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Gender Composition of the Boards of Directors of the Regional Federal Reserve Banks

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The Federal Reserve System is composed of the Board of Governors and twelve regional Federal Reserve Banks (the "Feds"). While the Board of Governors is a government agency, the Feds are semiprivate corporations with a governance structure similar to that of companies in the private sector, with the Feds' presidents serving as CEOs of their Banks. In particular, each Bank has a board of directors with oversight responsibilities similar to those of their private sector counterparts. Moreover, each board nominates the president of its Fed, indirectly influencing monetary policy.[1] In this article, we present new data on these boards and analyze female representation among directors.

There is an explicit interest in increasing the diversity of policymakers at the Federal Reserve System.[2] It is well-known that women and

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[1] A subset of the directors of the main branch of each Fed nominates the new president of their Bank. These nominations need to be confirmed by the Board of Governors. In contrast, candidates for the Board of Governors are nominated by the president of the U.S. and need a U.S. Senate confirmation.

[2] During the search for presidents for the Federal Reserve Banks of San Francisco, Richmond, and Atlanta, Rep. Maxine Waters, together with other congressional Democrats, wrote letters to former Chair Janet Yellen and current Chair Jerome Powell calling for search processes that consider gender and racially, ethnically, and occupationally diverse candidates. See, also, Chair Powell's speech on diversity and inclusion in

minorities have traditionally been underrepresented among governors of the Federal Reserve Board and among the presidents of the Feds. It has been argued that this lack of diversity may limit the representation of the interests of these groups.[3] Moreover, there is some evidence that opinions among economists about policy differ across genders and that diversity changes group dynamics and decision-making.[4] These concerns are also relevant for Fed officials beyond the presidents and governors, such as the members of the boards of directors of the Regional Banks, but the extent of female representation on these boards has not been, to our knowledge, documented systematically.[5] This article seeks to fill this gap.

Using our hand-collected data, we analyze the gender composition of boards of directors of the twelve Regional Banks. There are nine head-office director seats per Bank.[6] The first year women were hired as directors was 1977. That year there were five women out of the total 108 directors. As seen in Figure 1, the proportion of females has increased significantly since 1977, reaching its peak of 31.5 percent (thirty-three women) in the last year of our sample, 2017. The average annual rate of increase during the whole period has been 0.5 percentage points. A simple extrapolation of this linear trend implies that it will take thirty-one more years to achieve an aggregate representation rate of 50 percent. If, instead, we wanted to achieve equal representation in only ten years, the annual increase in representation should be 1.85 percentage points.

In this article, we will analyze in detail the director data in order to perform an accounting exercise: we want to determine whether the increase in representation so far has been driven by changing selection ("hiring") practices, changes in retention, or both. This should help us identify the most effective ways to achieve higher female representation.

October 2018—available at https://www.federalreserve.gov/mediacenter/files/chairman-powell-diversity-transcript-20181009.pdf.

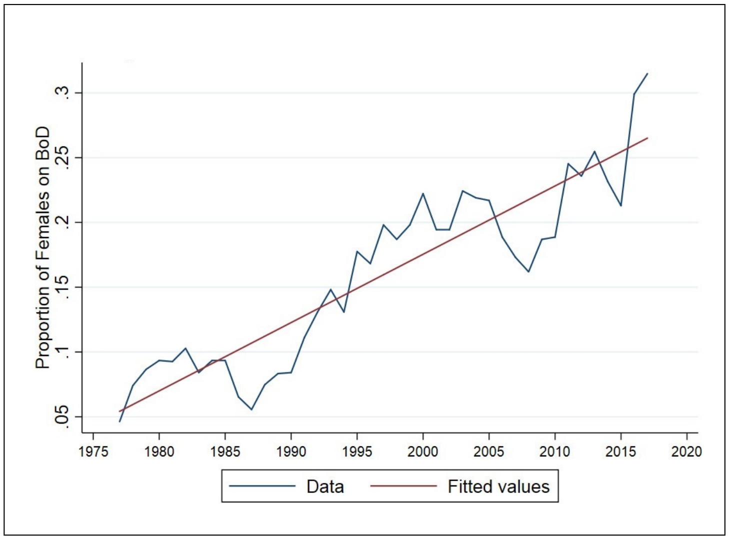
[3] In a letter to Chair Yellen in May 2016, Sens. Conyers and Warren stated: "Given the critical linkage between monetary policy and the experiences of hardworking Americans, the importance of ensuring that such positions are filled by persons that reflect and represent the interests of our diverse country, cannot be understated. When the voices of women, African-Americans, Latinos, Asian Pacific Americans, and representatives of consumers and labor are excluded from key discussions, their interests are too often neglected." (Conyers and Warren 2016).

[4] See Bayer and Rouse (2016) for a summary of these studies.

[5] Since the passage of the Dodd-Frank Act in 2010, the regional Feds and the Board have published annually a report on the diversity of their workforce and their inclusion efforts. There is no information in those reports on the gender composition of the boards of directors. The Government Accountability Office (GAO) published a report in 2011 that analyzed similar data for the years 2007-10.

[6] There are also boards for each of the branches of the regional Feds, but these do not play the governance role that head-office boards do.

Figure 1 Representation of Female Board Members over Time



Note: Representation of females as a proportion of the 108 total director seats over time. We overlap the fitted trend of an OLS regression of representation on time (with an estimated coefficient of .005, i.e., half a percentage point increase every year).

Most directors in our sample are subject to maximum tenures of two three-year terms, with an extra year of service allowed for directors who were hired to finish someone else's term. Using detailed information at the director level on tenure and term completion to determine their eligibility to continue serving on the board, we construct quitting rates (i.e., the proportion of directors who leave their seats at a date when they could serve at least one more year). We find that directors do not quit very often in the middle of a term, and we find no important differences in quitting behavior across genders. We calculate a quitting rate for males of 7.6 percent, which is slightly higher than the average quit rate for females of 6.6 percent. There is no significant trend in quitting rates throughout our sample.

