized outcomes, due in part to their inability to predict further disruptions caused by events such as Russia's invasion of Ukraine.

Despite this, firms accurately anticipated the inflation cycle's turning point. Although they were reporting their highest year-over-year price increases in the fourth quarter of 2021, firms had begun to predict smaller price hikes for their own goods and services in the year ahead (Figure 3c). This roughly lined up with the start of disinflation. From the fourth quarter of 2022 through 2023, firms accurately forecasted lower price growth for their own goods and services. Although firms did not predict the steepness of actual disinflation, their forecasts were directionally correct (Figure 3d).

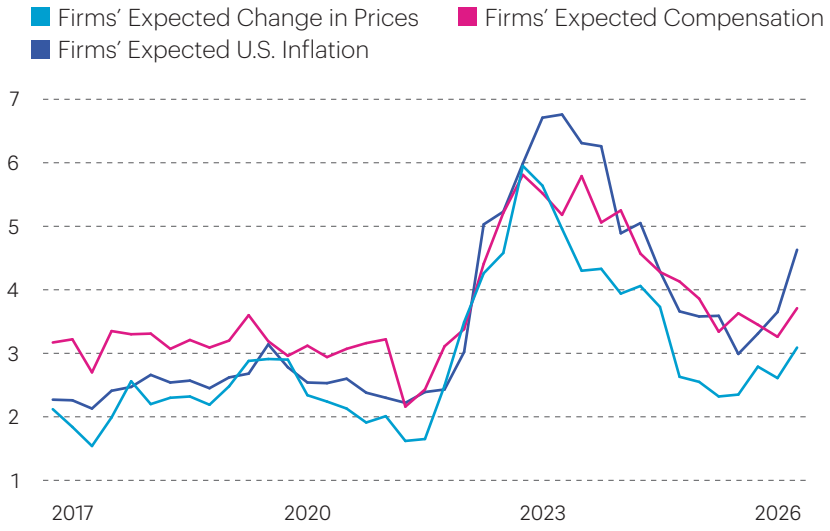
Notably, firms' forecast of U.S. inflation consistently exceeded their expectations for the growth of their own prices, even as inflationary pressures eased from 2023 through 2025. Although many firms anticipated or experienced easing inflationary pressures from supply costs, they continued to expect wage inflation to outpace their own price increases, driving expectations of overall U.S. inflation higher (Figure 4). This persistent gap between expected and realized inflation may also reflect the influence of prolonged exposure to news coverage that highlighted higher prices.[5] More recently, firms' expectations of changes in both their own prices and overall inflation have risen sharply for 2026 in response to new tariffs and potential shifts in trade policy.

In short, although PIES may not be a perfect indicator of the future level of inflation during and after an unprecedented crisis, it is still a valuable signal for turning points in inflation.

FIGURE 4

Firms' Expectations for U.S. Inflation and Changes in Compensation Remain Higher than Expected Changes in Own Prices

Mean percentages of firms' expected change in own prices, expected U.S. inflation, and expected change in compensation, 4q2016–2q2026



Data Source: Federal Reserve Bank of Philadelphia

Note: PIES data are the 10-percent trimmed mean of responses provided by firms. Data are plotted four quarters ahead to reflect the period for which they are forecast

PIES Compared with Other Inflation Expectations Surveys

PIES is not the only survey that captures the public's inflation expectations. Many surveys now track inflation expectations across different population segments. Comparing PIES with these surveys helps us understand how firms view inflation relative to households and experts.

For example, the Philadelphia Fed's Survey of Professional Forecasters (SPF) gathers the inflation expectations of professional forecasters. Both the University of Michigan's Surveys of Consumers and the New York Fed's Survey of Consumer Expectations (SCE) gather the inflation expectations of households. And the Atlanta Fed's Business Inflation Expectations survey (BIE) and the Cleveland Fed's Survey of Firms' Inflation Expectations (SoFIE) provide alternative measures of U.S. firms' inflation forecasts.

Although PIES has fewer than 10 years of data at the time of this publication, a preliminary comparison with other surveys is still informative. Using a Diebold-Mariano regression, we evaluated the accuracy of inflation expectations for PIES and each of the surveys mentioned above against the actual CPI inflation rate.[6]

Results suggest that the University of Michigan's Surveys of Consumers performed best, followed by PIES and the SCE (Figure 5). The well-anchored professional forecasters in the SPF were least accurate when inflation

FIGURE 5

Regression Results Suggest That the University of Michigan's Surveys of Consumers Performed Best, Followed by PIES and the SCE

Results from Diebold–Mariano regression used to evaluate the accuracy of inflation expectations for PIES and other inflation expectations surveys against the actual CPI inflation rate

> Indicates more accurate >> Indicates significantly more accurate

Survey	UMich	PIES	SCE	BIE	SoFIE	SPF
UMich		>	>	>	>>	>
PIES			>	>	>>	>
SCE				>	>	>
BIE					>	>
SPF						>
SoFIE						

Data Sources: Federal Reserve Bank of Philadelphia, Federal Reserve Bank of New York, Federal Reserve Bank of Atlanta, Federal Reserve Bank of Cleveland, University of Michigan

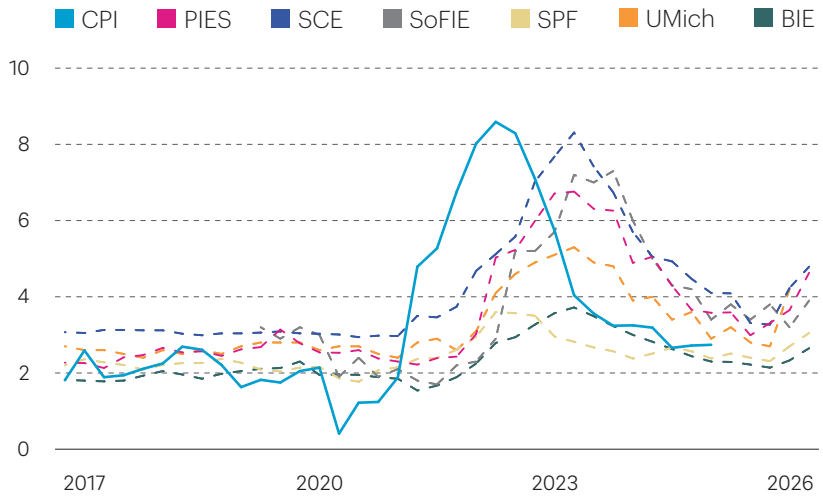
Note: PIES and SoFIE are means of responses; BIE, SCE, SPF, and UMich are median responses. The Diebold-Mariano (DM) test is a statistical method used to compare the predictive accuracy of two competing forecasts. Specifically, it tests whether the difference in forecast errors, measured as squared errors, is statistically significant over a given period. A significant result indicates that one forecast consistently outperforms the other in terms of accuracy. In the context of inflation expectations, the DM test helps us evaluate whether one survey provides systematically better predictions of realized inflation (CPI) than another.

FIGURE 6

Results Suggest All Respondent Types Were Slow to Increase Expectations of Inflation Compared with Realized Inflation

Some respondents expected higher inflation than others.

Quarterly U.S. CPI and results from inflation expectations surveys, 2017–2026



Data Sources: U.S. Bureau of Labor Statistics, Federal Reserve Bank of Philadelphia, Federal Reserve Bank of New York, Federal Reserve Bank of Atlanta, Federal Reserve Bank of Cleveland, University of Michigan

Notes: PIES and SoFIE are means of responses; BIE, SCE, SPF, and UMich are median responses. All surveys are plotted to reflect the period for which they are forecast.

surged over much of the analyzed period.

Differences across survey results may reflect the variation in how expectations are formed across respondent groups (Figure 6). Professional forecasters are typically anchored to monetary policy targets and macroeconomic models. Their forecasts for inflation stabilize around 2-3 percent, resting close to the Federal Reserve's 2 percent target.[7] In contrast, households often respond to and overweigh salient price changes in items such as food and gasoline.[8] Households have had consistently higher inflation expectations than professional forecasters since the early 1990s.[9]

Firms, as represented in PIES, appear to synthesize both cost-based pressures and broader economic signals. This produces expectations that are economically informed and responsive, although not necessarily accurate during periods of rapid change.