As a consequence of these low and gender-balanced quitting rates, the increase over time in the representation of women is due mostly to the natural work of term and tenure limits together with an increase in the hiring rate of females. The Fed's governance mandate of a maximum tenure of six years (or seven, for directors who came in as replacements) allows for relatively quick turnover of directors when compared with the private sector. We find that the female hiring rate has increased only modestly from 1977 to 2017, at about 6 percent per year on average. We find no significant differences in hiring rates of women, or in gender-specific quitting rates, across the twelve Banks.

We use the rates we recover from the data to calibrate a statistical model of the probability of having a woman occupy one of the 108 director seats. We use this model to perform predictions and counterfactuals. Under the quitting rates and the hiring trends we observe from 1977 to 2017, we forecast that in ten years from the end of the sample female representation will be 36.3 percent. An equal representation of females and males under the current parameters would occur thirty-one years out from 2017.

With the model in hand, we quantify the effect of a hypothetical change in hiring practices consisting of expanding the pool of candidates beyond CEOs, in the spirit of a recommendation from the Government Accountability Office (GAO) in 2011. To inform this exercise, we analyze the titles of directors hired (available starting in 1990) and interpret the representation of women across different "hiring pools" (CEOs versus lower-ranked executives) as the true rate of eligible women in them. Because we have no data on the offers made to potential candidates, nor their rate of acceptance, our interpretation cannot be validated and our counterfactual exercise should be interpreted with caution. We find that a shift in the hiring pool of directors (each Bank filling two positions from non-CEO executives instead of from the CEO hiring pool) may speed up female representation, reaching equal representation four years earlier than under current hiring policies. However, this is only the case if the growth rate in female hiring from lower ranks of corporations is close to that of the last twenty-five years. In the last ten years, the Feds seem to have been increasing the proportion of female hires within the CEO ranks faster than in hires from lower tiers of the corporate ladder. If that is more indicative of the expected representation of eligible women going forward, hiring from outside of the CEO pool would slow down the increase in female representation (reaching 50 percent one year later) and should probably be considered only under an explicit target of women.

Given our finding that changes in the female hiring rates have been the main driver of changes in female representation, we explore potential factors influencing the rate at which women are recruited to be directors of the Feds. Comparing female hires across female and male Fed presidents, we find no evidence that female presidents favor the hiring of—or are more successful in attracting—female directors. The board's gender imbalance, instead, seems to be an important driver of female hires: the probability of hiring at least one woman in a year with vacancies decreases with the number of women already serving on that board. In general, replacement is a common practice: when a female director leaves a board, the probability that a new female director will join the board the next year is 43.6 percent versus 21.5 percent if no female left. The proportion of new hires who are women in the year after a female director left the board is 23 percent, while only 12 percent of new hires are women when no female left.

The next section describes the data sources and the governance of the boards and lists the first female directors at each Fed. Section 2 discusses diversity in private sector boards to frame the discussion about Fed directors. In Section 3, we present a simple model of female representation as a function of hiring rates, quitting rates, and term restrictions, and we present data on each of these separately. Section 4 presents the results of our accounting exercise, where we use the rates recovered from the data to forecast female representation. We explore the hiring practices counterfactual in Section 5. Section 6 documents the effect of board diversity on hiring practices. Section 7 concludes.

1. DATA DESCRIPTION AND INSTITUTIONAL DETAILS

We use the hand-collected data in Jarque and McCrary (2017) that contains the name and dates of service of each director at the twelve Federal Reserve Banks. This information comes originally from the annual reports of the Federal Reserve System from 1914-2017, which are publicly available at the Board's website. We use the names of directors to determine their gender. We complement this data with public information online to determine the gender whenever the name is ambivalent. We also use information on Fed presidents' tenures and gender from Jarque and McCrary (2017). Once we determined the first year with a female director (1977), we limited our analysis to observations after that date.

Next we describe the rules governing the appointment of Bank directors, as well as their main responsibilities, compensation, and term limits.[7] Although historical documentation of these rules and practices is not readily available, the data suggest that the current rules have been in place for most of our period of analysis (1977-2017).

[7] See "Roles and Responsibilities of Federal Reserve Directors" and other documents by Federal Reserve System Publications, available at https://www.federalreserve.gov /aboutthefed/directors/pdf/roles_responsibilities_FINALweb013013.pdf. See also the GAO report of 2011.

There are nine head-office directors on each Bank's Board, with three directors in each of three classes, denoted A, B, and C:

- Class A directors represent the member banks in the district. They are chosen by member banks.
- Class B and C directors represent the public and "shall be elected... with due but not exclusive consideration to the interests of agriculture, commerce, industry, services, labor, and consumers."[8]
  - Class B directors may not be employees or directors of any Bank or any "financial affiliation company." They are chosen by member banks.[9]
  - Class C directors are chosen by the Board of Governors.

The Board of Governors also chooses who, among the Class C directors, will serve as the chair and deputy chair of the board of directors, who are appointed annually. These appointments can be renewed for up to three years. Fed presidents, branch executives, and previous directors have strong influence on candidate proposals of all classes, and the final invitation is extended by the Fed president. Business and community contacts who are used by the Feds to gather information on the regional economy are often included in the candidate pools, though searches also extend to qualified candidates in the region who have no previous ties to the Feds. For bankers, state banking organizations were tapped in the past to propose candidates, though in recent years this

[8] See Federal Reserve Act, section 4, 12 U.S.C. section 302.