Conclusion

Measuring and understanding inflation expectations is an important aspect of understanding inflation dynamics overall. Surveys remain one of the most effective ways to gather information about these expectations.

Historically, few surveys focused on capturing the inflation expectations of businesses, a gap that PIES and other newer surveys have tried to fill. By surveying firms that set prices and wages, PIES plays an important role in the broader ecosystem of inflation expectations surveys.

PIES has performed as well as—or better than—most other surveys during the postpandemic inflationary cycle. Uniquely, PIES offers a comprehensive perspective on firms' thinking about inflation, capturing not only expectations for general inflation but also firm-specific projections for prices and compensation.

For policymakers, PIES and other inflation expectations surveys are an important complement to the CPI and model-based forecasts. Firm-level surveys such as PIES offer important insights into demand-side pressures, changing input costs, competitors' pricing behavior, and on-the-ground sentiment. In periods of heightened uncertainty, this information helps policymakers assess whether expectations remain anchored and how inflation risks are perceived across the economy.[10]

PIES Questions

To gather information on firms' price and inflation expectations, firms are asked a standardized core set of five quantitative questions each quarter. One retrospective question asks firms to report the actual percentage change in their own prices over the past year. Two questions address each firm's own inflation expectations for the next year. One of these questions asks for the expected percentage change in the prices the firm will receive for its goods and services. The other question asks for the expected percentage change in the firm's employee compensation (wages and benefits). The remaining two questions address broader inflation expectations. The first of these questions asks for the firm's forecast for the percentage change in U.S. consumer prices over the next year. The other question asks for the firm's forecast over the next 10 years.

In addition to the core set of quantitative questions outlined above, we gather information on the key motivators that play a role in how firms form their expectations.[11] In the second quarter of 2025, we introduced additional questions on the price sensitivity of firms' customers, expectations of industry costs, and expected price-setting behavior of firms' competitors.

Notes

1 See Armenter (2008), Armenter (2018), and Coibion and Gorodnichenko (2025).

2 See Coibion et al. (2018).

3 See Coibion et al. (2020) and Abberger et al. (2025).

4 The CPI is published monthly by the BLS, but we have averaged the published series to a quarterly frequency for direct comparison with PIES and other inflation expectations surveys.

5 See Chahrour et al. (2025).

6 The Diebold–Mariano test is a statistical method used to compare the predictive accuracy of two competing forecasts. See Diebold and Mariano (1995).

7 See Candia et al. (2024) and Coibion and Gorodnichenko (2025).

8 See D'Acunto et al. (2021) and Berge (2018).

9 See Candia et al. (2024).

10 See Coibion and Gorodnichenko (2025).

11 Blinder et al. (1998) provides a framework for asking about firms' price expectations and price-setting behaviors.

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Banking Trends

How Banks Fund Their Lending

Since 2008, banks have increasingly relied on deposits for funding. But lending has changed, too.

Jim DiSalvo
Banking Structure Specialist
FEDERAL RESERVE BANK OF PHILADELPHIA

The views expressed in this article are not necessarily those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

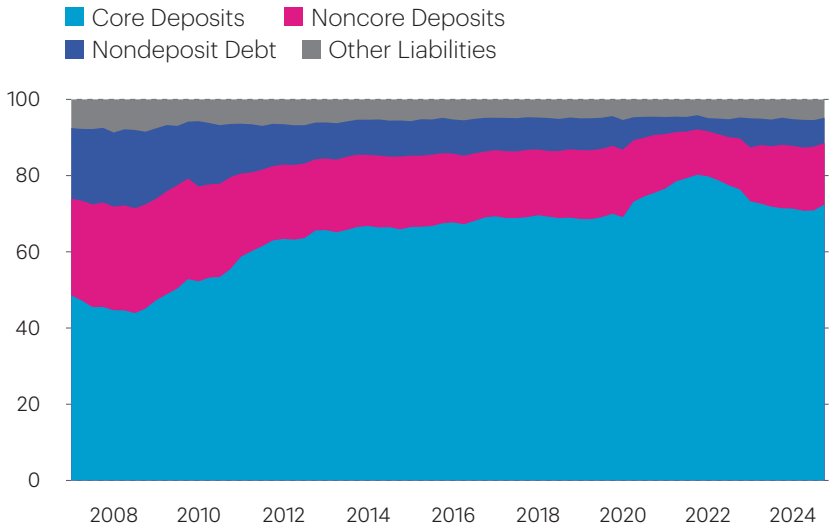
The 2007-2008 Global Financial Crisis (GFC) was characterized by a credit crunch that brought the financial system to the edge of collapse. Since then, much has been written about how bank lending has changed in the wake of the GFC. But banks have also changed how they fund this lending. This is important for two reasons. First, how a bank funds its lending affects its short- and long-term cost structure and, consequently, its earnings. Second, funding structure is also important for financial stability.

In this article, I examine how banks fund their lending. Specifically, I look at how banks' liabilities are distributed across deposits and debt; how this distribution varies with bank size; and how this distribution has changed since before the GFC.[1] (A bank's balance sheet is divided into assets and liabilities. For the bank, loans are assets, and anything that funds an asset is a liability.) I find that, while some of these changes have made the banking industry more stable, several sources of instability can arise from developments in the funding structure of banks. What's more, these changes in funding structure may pose new challenges for smaller banks.

FIGURE 1

Since 2007, Core Deposits Have Increased Substantially as a Share of Total Liabilities

Core deposits, noncore deposits, and nondeposit debt as a percentage of total liabilities, 2007–2024



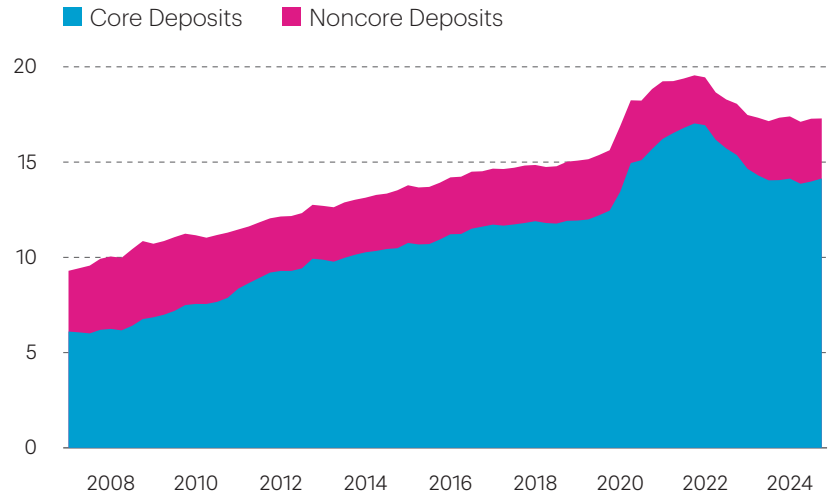
Data Source: FFIEC Call Reports

Note: "Other liabilities" comprise trading account liabilities, interest accrued but not yet paid, net deferred taxes, allowance for credit losses on off-balance-sheet exposures, accounts payable, deferred compensation, dividends declared but not yet paid, derivatives with a negative fair value held for purposes other than trading, operating lease liabilities, and anything else.

FIGURE 2

Core Deposits Have Increased Substantially in Real Terms, Too

Core and noncore deposits, billions of 2023 dollars, 2007–2024



Data Source: FFIEC Call Reports

Types of Funding

When it comes to funding their lending, banks have two options: deposits and debt. Of the two, deposits are typically the cheaper and more stable source of bank funding.[2] Deposits are cheaper because the interest rate that banks pay on deposits is significantly lower than what they pay on debt, and this spread has increased in the last several years. Deposits also tend to be more stable because many of them are insured, and because they are often part of a long-term relationship between a bank and its customers.[3] When studying these relationship-based deposits, bank analysts and regulators often focus on "core deposits," which comprise domestic deposits minus brokered deposits and large (greater than $100,000 before 2011, greater than $250,000 after) time deposits.[4]

Core deposits have increased substantially since 2007, both as a percent of liabilities (Figure 1) and in real terms (Figure 2). Core deposits tend to increase in times of economic uncertainty.[5] For example, during the pandemic, core deposits increased by nearly $4 trillion, to a total of over $17 trillion. (Core deposits returned to trend in 2023.)