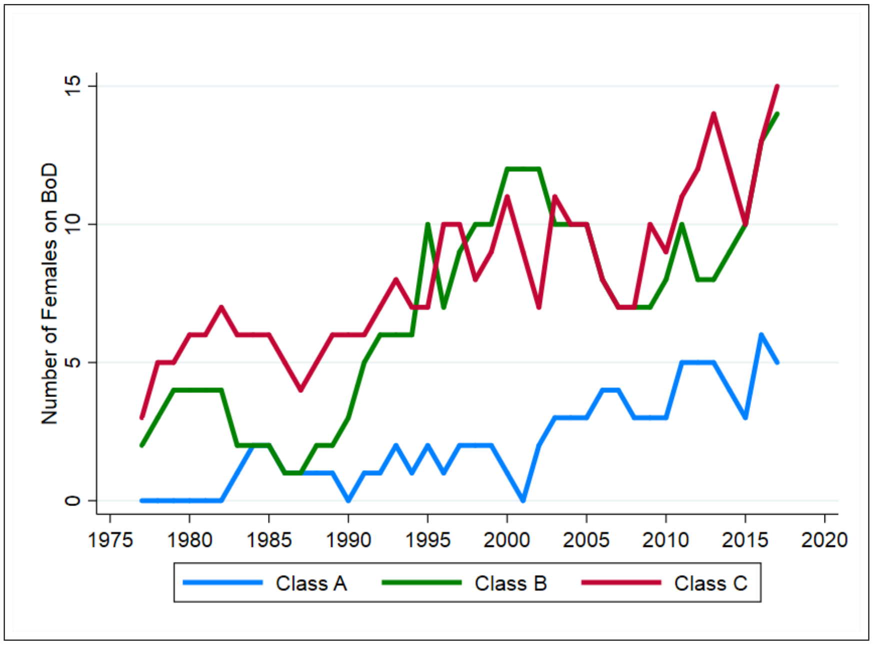
[9] From the Board of Governor's website: "[...] it is the Board's policy that a Class B director may not be an officer, director (including advisory director), or employee of a financial affiliation company, except in the limited circumstances described below.

For purposes of this policy, a financial affiliation company is defined as any bank, bank holding company, branch or agency of a foreign bank, Edge Act or agreement corporation, thrift institution, credit union, designated financial market utility ("DFMU"), systemically important financial institution ("SIFI") or subsidiary of any such company or entity. A financial affiliation company also includes any thrift holding company (also known as a savings and loan holding company) and any company that owns a bank or thrift institution (but is not a bank holding company or a thrift holding company), if, at the time of election, either (1) the total of all banks and thrifts controlled by the company constitutes 15 percent or more of the assets of the consolidated holding company or (2) the total assets of the banks and thrifts owned by the company exceed $10 billion. Companies described in the previous sentence that fall below the 15 percent and $10 billion thresholds are referred to herein as "15 percent test companies."

A Class B director who is affiliated with a 15 percent test company should be selected because of the individual's connection with the nondepository activities of the company and may not be an officer, director, or employee of any bank or thrift institution or a subsidiary of either. Reserve Banks are encouraged to have no more than one Class B director affiliated with a 15 percent test company on the Reserve Bank board at any one time."

Source: https://www.federalreserve.gov/aboutthefed/directors/PDF/eligibility-qualifications-rotation.pdf.

Figure 2 Female Members over Time by Director Class



practice seems to have been discontinued to prevent potential conflicts of interest, as well as to minimize the potential signals that the acceptance or rejection of proposed candidates may give about solvency of the candidate's financial institution (which would have been acquired by the Feds through their confidential access to information via their supervision responsibilities).

Each of the three seats within Class A and Class B is chosen by a subgroup of member banks: all member banks are annually classified into large, medium, or small banks according to capital and surplus. Members in each of these three groups nominate and vote only on candidates who are to occupy the seat allocated to their group. The breakdown of female hires by director class is presented in Figure 2. A notable feature in this figure is that Class A directors, who come from the banking industry, have traditionally included fewer women overall.

Most Feds have at least one branch in addition to their head office. These branches have their own boards of directors, chosen partly by the directors of the head office and partly by the Board of Governors. In this study, we will restrict ourselves to analyzing the head-office boards of directors.[10]

The first woman to serve on a Board started her term at the FRB of Atlanta in 1977. A list of the first women hired for the Board of each Bank can be seen on Table 1. None of them were hired to a Class A seat. It is notable that it took eleven years for all the Feds to have had at least one woman on their Board, with five Banks hiring a woman in 1977 and Cleveland being a very late adopter. In contrast, Cleveland was the first Fed to have a female president (Karen Horn, who served as president from 1982-87).[11] In the rest of the article we restrict our analysis to the years after the first woman was elected.

According to the Board of Governors' website, "Directors play an important role in the effective functioning of the Federal Reserve. All directors are expected to participate in the formulation of monetary policy and to act as a link between the System and the public. In addition, head-office directors are responsible for supervising the administration of their Reserve Bank's operations, overseeing the Reserve Bank's corporate governance function, and maintaining an effective system of internal auditing procedures and controls. Directors are not involved, however, in any matters related to banking supervision, including specific supervisory decisions."

Since the Banking Act of 1935 and until 2010, all nine directors were in charge of appointing new Fed presidents and first vice presidents. The Dodd-Frank Act of 2010 changed this, restricting Class A directors and Class B directors with ties to the financial industry from most of the appointment process. In particular, these directors cannot be on the search committee that identifies candidates, and they do not vote to approve a candidate.

Compensation of directors has been modest enough since 1936 to make the job only suitable for outside directors. (Chairs were full-time employees for the first twenty years of the Fed, as discussed in McAfee [2004].) For illustration, directors are paid a daily fee ranging from $200 to $300 for attending directors' meetings, committee meetings, or other activities considered Bank business, including telephone conference calls. They are also paid an annual retainer of $2,000 to $2,500, or $5,000 for the chair. There are established funds available at each Federal Reserve Bank designated to award directors who go beyond the scope of their regular responsibilities ($6,000 available at

[10] A 2011 U.S. GAO report on Fed director diversity and governance reports statistics on gender diversity for the years 2006-10. While women represented 24 percent of new head–office directors, they represented 32 percent of the new directors of the branches. For details, see GAO (2011).