This shift to core deposits can potentially enhance financial stability, given the relative "stickiness" of relationship-based deposit balances. However, there are circumstances in which core deposits are unstable and may even render banks more vulnerable to runs. The problem is that some core deposits are uninsured (Figure 3).[6] These uninsured deposits are mainly transaction accounts, which means they are both core deposits and "runnable"—that is, they can be withdrawn easily should the bank's financial condition worsen significantly. The risk of a run on these deposits is increased if interest rates rise, if the bank in question has taken on substantial interest rate risk, and if it has a low capital ratio.[7] This is what happened in March 2023 with the failures of Silicon Valley Bank, Signature Bank, and First Republic Bank. At all three banks, a substantially higher-than-average percentage of deposits were uninsured; all three experienced losses due to their exposure to the tech sector; all three had lower-than-average capital (but still within regulatory guidelines); and all three had taken on substantial interest rate risk by using short-term deposits to fund long-term illiquid assets.[8]

Noncore deposits consist of foreign deposits, brokered deposits, and large uninsured time deposits. A substantial share of noncore deposits are time deposits, and they are essentially wholesale.[9] This means they are usually not generated through a long-term relationship between a customer and a bank.[10] They are more expensive than core deposits but cheaper than most forms of debt. They are more expensive than core deposits in part because depositors must pay a substantial fee to withdraw these funds early, so the bank must pay depositors a higher interest rate for them.[11] In addition, foreign deposits are subject to currency fluctuations and political risk, which renders them less reliable than core deposits. It is therefore unsurprising in a post-GFC environment that, since 2008, the spread between interest rates on core and noncore deposits has decreased[12] and that noncore deposits have shrunk as a percentage of deposits and in real terms.

The rest of bank funding comes from debt financing. Debt is not just more expensive than deposits–it is also riskier (at least relative to insured deposits) because available funds may dry up in a crisis, just when a bank needs liquid funds the most. As part of the post-GFC shift toward greater funding stability, banks have become much less reliant on debt. Part of this shift is due to Congress's expansion of deposit insurance, but there are additional reasons particular to each type of debt. Not all debt is the same, and some forms of debt have become relatively more important than others, with implications for the entire banking sector.

There are five categories of debt: fed funds purchased, securities sold under agreements to repurchase (repos), subordinated debentures (sub debt), Federal Home Loan Bank (FHLB) loans, and other borrowing. Banks' reliance on each category has changed since the GFC both as a percentage of their total debt (Figure 4) and in real terms (Figure 5).

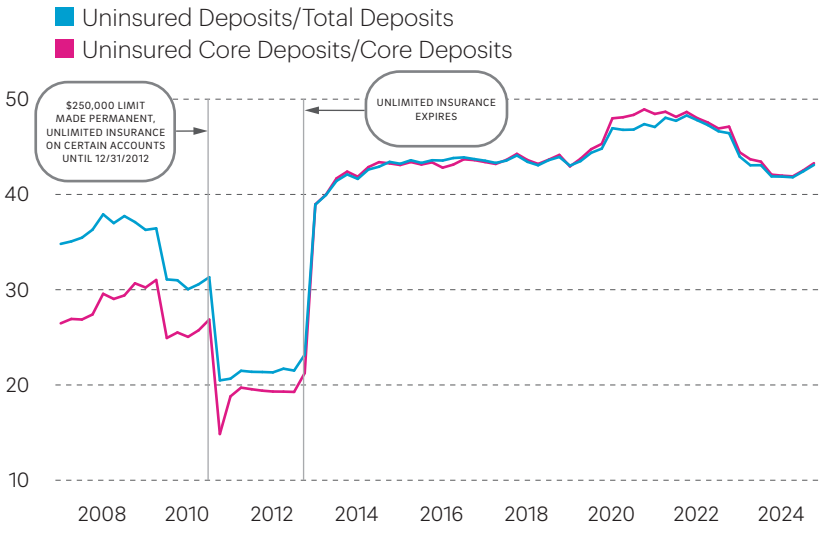
Fed funds are short-term (usually one day), unsecured, interbank loans that enable a bank to obtain short-term liquidity and, until recently, maintain its required reserve with the Federal Reserve. They can be either purchased or sold. When purchased (borrowed), they are a liability. Because they are used for such a specific purpose, fed funds represent a small portion of overall bank finances.[13] The fed funds market has shrunk significantly since the GFC because banks now maintain substantially more reserves on deposit at Federal Reserve Banks.[14]

FIGURE 3

Some Deposits, Including Some Core Deposits, Are Uninsured

That means there are circumstances in which core deposits are unstable and may even be the source of bank runs.

Uninsured deposits as a percentage of total deposits; uninsured core deposits as a percentage of total core deposits; 2007–2024



Data Source: FFIEC Call Reports

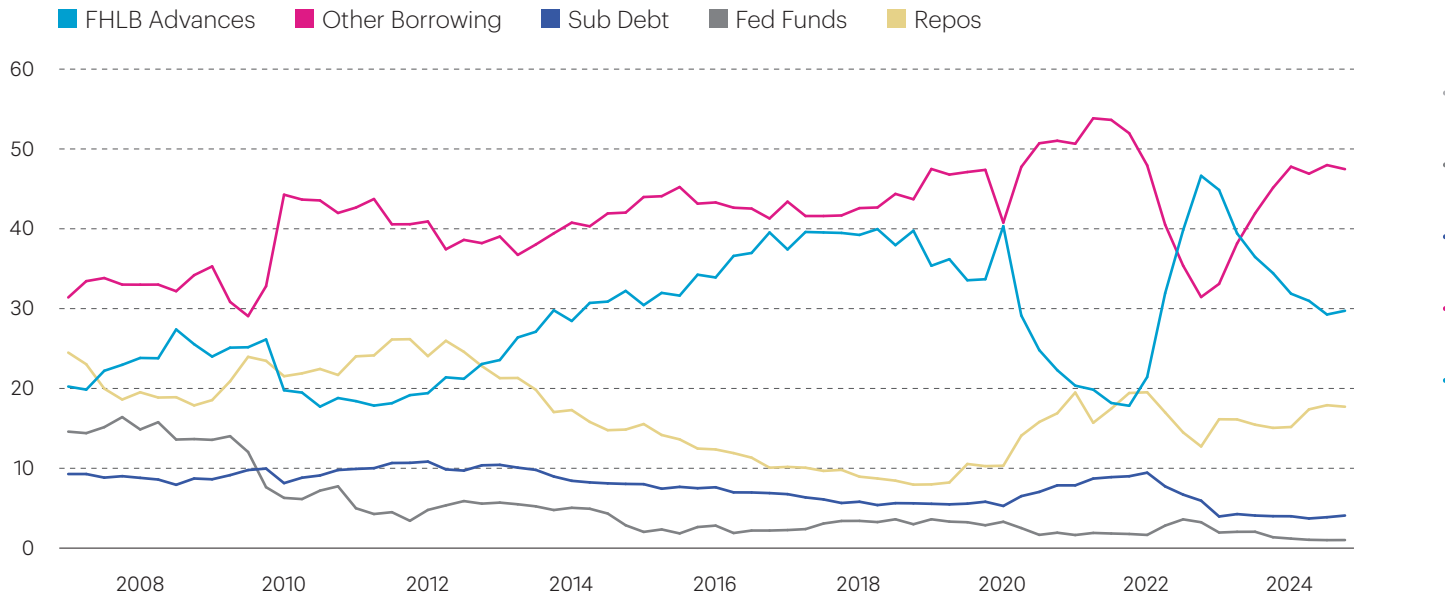
Repos are also typically for one business day, but unlike fed funds they are secured and can be used for a variety of purposes. In a repo transaction, one financial institution sells securities to another institution for less than their market value. The seller at the same time agrees to repurchase the securities at a specified time and price. The difference between the price the seller receives and the market value is referred to as a "haircut," and

FIGURE 4

As a Share of Debt, Banks' Reliance on Each Category of Debt Financing Has Changed

Sub debt and fed funds have fallen to insignificance.

Components of debt as a percentage of total debt, 2007–2024



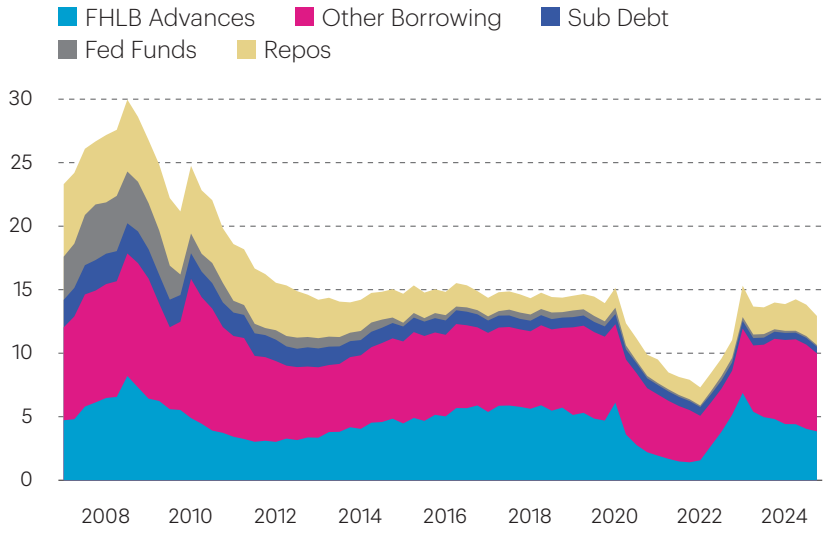
Data Source: FFIEC Call Reports

FIGURE 5

Banks' Reliance on Each Category of Debt Financing Has Changed in Real Terms, Too

Other borrowing and FHLB loans loom larger, relative to other forms of financing.

Components of debt in real terms, billions of dollars, 2007–2024



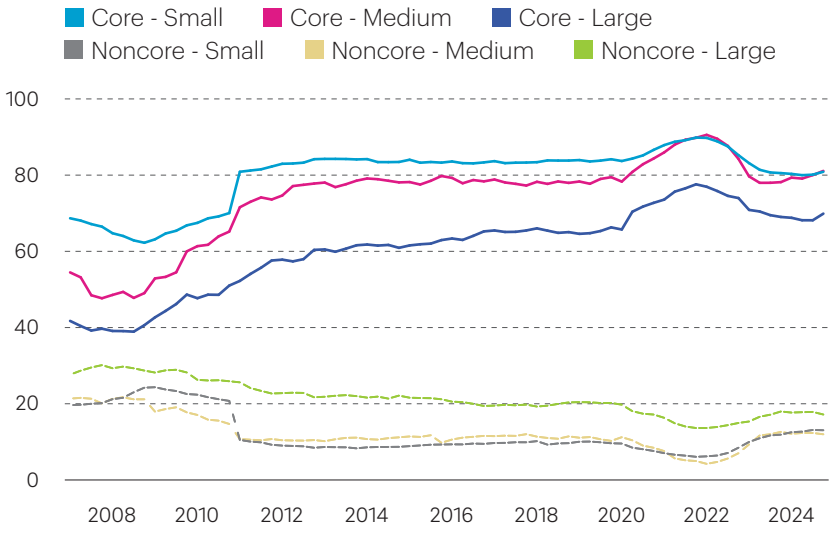
Data Source: FFIEC Call Reports

FIGURE 6

All Banks Are Becoming More Reliant on Core Deposits and Less Reliant on Noncore Deposits and Debt

But there are still substantial differences by bank size.

Core and noncore deposits as a percentage of total liabilities, by bank size, 2007–2024



Data Source: FFIEC Call Reports

the difference between the price the seller receives and the buyback price is called the "repo rate."[15] Both the haircut and the repo rate reflect the seller's overall financial condition as well as the quality of the collateral.[16] If the seller is unable to buy back the securities, the buyer keeps them. Although repos were shrinking in importance after the GFC, they've grown rapidly since 2020.

Sub debt is unsecured long-term bonds (up to 30 years) in which the holder is the next-to-last in line—in front of shareholders but behind everyone else—for repayment if a bank fails or defaults. As such, sub debt, although relatively stable, can be more expensive than other forms of debt, which may explain why sub debt has declined substantially since 2007. Sub debt is also a form of capital. As banks increased their other forms of capital, they had less need for sub debt.

FHLBs are the banking industry's lender of second-to-last resort. (The industry's lender of last resort is the Federal Reserve.) FHLB loans, also known as advances, can be either direct loans or lines of credit. To receive a loan, a bank must become a member of the FHLB system and make an equity investment in at least one FHLB. Most FHLB loans must be used to support mortgage and mortgage-related lending.[17]

FHLB loans are also oversecured, meaning the collateral—either mortgages, securities, or an equity investment in the lending FHLB—exceeds the size of any loan.[18] The amount of overcollateralization, also referred to as a "haircut," varies by borrower and type of loan.[19] FHLB loans are considered a reliable source of funding because they are collateralized and because there is a general belief that FHLB debt has an implicit guarantee from the federal government. As such, these loans are less expensive than other forms of debt, which may explain why they have grown substantially as a percentage of total debt even as they've shrunk in real terms.

See ***The Role of Federal Home Loan Banks in the U.S. Banking System***

The largest category of debt is "other borrowing," which is a catch-all term for mortgages on bank property, bonds that are not sub debt, loans from other financial institutions, commercial paper, and any other debt that isn't easily classified. From 2007 to 2024, other borrowing shrank both as a percentage of total liabilities and in real terms, although it is still the largest category of debt financing for reasons discussed below.

Since the GFC, bank funding has moved away from noncore deposits and debt financing and toward core deposits. Meanwhile, all forms of debt financing have shrunk, but some have shrunk more than others. In particular, FHLB loans and other borrowing have become relatively more important than other forms of debt financing.

These shifts in the composition of funding can make the banking system more resilient, given that core deposits are cheaper and more stable than other types of funding. However, this conclusion comes with caveats. First, some forms of debt are more reliable funding sources than others. For example, long-term debt, or debt secured by high-quality collateral, is likely to be a relatively more stable form of funding. Second, as discussed earlier, uninsured demand deposits have increased as a share of bank liabilities; such liabilities can pose a risk to financial stability, as shown by the events of March 2023.

Furthermore, these changes in funding mix do not affect all banks equally. In the next section, I explore how changes in the liability side of banks' balance sheets vary across small, medium, and large banks. By exploring these differences, we see how these changes create more risk for larger banks and more competition for smaller banks.

Bank Size Matters

To study the relationship between bank size and financing, I split banks into three categories: small banks, with less than $10 billion in assets; medium banks, with assets between $10 and $50 billion; and large banks, with assets greater than $50 billion (all assets in 2023 dollars). Most banks are small, but the number of small banks is shrinking. At year-end 2007, there were 7,123 small banks. By year-end 2024, there were 3,779.[20]

Liabilities at banks of different sizes are becoming more similar: All three categories are becoming more reliant on core deposits and less reliant on noncore deposits and debt. However, there are still substantial differences by bank size (Figure 6). Compared with smaller banks, large banks rely more on noncore deposits and other borrowing; compared with large banks, smaller banks rely more on core deposits and FHLB loans.

From 2007 to 2024, small banks held a higher percentage of their liabilities as core deposits, but medium and large banks are catching up. This change is mostly due to large banks: Core deposits increased 16.7 percent at small banks, 114.3 percent at medium banks, and 191.7 percent at large banks. Nonetheless, as of 2024, large banks were still less reliant on core deposits than smaller banks.

Large banks, and to a lesser extent medium banks, also rely more on uninsured deposits, both currently and historically (Figure 7). These differences are substantial. For example, uninsured core deposits make up about 50 percent of core deposits for large banks but only 20 percent for small banks.[21] That said, uninsured core deposits have risen as a funding source for all three size groups since 2007, albeit with some decline since the banking turmoil in 2023.

As large and medium banks increase their holdings of deposits in general and core deposits in particular, it becomes harder for small banks to compete. Large and medium banks typically pay depositors roughly 20 to 30 basis points more on deposits than small banks. As interest rates rise, the inability of small banks to offer higher rates may make it harder for them to attract deposits. Also, large and medium banks are typically more convenient for customers. They have larger branch and ATM networks that allow them to not only serve their existing customers but to also reach more potential new depositors.[22] That said, small banks can still compete because they charge lower fees for their services.

Banks of different sizes have also converged in their reliance on debt financing since the GFC, even while their overall reliance on debt has decreased (Figure 8). In 2007, large and medium banks had a ratio of debt to liabilities roughly double that of small banks. However, by 2024 medium and small banks had roughly equal ratios, whereas the ratio at large banks was only slightly higher.