[11] We will explore ties between female presidents and board members in Section 6.

Table 1 First Female Appointment at each Regional Bank's Board with the First Year They Served

Year	Bank	Class	Name	Employment
1977	Atlanta	B	Jean McArthur Davis	McArthur Dairy, Inc., Miami, FL
1977	Dallas	C	Margaret S. Wilson	Scarbroughs Stores, Austin, TX
1977	Philadelphia	C	Jean A. Crockett	U. of Pennsylvania (Wharton), Philadelphia, PA
1977	San Francisco	C	Dorothy Wright Nelson	U. of Southern Calif., (Law Center), Los Angeles, CA
1977	St. Louis	B	Virginia M. Bailey	Eldo Properties, Little Rock, AR
1978	Boston	B	Carol R. Goldberg	The Stop & Shop Companies, Inc., Boston, MA
1978	Minneapolis	C	Sister Generose Gervais	Saint Mary's Hospital, Rochester, MN
1978	New York	C	Gertrude G. Michelson	R.H. Macy & Co., Inc., New York, NY
1979	Chicago	B	Mary Garst	Garst Company, Coon Rapids, IA
1980	Kansas City	C	Doris M. Drury	U. of Denver, Englewood, CO
1985	Richmond	C	Hanne Merriman	Retail Business Consultant, Washington, D.C.
1988	Cleveland	C	Verna K. Gibson	Outlook Consulting International, Inc., Columbus, OH

each Bank for all head-office directors), but the use of these funds has historically been very rare. Moreover, these compensation figures have been unchanged since 1981.

Directors are appointed to serve three-year terms, although they can—and sometimes do—quit at the end of the calendar year even if they have not completed their terms. Each of the three seats within each class has a three-year term assigned to it, in a staggered fashion; if a director leaves before his or her seat's term has expired, the new director completes the term of the outgoing one. This means that within each class, at the beginning of each year, one seat has a full term of three years remaining ("slot 1"), one has two years of the term remaining ("slot 2"), and one has only one year left ("slot 3").

Although only Class C directors have explicit tenure limits, Banks are encouraged by the Board to follow the same rules for all classes:

directors cannot be reappointed for more than two full three-year terms and cannot be reappointed for a term if by the end of the term they would have served for more than seven years. Exceptions are allowed with waivers from the Board of Governors. In our sample all classes seem to be working under these maximum tenure rules.[12,13] The maximum tenures of eight or nine years observed in our sample constitute exceptions to the rule, and anecdotal evidence suggests that these requests to keep directors in their seats for longer had the objective of maintaining continuity in instances when otherwise there would be particularly high turnover of directors.

Data, confirmed by anecdotal evidence, suggest that some of the regional Banks operate on a different term structure for Class A directors: they do not offer a second term to the same person, presumably to increase turnover and maximize representation of member banks in the district. We will discuss these practices in Section 3.

The Fed governance rules for maximum tenure of directors are stricter than those for most boards of private sector companies. In a survey of practices of S&P 500 companies, PwC found that in 2017, director term limits were only used by 5 percent of S&P 500 boards, and most are set at fifteen years or more. According to the survey, 73 percent of boards had adopted mandatory retirement ages, but for 96 percent of these boards, the retirement age was seventy-two or higher, with this age limit increasing in the last decade.[14] This is thought to represent the reluctance of boards to replace currently serving directors who are useful to the company. The average tenure of independent S&P 500 directors was 8.2 years in 2017, while for Fed directors it was, on average, 4.84 years from 1977 to 2017. Institutional investors such as Blackrock or the California Public Employees Retirement System have pointed out that longer tenures have the obvious advantage that comes with experience but that they may be a problem if viewpoints do not evolve over time and become stale, and they may compromise independence (PwC 2018a).

For the purpose of putting the statistics we provide in this study into perspective, in the next section we present some information on the representation of females on the boards of private sector compa-

[12] We end the sample in 2011 for replacement directors or 2012 for nonreplacements when constructing these statistics since we do not observe complete histories for the directors starting after these years.

[13] Based on tenure data, these seem to be the governing rules for all classes starting in the mid-1960s. In earlier years, some directors were completing upward of twenty years of service.

[14] We are not aware of retirement age limits for Fed directors, and we do not have age information for the directors in our dataset.

nies. This comparison should be taken with caution: since the Feds have a markedly different objective and way of operating than most private sector companies, the role of Fed directors is somewhat different from those of private sector company boards. For example, each individual Fed has limited discretion over their own budget, and hence directors are not expected to monitor it. However, many oversight responsibilities, such as auditing financial statements, approving compensation of executives, and contributing to succession planning, are similar to those in the private sector, and they constitute an important part of the Fed's directors' duties. Hence, the pool from which Fed directors are typically hired is similar to that of hires of private sector boards: CEOs and other high-ranking executives. The gender composition of this hiring pool will naturally influence female representation among directors. It should be noted, however, that for an executive to be eligible as a Fed director, he or she needs to satisfy numerous restrictions, and this restricts the hiring pool further. Directors need to be chosen in equal representation from member banks (Class A), the broader economy (Class B), and certain sectors that represent the general public (Class C). Different classes face different requirements; for example, class A directors should be chosen over time so that they represent all states within a district. Other requirements applying to all directors are a two-year residency in the district, the expectation of experience serving on other boards, active employment rather than retirement, and a record of community service. There are also disqualifying situations, such as political affiliations or receiving appointments or funding from elected officials and parties. Finally, another important difference between director positions in the private sector and the Fed is that compensation for Fed directors is nominal. Serving on the Board is mainly considered public service, with its main tangible benefit arguably coming from reputation and networking opportunities.