The same cannot be said, however, for the *composition* of their debt. Although fed funds and sub debt have shrunk to practical insignificance for all three categories, and repos are also shrinking yet again, there are substantial differences in other borrowing and their FHLB loans.

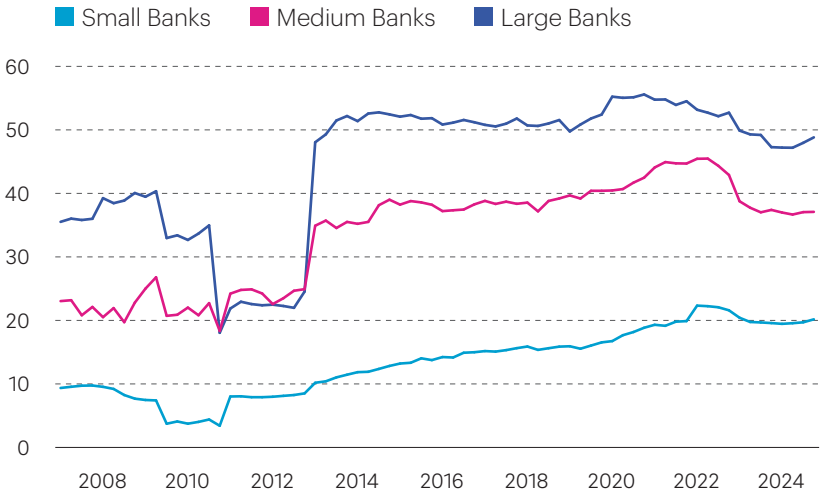
Other borrowing at large banks has always been roughly triple that of medium banks and over 10 times that of small banks. Why do large banks continue to engage in this short-term borrowing? Probably because of changing regulations. In 2017 bank regulators required some (mostly very large) banks to maintain a minimum liquidity coverage ratio (LCR), which means that they have sufficient liquid assets to cover their net outflows for at least 30 days.[23] These short-term funds are either held as cash, placed on deposit at a Federal Reserve Bank, or used to buy short-term securities, which then count as liquid assets in calculating a bank's LCR. Small banks eschew most short-term debt, most likely because they lack access to capital markets.

Although all three categories of banks have reduced their reliance on FHLB loans, at small and medium banks these loans still represent a larger ratio of total debt than other forms of debt financing (Figure

FIGURE 7

Large and Medium Banks Rely More on Uninsured Deposits, but with Substantial Differences

Uninsured core deposits as a percentage of total core deposits, by bank size, 2007–2024

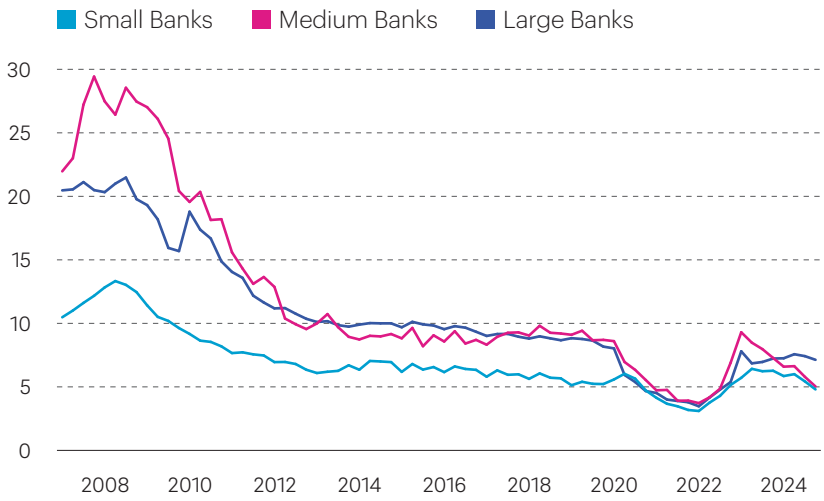


Data Source: FFIEC Call Reports

FIGURE 8

Banks of Different Sizes Have Converged in Their Reliance on Debt Financing Even While Their Overall Reliance on Debt Decreases

Nondeposit debt as a percentage of total liabilities, by bank size, 2007–2024



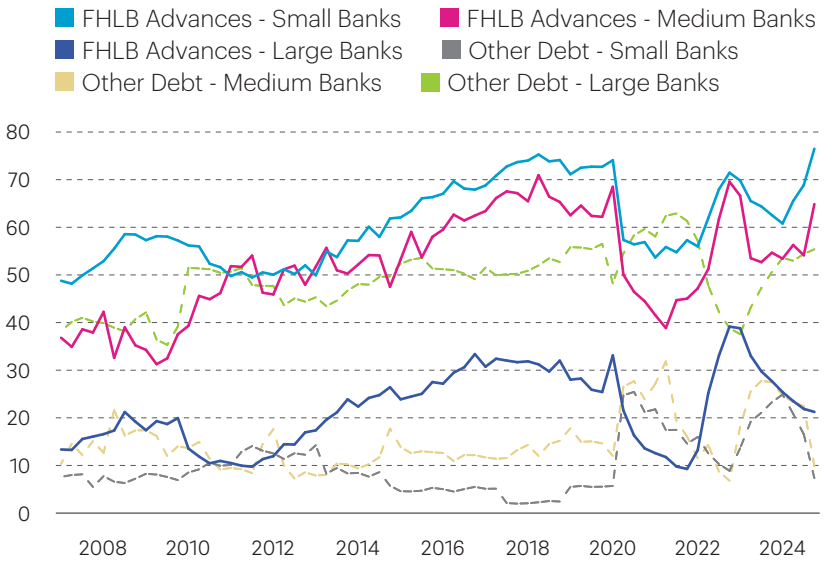
Data Source: FFIEC Call Reports

FIGURE 9

Banks of All Sizes Have Reduced Their Reliance on FHLB Loans

But at small and medium banks these loans still represent a larger ratio of total debt.

FHLB advances and other debt as a percentage of total debt, by bank size, 2007–2024



Data Source: FFIEC Call Reports

9). The difference in FHLB loans as a percentage of total debt is striking: They are nearly 80 percent of total debt at small banks, about 65 percent at medium banks, but just 21 percent at large banks.[24]

Banks use FHLB loans for various reasons. There is evidence that large banks use them to buy liquid assets that satisfy their LCR requirements,[25] whereas small and medium banks use them as substitutes for deposits to fund loan growth.[26] Small banks don't have the branch networks or the ability to advertise widely, both of which they need if they are to gather enough deposits to grow.[27] Medium banks have more extensive branch networks, but their deposit growth is still limited.[28] Without access to a large pool of depositors, small and medium banks must still rely on at least some debt financing. And, of the five forms of debt financing, FHLB loans are deemed the least risky because of their implicit governmental guarantee.

For these reasons, small and medium banks were the first and heaviest users of FHLB loans. However, now that large banks are also using them, FHLB loans have become yet another area in which banks of different sizes compete for the same funds. Additionally, the haircut on FHLB loans is likely more of a hardship for smaller banks because those loans tie up a larger proportion of their limited funds.

Liability Structure and Lending

Banks structure their liabilities to find the most efficient way to fund their loans. Thus, differences in bank lending are correlated with how banks structure their liabilities.

Large banks extend a lot more credit lines, whereas small and medium banks are more likely to make term loans.[29] As a percentage of total assets, large banks' unused commitments are three times those of small banks and 1.5 times those of medium banks (Figure 10). Unused credit lines have fallen in real terms at small and medium banks while growing at large banks. This may explain why large banks have shifted toward core deposits and away from debt. Because core deposits usually increase in times of stress, banks can use them to provide lines of credit without risking a lapse in funding. This is what makes these banks their customers' last-resort source of liquidity.[30]

None of this proves a causal relationship. The literature is split as to whether banks garner more deposits because they have increased their credit lines (the demand-side argument), whether they provide more credit lines because they have garnered more deposits (the supply-side argument), or whether an increase in deposits and an increase in credit lines reinforce each other (the mixed argument).[31] Suffice it to say that market conditions have determined that credit lines are the better source of liquidity for borrowers and that deposits are the more efficient way to fund those credit lines.[32]

Conclusion

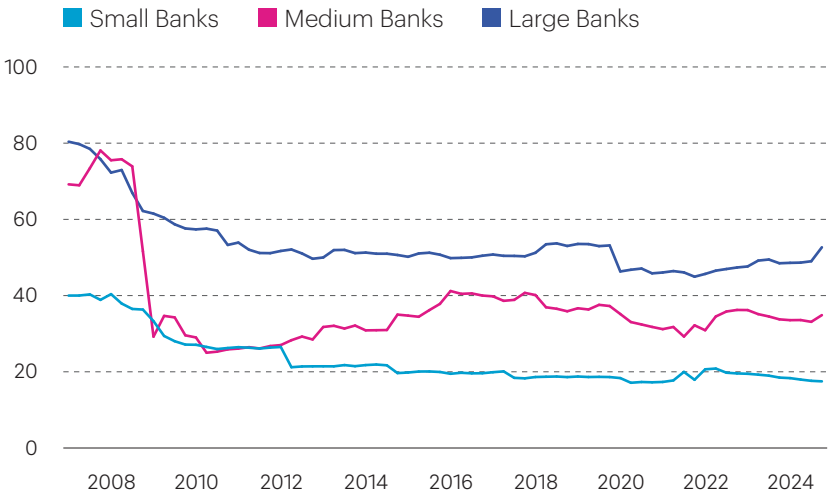
Since the GFC, banks have changed both sides of their balance sheets. This may or may not have led to a more stable banking system. On the liabilities

FIGURE 10

Large Banks Rely More on Credit Lines

Small and medium banks are more likely to make term loans.

Unused commitments as a percentage of total assets, by bank size, 2007–2024



Data Source: FFIEC Call Reports

side, banks have shifted away from most debt financing in favor of deposits. While a shift toward core deposits may seem to be stabilizing, a lot of the increase in core deposits has been in uninsured deposits. There are also significant differences in liability structure depending on the size of the bank. Compared with small and medium banks, large banks are more reliant on uninsured core deposits, noncore deposits, and other borrowing, whereas small and medium banks rely more heavily on insured core deposits and FHLB loans.

These changes on the liabilities side of the balance sheet have gone hand in hand with changes on the assets side. Large banks are more likely to offer credit lines, particularly for business loans, whereas small banks mainly offer term loans. Medium banks are in between. Large banks need a lot more short-term liquidity in case their customers begin drawing heavily on their credit lines. Small and medium banks are more concerned with protecting themselves from an increase in interest rates, which would make it still harder for them to attract deposits.

In short, bank customers have switched to more liquid credit while banks have sought more liquid funding. But this transition toward greater liquidity is harder for small banks because they have less access to capital markets and fewer customers to rely on for deposits. This leaves them more reliant on FHLB financing, which comes with a big haircut.

The Role of Federal Home Loan Banks in the U.S. Banking System

The system of Federal Home Loan Banks (FHLBs) was created by Congress in 1932 to support the thrift industry. It was originally conceived as the lender of last resort for savings and loans and savings banks, and only those institutions plus some insurance companies were permitted to become members. The Financial Institutions Reform, Recovery, and Enforcement Act (FIRREA) of 1989, which Congress passed in response to the crisis in the thrift industry, opened the FHLB system to other depository institutions, including commercial banks and credit unions. Since then, FHLBs have become an integral source of liquidity for the banking system.

Although FHLBs are generally safe and a stabilizing influence, they are not without risks both individually and systemically. All FHLBs are highly leveraged. At year-end 2024 the aggregate equity-to-assets ratio of the 11 FHLBs was about 5.65 percent.[33] FHLBs are primarily funded by bond sales on the global market. These bonds were traditionally a mix of long-, medium-, and short-term bonds, but beginning in about 2016 FHLBs began shifting to short-term borrowing.[34] This has exposed them to greater interest rate risk.[35] Finally, FHLBs have taken on an increasing role in the fed funds market. They maintain a steady supply of fed funds as a liquidity buffer, but because the fed funds market has shrunk, FHLBs' share of this market has grown. If they need to withdraw those funds, that could severely disrupt the market. And because the fed funds rate is used as a benchmark for other rates, that could have a ripple effect.

Notes

1 Although deposits are also a form of debt (in that they are funds owed by a bank), for this paper I use "deposits" to describe customer accounts reported on the Call Report as deposits and "debt" to describe nondeposit debt instruments as described below.

2 Unless otherwise noted, all data used in this article are from Federal Financial Institutions Examination Council (FFIEC) Call Reports. The data include all commercial banks as defined by the Federal Reserve Board's RSSD System.

3 See Berlin and Mester (1999), Kashyap et al. (2002), and Drechsler et al. (2017).

4 Brokered deposits are placed on behalf of individuals or institutions by a third party for a fee. Domestic deposits are deposits in domestic offices, which can include transaction accounts (including nearly all demand deposits), insured time deposits, and savings deposits.

5 See Berlin and Mester (1999) and Kashyap et al. (2002).

6 Only banks with total assets over $1 billion report their estimated uninsured deposits. Prior to the GFC, the limit on deposit insurance was $250,000 for retirement accounts and $100,000 for all other accounts. In the fourth quarter of 2008 Congress temporarily (until December 31, 2009) expanded deposit insurance to $250,000 for all accounts. The next year this was extended until December 31, 2013. Because these expanded limits were regarded as temporary, banks still reported deposits over $100,000 as uninsured, even though they were covered to the higher limit. In 2010, Congress passed the Dodd–Frank Act, which made the

$250,000 limit permanent and allowed unlimited insurance on noninterest-bearing transaction accounts until December 31, 2012. From the fourth quarter of 2010 onward, banks reported deposits over $250,000 as uninsured, except those accounts Dodd–Frank gave temporary unlimited insurance to.

7 See Kelly and Rose (2025), Jiang et al. (2024), and Bao et al. (2025).

8 See Kimble and Seay (2024).

9 Time deposits are accounts in which the depositor pays a fee when withdrawing funds before a specified date.

10 See Drechsler et al. (2017) and Supera (2021).

11 See Hahm et al. (2011).

12 See Hahm et al. (2011).

13 However, the fed funds rate is very important in determining other interest rates. Some studies—for example, Drechsler et al. (2017)—have found that banks match the sensitivity of their deposit and loan rates with respect to changes in the fed funds rate. Although deposit and loan rates move with the fed funds rate, they do so significantly less than one-for-one.

14 The Financial Services Regulatory Relief Act of 2006 allowed Federal Reserve Banks to pay interest on bank reserves held on deposit beginning October 1, 2011. This date was advanced to October 1, 2008, by the Emergency Economic Stabilization Act of 2008. Thus, reserves have replaced much of the fed funds market.

15 See Gorton and Metrick (2009).

16 See Gorton and Metrick (2009).

17 See CBO (2024).

18 See Gissler and Narajabad (2017a).

19 The Congressional Budget Office (CBO) estimates that the average haircut is about 28 percent for residential mortgages and about 34 percent for commercial mortgages, although haircuts vary widely. See CBO (2024).

20 Although the changes discussed in this article are likely putting more stress on small banks, that alone doesn't necessarily explain why they are becoming rarer. This is an area for future research.

21 Some research—for example, Bao et al. (2025)—suggests that uninsured depositors use larger banks in the belief that, should the bank have financial troubles, the government will take extraordinary measures to prevent a run on that bank, which might otherwise trigger runs on other banks. This is what happened during the SVB/Signature/First Republic failures. Once there was a run on their uninsured deposits, the Federal Deposit Insurance Corporation (FDIC) announced that it would insure all depositors.

22 Nonetheless, there is some evidence that customers of smaller banks are willing to accept lower rates for more personal services.

23 The rule was finalized in 2014 and phased in beginning in 2015, with full implementation in 2017.

24 In real terms, however, large banks' FHLB borrowing is more than double that of small and medium banks combined. Also, while FHLB loans decreased by 27.4 percent at small banks and 59.4 percent at medium banks, at large banks the decrease was only 4.2 percent.

25 See Gissler and Narajabad (2017a, 2017c).

26 See Stark and Spears-Reed (2004) and Frame et al. (2012).

27 See DiSalvo (2021).

28 Small and medium banks may use FHLB loans for other reasons as well, such as purchasing securities, managing interest rate risk, and paying down higher-interest debt. See Stark and Spears-Reed (2004) and Frame et al. (2012).