2. DIVERSITY IN PUBLICLY HELD COMPANY BOARDS AND IN THE FINANCIAL INDUSTRY

Diversity within the boards of publicly held companies has been an issue of interest in recent years. Vinnicombe (2008) provides an international perspective both on representation and on accessibility issues. A PwC report on survey results stressed the importance of diversity by providing anecdotes of institutional investors voting against directors in companies that did not have enough diversity — or that did not address the problem adequately according to the investors (PwC

Table 2 Women as a Percentage of Board Seats for Fortune 100 Companies, Fortune 500 Companies, and the Twelve Federal Reserve Banks

	2004	2010	2012	2016
FRB	21.9	18.7	24.5	29.9
Fortune 100	16.9	18.0	19.8	22.9
Fortune 500	n/a	15.7	16.5	20.2

2018b).[15] Moreover, the report documented divergence of opinions between male and female directors regarding issues of corporate culture, talent management, social concerns, and the diversity of the board itself.

Table 2 presents data from a 2016 report by Deloitte, another consulting firm, that pertains to two groups of companies: Fortune 100 and Fortune 500 companies.[16] The report presents data in four nonconsecutive years in the 2004-16 period and for 492 companies, for a total of 5,440 board seats. In each year there is a greater percentage of women on Fortune 100 boards than on Fortune 500 boards. We report in the table, for comparison, the corresponding proportion of women on the boards at the twelve Reserve Banks for the years in their sample. The representation at the Fed surpasses that of the Fortune companies.

Given that the pool of potential directors draws mostly from senior management positions, representation of women in those positions is a necessary condition for having a diverse pool of directors. In particular for the Fed positions, representation in banking is key: the lower rate of female hiring in Class A could be due in part to a lower availability of female CEOs in banking. According to a recent report by the GAO, in the financial services industry representation of women remained largely unchanged between 2007 and 2015, around 48 percent among first- and mid-level managers and around 29 percent among senior-level managers (GAO 2017). The study also explored the pipeline for those management positions, both external and internal, to companies. The external pool includes those with undergraduate or graduate degrees, such as a master's of business administration; in 2015, about 60 percent of this pool were women. The internal talent pool for potential

[15] The 2018 annual PwC survey of U.S. corporate directors included 714 directors from a cross-section of companies from over a dozen industries, of which 76 percent have annual revenues of more than $1 billion. Eighty-one percent of the respondents were men, and 19 percent were women (PwC 2018b).

[16] These are, respectively, the top 100 and 500 publicly held U.S. companies by revenue, in a given fiscal year, according to *Fortune* magazine.

Table 3 Proportion of Females on the Boards of the Feds Compared with the Proportion of Females among Senior Executives

	2007	2008	2009
Directors of regional Feds	17.4	16.4	17.7
All-industry senior executives	28.6	29.0	28.3
- in banking	30.9	30.0	29.0
- in industries other than banking	28.5	28.9	28.3

Note: According to EEOC statistics. Source: GAO (2011).

managers in financial services includes those already in professional positions; in 2015, just over 51 percent were held by women.

More specifically for the banking sector, Haslett and Dholakia (2018) report that since 2013 the percentage of women CEOs among public banks and thrifts has increased only 0.8 percentage points, from 3.5 percent to 4.3 percent in 2017. However, a 2011 GAO study comparing female representation in Fed directors and private companies did not find a significantly lower availability of qualified candidates in banking compared with other sectors. The GAO's analysis of Equal Employment Opportunity Commission (EEOC) data found that diversity among senior executives is generally limited, but Fed boards had less female representation than was found in the senior management of private sector companies: as reflected in Table 3, the representation of women was about 10 percentage points lower among the Fed boards than in the EEOC data.[17] The report found that the Feds generally limit their director search efforts to senior executives. While some Reserve Banks recruit more broadly, the GAO recommended that the Federal Reserve Board encourage all Reserve Banks to consider ways to help enhance the economic and demographic diversity of perspectives on the boards, including by broadening their potential candidate pool.

[17] Data reported in GAO (2011). For their benchmarking to industry standards, they analyzed EEOC's EEO-1 data for employers with 100 or more employees from 2007 through 2009. The EEO-1 data provide information on racial/ethnic and gender representation for various occupations within a broad range of industries. We used the EEO-1 "executive and senior level officials and managers" job category as the basis for our analysis because this is the category of employees from which Reserve Banks would most likely recruit directors. EEOC defines the job category of executive and senior-level officials and managers as individuals residing in the highest levels of organizations who plan, direct, and formulate policies and provide overall direction for the development and delivery of products and services.

We will consider this recommendation when exploring counterfactual policies in Section 5.

The findings in the corporate governance literature about the effect of female directors in the private sector provide a useful background for our study, even if directors at the Feds have slightly different responsibilities and objectives than those in private companies.[18] Using a panel of approximately 300 unregulated Fortune 1000 firms in the '90s, Farrell and Hersch (2005) find that the increase in representation during this period from 5.6 percent in 1990 to 12.26 percent in 1999 is most likely driven by internal or external calls for diversity rather than by the expectation that women bring more value to the firms. We check for this type of hiring dynamic in our data in Section 6 and find a similar pattern: the probability of hiring a new female director increases significantly when a current female director leaves and is negatively affected by the number of women already on the board. There is some evidence within the banking sector that questions this hiring practice: using data on U.S. bank holding companies, Owen and Temesvary (2018) document a nonlinear relationship between gender diversity on boards and various measures of bank performance: adding more women to the board improves overall performance only if there is already at least one woman on the board. Adams and Ferreira (2009) find that female directors are better monitors: they have better attendance, participate in more committees, and the CEOs of their companies have more variable pay. However, they only find a positive influence of women on firm performance for firms that have worse governance to start with.

A few papers have studied the effect of the minimum quota of 40 percent female representation introduced in Norway in 2003. Ahern and Dittmar (2012) find that the introduction of the measure had a negative effect on firm value. It led to younger and less experienced boards, increases in leverage and acquisitions, and deterioration in operating performance. However, Bertrand et al. (2019) present evidence from the same Norwegian episode that women appointed as directors were better qualified than their female predecessors and benefitted in terms of wage from this policy, while the gains for similarly qualified females who were not appointed as directors were limited. Finally, Matsa and Miller (2013) compare affected firms with other Nordic companies, public and private, that are unaffected by the rule and find that affected firms undertake fewer workforce reductions than comparison firms, increasing relative labor costs and employment levels and reducing short-term profits.

[18] Recent papers studying the effect of female managers and CEOs on private sector firm performance and wages include Flabbi et al. (2018) and Kunze and Miller (2017).

3. THE DETERMINANTS OF FEMALE REPRESENTATION

The proportion of females on Fed boards of directors (what we refer to as the rate of "representation") has been increasing fairly steadily since 1977, as seen in Figure 1. Representation depends on quitting rates, hiring rates, and maximum-tenure practices. The following simple model of the representation of females in one single slot illustrates this point and provides a framework for our measurements later in the paper.

A simple model of representation for one seat on the board

At any point in time (t) a given seat on a board may be occupied by a female or a male director. Assume that there are no term limits, so that both the slot occupied or the tenure of the director are irrelevant for transitions. Simply, every time a director quits, the new director hired is a female with probability π. Assume as well that females quit in a given period with a probability of q, while males quit with a probability of $q + \Delta$, where Δ can be positive or negative. The probability that a female is occupying that seat in period $t+1$, denoted by γ_{t+1}, together with the corresponding probability for a male, $1 - \gamma_{t+1}$, is given by the following equation:

$$\left[\gamma_{t+1}, 1 - \gamma_{t+1}\right] = \left[\gamma_t, 1 - \gamma_t\right] \Pi,$$

where Π is the transition matrix:

$$\Pi = \begin{bmatrix} 1 - \Pr(male \mid female) & \Pr(male \mid female) \\ \Pr(female \mid male) & 1 - \Pr(female \mid male) \end{bmatrix}.$$

As in any model of transitions, the key parameters are the "switching" probabilities; the comparison of $\Pr(male \mid female)$ and $\Pr(female \mid male)$ (the probability that a male occupies a seat next period, conditional on it being occupied by a female today, and vice versa) will be informative about long-term female representation, as we show next. In terms of the parameters of our model, we have:

$$\Pi = \begin{bmatrix} (1-q) + q\pi & q(1-\pi) \\ (q+\Delta)\pi & (q+\Delta)(1-\pi) + (1-q-\Delta) \end{bmatrix}.$$

It can be shown (see the Appendix) that n periods ahead, the probability of having a female director in that slot, γ_{t+n}, given an initial representation of γ_0, is equal to

$$\gamma_{t+n}(\gamma_0) = (1 - q - \pi\Delta)^n \gamma_0 + \left[1 - (1 - q - \pi\Delta)^n\right] \frac{\pi q + \pi\Delta}{q + \pi\Delta}. \quad (1)$$

The term $(1 - q - \pi\Delta)$ captures the combined rate at which the gender of the seat is not switching (1 minus the sum of the switching rate of a seat occupied by a male and the switching rate of a seat occupied by a female). When n is small, the term $(1 - q - \pi\Delta)^n$ is closer to 1 and representation is closer to the initial representation, γ_0. When n is very large, the term $(1 - q - \pi\Delta)^n$ is small and representation is closer to $\frac{\pi q + \pi\Delta}{q + \pi\Delta}$; this is the probability of having a female occupy the seat in the long term. In other words, we can characterize period-n representation, for a given initial condition, as a weighted average of initial conditions and the long-term distribution. As n grows, the weight of the initial conditions goes to zero. Note that if the quitting probability is the same for females and for males (i.e., $\Delta = 0$), representation after n periods simplifies to:

$$\gamma_{t+n}(\gamma_0) = (1 - q)^n \gamma_0 + [1 - (1 - q)^n]\, \pi.$$

Here, the combined nonswitching rate is simply $1 - q$, and the long-term representation of females is equal to their hiring rate π. If Δ is positive (negative), it decreases (increases) the combined nonswitching rate by $\pi\Delta$ (since males quit Δ more than females, and the hire to replace them will be female—a switch—with probability π). A positive (negative) value of Δ also pushes the long-term female representation rate upward (downward):

$$\frac{\partial \left(\frac{\pi q + \pi\Delta}{q + \pi\Delta} \right)}{\partial \Delta} > 0;$$

that is, for a given female hiring rate of π, long-term representation of women is higher if females quit less often than men.

In the case of the Fed boards, term limits imply that long-term representation will not be determined by these simple expressions. In particular, tenure limits imply that after a maximum of seven years, there will be a new hire, even without observing a quit by the incumbent. We will document the way in which term completion and tenure affect quitting rates, so we can understand how allowing replacement directors to serve a second term can affect retention and overall representation.

Once we incorporate in our model the formal tenure and term restrictions, at any point in time the transition probabilities governing each of the 108 slots in the Fed will vary. As a result, an analytical solution is unavailable, and we must rely on numerical models to measure the aggregate transitions. To get the parameters that guide these transitions, we analyze separately quitting rates, hiring rates, and maximum-tenure practices in the rest of this section. We present a summary of our findings in Table 4. We report the average proportion