29 See DiSalvo (2021) and DiSalvo (2024).

30 See DiSalvo (2024).

31 See Strahan (2008).

32 Numerous studies have shown that core deposits fund credit lines. See Kashyap et al. (2002), Strahan (2008), and DiSalvo (2024).

33 Source: Individual Federal Home Loan Bank Securities Exchange Commission 10-K filings. The ratios ranged from 5.01 to 8.57 percent, with a mean of 5.72 and a median of 5.35 percent.

34 Source: Gissler and Narajabad (2017a, 2017b, 2017c).

35 Interest rate risk is the risk that changes in interest rates will result in a decrease in the value of a bank's assets or an increase in the cost of its liabilities. Interest rate risk arises when the maturities of assets and liabilities are mismatched. A rise in interest rates decreases the value of the security, resulting in realized or unrealized losses on that security. See Saunders and Cornett (2003).

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Research Update

These papers by Philadelphia Fed economists, analysts, and visiting scholars represent preliminary research that is being circulated for discussion purposes.

The views expressed in these papers are solely those of the authors and should not be interpreted as reflecting the views of the Federal Reserve Bank of Philadelphia or Federal Reserve System.

Can LLMs Credibly Transform the Creation of Panel Data from Diverse Historical Tables?

Multimodal LLMs offer a watershed change for the digitization of historical tables, enabling low-cost processing centered on domain expertise rather than technical skills. We rigorously validate an LLM-based pipeline on a new panel of historical county-level vehicle registrations. This pipeline is estimated to be 100 times less expensive than outsourcing options, reduces critical parsing errors from 40 percent to 0.3 percent, and matches human-validated gold standard data with an R^2 of 98.6 percent. Analyses of growth and persistence in vehicle adoption are statistically indistinguishable whether using LLM or gold standard data. LLM-based digitization unlocks complex historical tables, enabling new economic analyses.

WP 25-28. Verónica Bäcker-Peral, Massachusetts Institute of Technology; Vitaly Meursault and Christopher Severen, Federal Reserve Bank of Philadelphia

Financial Fraud Through the Lens of Extended Fraud Alerts

We use extended fraud alerts in anonymized credit reports to examine how identity theft, and subsequent clean-up, affects consumers' credit outcomes. The immediate effects of fraud for these consumers are negative, relatively small, and transitory. After placing an alert, these consumers experience persistent declines in delinquencies and a 12-point increase in credit scores, and 11 percent of filers become prime consumers. Many of these consumers take advantage of their improved creditworthiness and obtain additional credit. Although alert filers have larger balances, their performance on loans is as good as or better than before fraud, suggestive of a change in behavior following fraud.

WP 25-29. Nathan Blascak, Julia Cheney, Robert M. Hunt, Vyacheslav Mikhed, and Dubravka Ritter, Federal Reserve Bank of Philadelphia Consumer Finance Institute; Michael Vogan, Upstart

Incomplete Pass-Through in Mortgage Markets

This paper studies the May 2023 change in the conforming mortgage upfront guarantee fee schedule. Consistent with incomplete pass-through, lenders raise rejection rates and sell fewer loans to the GSEs when fees rise. For small-dollar mortgages (SDMs), pass-through is near zero and rejection rates are more sensitive to fee increases. This implies that the overall incomplete pass-through is partly driven by liquidity-constrained borrowers and that the inequality in mortgage access via higher rejection rates on SDMs is partly driven by lenders' inability to pass costs onto SDM borrowers. Without offsetting effects from fee cuts, fee hikes reduced aggregate mortgage origination in 2023 by 8 percent.

WP 25-30. Natee Amornsiripanitch, Federal Reserve Bank of Philadelphia Supervision, Regulation, and Credit Department; Judith Ricks, Mortgage Bankers Association

Capitalization as a Two-Part Tariff: The Equilibrium Structure of Housing Prices

This paper investigates whether neighborhood amenities are capitalized into housing prices via a two-part tariff: an extensive margin price for housing of any size or quality and an intensive margin price that raises the price per unit of housing services. A stylized model shows that extensive margin pricing will emerge when there are frictions (such as density regulations) to the allocation of housing across space. Using a data set of housing transactions across markets of the United States, we show that two-part tariff pricing is ubiquitous and especially pronounced in markets with high regulation and older housing stock. Ignoring two-part pricing will understate poorer households' willingness to pay for nonmarketed goods.

WP 19-20R. H. Spencer Banzhaf, North Carolina State University, PERC, and NBER; Kyle Mangum, Federal Reserve Bank of Philadelphia

The Price of Housing in the United States, 1890–2006

We construct the first annual market rent and home sales price series for American cities over the 20th century using 2.7 million newspaper real estate listings. Our findings revise several stylized facts about U.S. housing markets. Real market rents did not fall during the postwar period in most cities and rose nationally by 60 percent from 1890 to 2006. Real prices reached almost four times their 1890 level by 2006. Prices grew most in met-

ros with high demand and low levels of construction. The rent-to-price ratio fell from about 8 percent in the early 20th century to 3 percent by 2006, consistent with declines in the cost of owning housing relative to renting. For the typical year in our period, the annual return to owning housing was 9 percent, driven mostly by rental returns of 7.7 percent, with capital gains contributing only 1.3 percent. While capital gains were close to zero from 1890 to 1940, they grew to nearly a third of total returns from 1970 to 2006.

WP 24-12R. Ronan C. Lyons, Trinity College Dublin; Allison Shertzer, Federal Reserve Bank of Philadelphia; Rowena Gray, UC Merced, David Agorastos

Underwater: Strategic Trading and Risk Management in Bank Securities Portfolios

We use bond-level data to study how U.S. banks manage risk in their securities portfolios, focusing on the period of rapidly rising interest rates in 2022–2023, and examine the role of financial and regulatory frictions in shaping bank behavior. Interest rate risk in bank portfolios increased sharply as rates rose, with significant cross-bank heterogeneity depending on ex ante holdings of bonds with embedded options. In response, exposed banks shortened the duration of bond purchases but did not actively sell risky securities or expand "qualified" hedging activity; securities also played a limited role in banks' responses to deposit outflows. We identify two frictions. First, we find that banks are highly averse to selling underwater bonds at a discount to book value. This "strategic" trading is more pronounced for banks that do not recognize unrealized losses in regulatory capital and banks facing stock market pressure. Second, frictions in establishing qualified accounting hedges limited hedging activity depending on bond type and accounting classification. But banks reduced the interest-rate sensitivity of regulatory capital by classifying the riskiest bonds as held-to-maturity.

WP 25-31. Andreas Fuster, École Polytechnique Fédérale de Lausanne; Teodora Paligorova, Board of Governors of the Federal Reserve System; James Vickery, Federal Reserve Bank of Philadelphia

The Opposing Effects of Wealth on Younger and Older Entrepreneurs

Using wealth windfalls from lottery winnings and matched employer-employee tax files, we compare the effect of additional wealth on the entrepreneurial activity of older and younger individuals. We find that additional wealth leads older winners (aged 55 to 64) to reduce business ownership and growth. In contrast, extra wealth increases younger winners' (aged 21 to 54) business ownership but has no effect on business growth. The increase in business activity of a young winner does not offset the negative growth for an older winner, which may hurt economic growth.

WP 25-32. Philippe d'Astous, HEC Montréal; Vyacheslav Mikhed, Federal Reserve Bank of Philadelphia Consumer Finance Institute; Sahil Raina, Alberta School of Business; Barry Scholnick, Alberta School of Business and Consumer Finance Institute Visiting Scholar

Bankruptcy Lawyers and Credit Recovery

I study how bankruptcy law firm advertisements affect household credit, exploiting the borders of local TV advertisement media markets. I document a significant advertising effect on filing rates and subsequently show that ad exposure is associated with better postbankruptcy financial outcomes. I also find that ad-induced filers are more likely to receive a discharge, file with lawyer representation, and be first-time filers. I interpret these findings as evidence that bankruptcy law firm advertisements help mitigate underinformation and stigma in bankruptcy.