Table 4 Average over Time of the Main Statistics in our Sample

			Class		
		All	A	B	C
Female representation (γ) (%)	1977-2017	16.0	5.8	19.3	22.8
	Last 10 yrs	23.3	11.7	26.6	31.7
Yearly increase in representation (%)	1977-2017	0.53	0.34	0.69	0.55
	Last 10 yrs	1.37	0.60	1.75	1.74
Proportion of females in new hires	1977-2017	16.6	7.3	21.3	23.6
(π) (%)	Last 10 yrs	26.8	15.9	28.5	38.0
Yearly increase in π (g) (p.p.)	1977-2017	0.57	0.43	0.65	0.62
	Last 10 yrs	1.98	0.44	4.05	0.25
Female quitting rate (q) (%)	1977-2017	6.6	4.4	6.9	7.0
(incl. only directors with tenure ≤ 6)	Last 10 yrs	8.0	10.0	8.1	6.3
Excess male quitting rate (Δ) (%)	1977-2017	1.0	1.8	0.8	2.3
(incl. only directors with tenure ≤ 6)	Last 10 yrs	0.8	−3.0	0.6	4.9

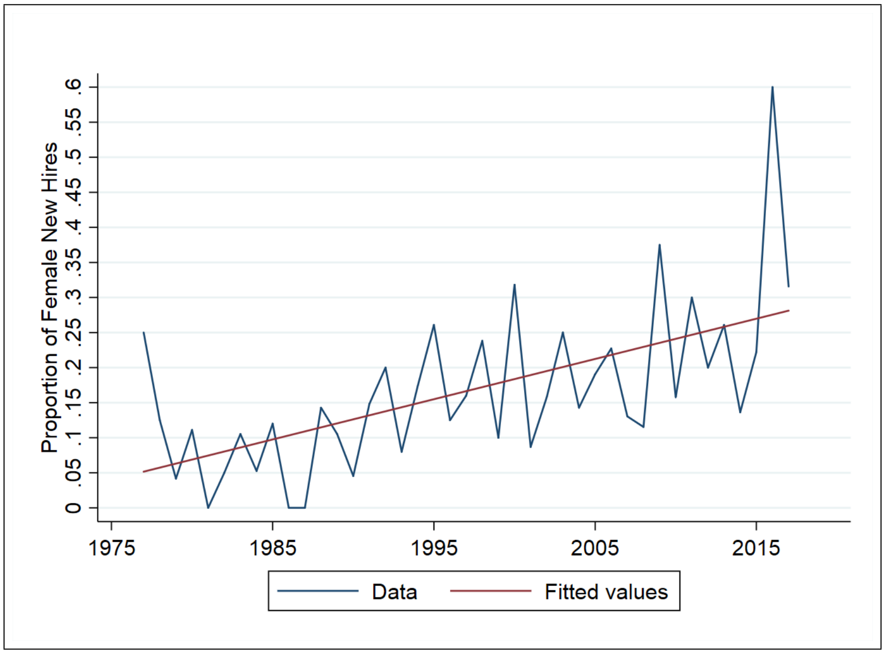
of board seats occupied by women (γ) and its growth rate, the proportion of new hires who are women (π) and its growth rate (g), and the "true" quitting rate (q), which corrects for exits due to reaching maximum tenure. We report these rates for the 1977-2017 overall sample period, as well for the last ten years (2008-17).[19]

A significant increase in the hiring rate, π, can be seen by comparing the rate for the entire sample period (16.6 percent) with that of the last 10 years (26.8 percent). This trend is captured by the growth in the hiring rate, g, which is 0.57 percentage points over the entire sample but has been 1.98 percentage points in the last ten years. Class A seats tend to have fewer female hires per year than Class B and Class C seats, and when we check our data, we see that Class A accounts for a larger number of hires each year. Figure 3 shows a steady increase of the female hiring rate over the sample period. In contrast, the number of directors hired each year stays somewhat constant over time, with an average of 22.4 directors per year.

When looking at average quitting rates, we note that for the entire sample, males quit a bit more often than females (1 percentage point more), although in the last ten years this has decreased slightly, to be

[19] We check for differences in hiring and quitting rates across the twelve regional Banks. There are no stark differences across Banks in representation, hiring, or quitting rates. Statistics by Bank are available upon request.

Figure 3 Females as a Proportion of New Hires



0.8 percentage point more than females. A quick back-of-the-envelope calculation using the average rates for the last ten years in our simple model can help us understand the edge over the hiring rate that comes from the difference in quitting rates between females and males. We plug the parameters from the last ten years into equation 1, using as an initial condition a male in the seat at time 0 $(\gamma_0 = 0)$. We find that by the tenth year, the probability of having a female in that seat is $\gamma_{10}(0) = 0.17$. This probability goes up to $\gamma_{10}(0) = 0.19$ if we cut the female quitting rate in half (4 percent) but keep the male rate at the 8.8 percent found in the data. If instead we consider a seat initially occupied by a female $(\gamma_0 = 1)$, this probability is $\gamma_{10}(1) = 0.59$ when q and Δ take their true sample values, and it becomes $\gamma_{10}(1) = 0.77$ when we artificially set females quitting rates to 4 percent and keep male ones at 8.8. The difference in the effect of this policy across the two examples is due to π being set to 26.8 percent, the average over the last 10 years. Because it is significantly lower than 50 percent, the initial gender of the director is very decisive. Recall that π has been growing over time, at about 2 percentage points per year during the

Table 5 Classification of Hiring Model by Percentage of Class A Directors who Start a Second Term (T2)