WP 24-10R. Brian Jonghwan Lee, Emory University and Federal Reserve Bank of Philadelphia Consumer Finance Institute

School Closures, Parental Labor Supply, and Time Use

This paper re-examines the response of parental labor supply to the pandemic-era suspension of in-person instruction. The effect of school closures is undetectable after controlling comprehensively for unobserved heterogeneity. Even excluding such controls, a shift from fully virtual to in-person implies an increase in weekly hours worked of just 2 to 2.5. These estimates are used to inform a simple model of the household in which access to telework and nonparental care mitigate the labor supply impact of school closures. Time use data suggest telework and nonparental care indeed helped some parents balance work and child care during the pandemic.

WP 25-33. Enghin Atalay, Ryan Kobler, and Ryan Michaels, Federal Reserve Bank of Philadelphia

At-Risk Transformation for U.S. Recession Prediction

We propose a simple binarization of predictors—an "at-risk" transformation—as an alternative to the standard practice of using continuous, standardized variables in recession forecasting models. By converting predictors into indicators of unusually weak states, we demonstrate their ability to capture the discrete nature of rare events such as U.S. recessions. Using a large panel of monthly U.S. macroeconomic and financial data, we show that binarized predictors consistently improve out-of-sample forecasting performance—often making linear models competitive with flexible machine learning methods—and that the gains are particularly pronounced around the onset of recessions.

WP 25-34. Rahul Billakanti, Wayzata High School; Minchul Shin, Federal Reserve Bank of Philadelphia

Aging and Housing Returns

Older home sellers receive lower returns than younger home sellers. Homes sold by older people have fewer major renovations but higher rates of poor upkeep. Older sellers are also more likely to sell off-MLS ("pocket listings") and to sell to investors, leading to lower prices. These patterns suggest that older sellers may be disproportionately disadvantaged by agents' incentive to maximize fees through generating high sales volume instead of maximizing sale prices. Age-related cognitive decline makes the elderly more vulnerable. For causal evidence, we show that reforms making private listings more transparent reduced both the prevalence of pocket listings and the magnitude of the age gap in returns.

WP 25-35. Natee Amornsiripanitch, Federal Reserve Bank of Philadelphia Supervision, Regulation, and Credit Department; Philip E. Strahan, Boston College and NBER; Song Zhang, University of Delaware

The Great Reshuffle: Remote Work and Residential Sorting

This paper studies the significance of migration in evaluating the welfare impacts of remote work. By analyzing individual location history data, we first document an increase in net migration toward suburbs and smaller cities since 2020. The migration wave has been disproportionately fueled by high-income individuals, who were more likely to move due to remote work. Consequently, regions with substantial in-migration observed the greatest rise in housing expenses. This also led to changes in local demand for services and associated employment. Employing a stylized welfare accounting framework, we show that migration mitigated the increase in housing cost burdens for both high- and low-income groups, with the advantages being greater for low-income individuals. Conversely, dispersed job growth curtailed the increase in job accessibility, especially for high-income groups. Factoring in the spatial impacts of migration on housing costs and job accessibility, the welfare inequality surge related to remote work is considerably tempered.

WP 25-36. Wenli Li, Federal Reserve Bank of Philadelphia; Yichen Su, Southern Methodist University

Single-Family REITs and Local Housing Markets

We study the rise of single-family real estate investment trusts (SF-REITs) using a novel property-level data set. SF-REITs tend to buy homes in neighborhoods near city centers, where housing supply is relatively elastic and residents are on the lower rungs of the homeownership ladder. Exploiting spatial differences, we find that SF-REIT growth modestly raises prices and increases overall housing supply, with individual ownership rising at a similar rate. However, we find no evidence that SF-REITs reduce financing accessibility.

WP 25-37. Marco Giacoletti, University of Notre Dame and Visiting Scholar, Federal Reserve Bank of Philadelphia Research Department; Rawley Z. Heimer, Arizona State University and Visiting Scholar, Federal Reserve Bank of Philadelphia Research Department; Wenli Li, Federal Reserve Bank of Philadelphia; Edison G. Yu, Federal Reserve Bank of Philadelphia

Financial Consequences of Student Loan Delinquency, Default, and Servicer Quality

Using anonymized consumer credit bureau data, I examine the credit market consequences of student loan delinquency and default and the role that student loan servicers play in contributing to borrower outcomes. I exploit random assignment of student loan borrowers to student loan servicers of varying quality to study the direct effect of servicers on borrowers' credit outcomes and to isolate variation in the likelihood of default that is not correlated with borrower characteristics. I find that being assigned to a higher-default servicer increases a borrower's likelihood of default by approximately 6 percent. However, there is a precisely estimated null effect of servicer assignment on measures of borrowers' likelihood of financial distress, credit access, and zip code characteristics. These findings suggest that averting a servicer-induced default does not yield considerable benefits for marginal borrowers' credit outcomes but that servicers are meaningful drivers of student loan repayment outcomes.

WP 25-38. Meredith Welch, PEER Center, American University

Hospital Billing Regulations and Financial Well-Being: Evidence from Calif.'s Fair Pricing Law

We examine the financial consequences of the 2007 California Fair Pricing Law, which places a price ceiling on hospital bills for financially vulnerable individuals. Exploiting cross-sectional variation in exposure to the law, we estimate its impact on individual financial distress. We find that the law reduces the likelihood of incurring nonmedical debt in collections by 19.8 percent and the number of nonmedical collections by 39 percent for an individual living in a county with average exposure in California. In addition, we find suggestive evidence that the number of delinquent accounts decreased for exposed individuals. Our results suggest hospital billing regulations can improve targeted individuals' financial outcomes.

WP 25-39. Yaa Akosa Antwi, Johns Hopkins University and Consumer Finance Institute Visiting Scholar; Marion Aouad, UC Irvine, and Consumer Finance Institute Visiting Scholar; Nathan Blascak, Federal Reserve Bank of Philadelphia Consumer Finance Institute

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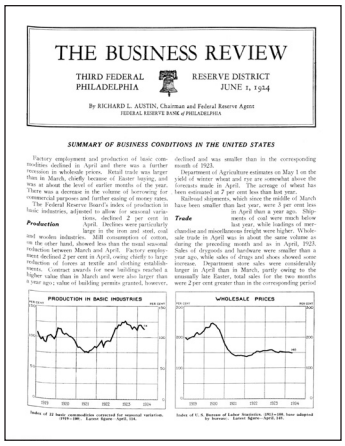

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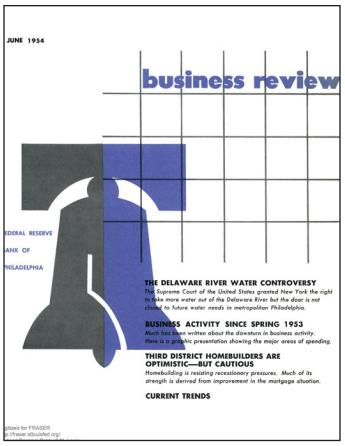

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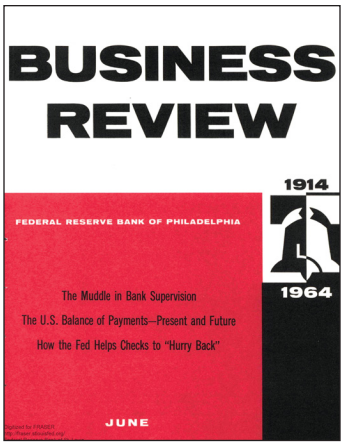

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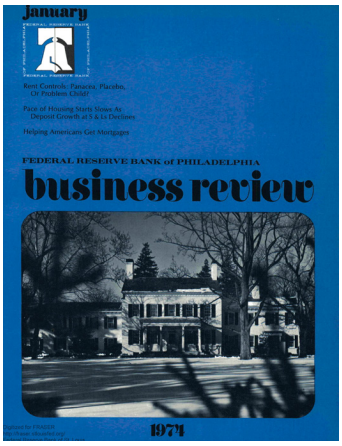

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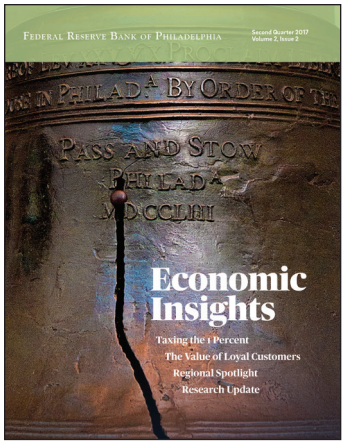

2010s

2020

2023