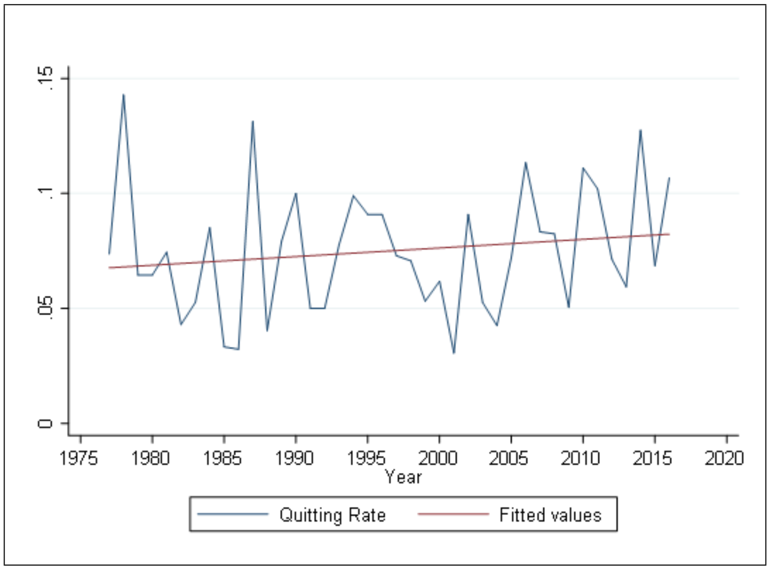
Bank	T2 Starting Rate (%)	Hiring Model
Atlanta	89.5	2
Chicago	85.0	2
Dallas	85.0	2
Kansas City	76.2	2
St. Louis	76.2	2
New York, 1993 and after	75.0	2
San Francisco	64.0	2
Cleveland	62.5	2
Boston	13.3	1
Philadelphia	12.1	1
Minneapolis	5.4	1
New York, before 1993	0.0	1
Richmond	0.0	1

last ten years. When we simulate the full model with variable quitting rates, we will also consider the growth in hiring rates over time.

Exits and quits

Using our data to learn about the relevant quitting rates in our statistical model takes some work. In order to correctly estimate the probability that a director leaves their position before his or her maximum tenure is reached (what we call a "true quit"), we need to understand the term structures. Formally, the tenure rules put forth by the Board of Governors for Class C directors allow them to serve for two complete terms. Although the Board has recently encouraged the Feds to follow these rules for all classes, we find both empirical and anecdotal evidence that a number of the Feds traditionally have not offered a full second term to their Class A directors. We classify Banks as "Hiring Model 1" (HM1) if they only offer one term and "Hiring Model 2" (HM2) if they offer two. To sort the Banks into these two models based on their treatment of Class A directors, we look at the proportion of new hires in a given year who eventually start a second term. Table 5 displays this rate for each Bank. We assign the hiring model based on the clear two groups defined by the stark differences in the rates: we classify the four Banks with fewer than 14 percent of directors starting a second term (Boston, Minneapolis, Philadelphia, and Richmond) as HM1. The rest all have rates above 62 percent, and we classify them as HM2.

Figure 4 Average Quitting Rates over Time



For New York, we see that before 1993 no Class A hires ever started a second term. Instead, after 1993 we see that 75 percent of directors start a second term, hence making this Bank's term structure similar to other Banks that we have classified as hiring according to HM2. Because for no other Bank in HM2 do we see such a long stretch of time with no second terms started, we decide to classify New York as two different models: before 1993, New York is hiring according to HM1, and after 1993, it is hiring according to HM2.

With that classification of Banks into HM1 or HM2, we can construct a measure of "true" quits (i.e., an instance when we observe a director leaving even though the corresponding tenure restrictions given the hiring model that applies to this director would allow him or her to serve at least one more year). Figure 4 plots the evolution of the average quitting rate over time. When the quitting rate is regressed on year, the coefficient is .00038, implying that the quitting rate increases about 0.04 percentage points on average.

Table 6 presents the weighted (by numbers of males and females in each class) average quitting rates across classes, for the whole period and for the last ten years. Because there are fewer observations when we restrict the sample to the last ten years, we exclude from the table

Table 6 Quitting Rates by Tenure of Female and Male Directors

	1977-2017		Last 10 years	
Tenure	q	Δ	q	Δ
1	.03	.01	.03	.01
2	.03	−.01	.04	.01
3	.23	−.02	.24	−.10
4	.02	.04	0	.06
5	.08	−.02	.07	.04
Average	6.6	1.0	8.0	.8

Note: Statistics for sample of nonreplacement directors who started in 2012 or earlier (i.e., directors who could have completed at least two full terms by end of 2017).

the replacement directors.[20] This means that for any given tenure, the director can only be serving in one particular slot (which determines years left in current term); for example, a nonreplacement director can only have a tenure of four years when he or she is in slot 1 (in their second term of service). Over all classes, quits after three years are a lot more common, about 20 percent, while for other tenures the quitting rate ranges from 2 to 8 percent.

As illustrated in the simple model presented earlier, a difference in the quitting rates across genders can have important implications in the long-term representation of females. Figure 11 in the Appendix presents the complete set of quitting rates by gender, class, slot, and tenure that we will use in our numerical examples. We find that most of the measured values of Δ are small but positive (i.e., males quit at slightly higher rates than females), but negative values are not uncommon. One notable change in recent years is the increase in absolute terms of the negative Δ for directors occupying a slot 3 with a tenure of three years. This means that while females were only quitting slightly more often than men in a $(3,3)$ position in the past, in the last ten years females have been quitting twice as often as men.

These patterns are the flip side of tenure (total number of consecutive years a director has served) and term completion. Over the entire

[20] The corresponding statistics for replacement directors are included in the appendix, together with the statistics for the last ten years.

sample, 1977-2017, average tenure is 4.82.[21] The average tenure for men is 4.76 years, while women have a tenure 0.43 years longer; this difference is significant at the 5 percent level. Over 92.5 percent of all directors complete their first term, with no significant difference by gender.[22]

4. IMPLICATIONS OF HIRING AND QUITTING RATES FOR LONG-TERM REPRESENTATION OF FEMALES

We saw in our simple model of transitions that, for a constant hiring rate over time of π, if quitting rates are the same across genders (i.e., $\Delta = 0$), then the long-term female representation is equal to the hiring rate π. On the Fed boards, because complete refreshment happens in at most six periods (due to the maximum tenure rules), after period seven the expected representation would be equal to the prevalent hiring rate π, regardless of the value of the quitting rates. This means increases in the hiring rate can be very effective in increasing female representation in less than a decade. To project the potential effects of the increasing trend in female hiring we observe in the data, in this section we use a statistical model of the comings and goings of directors according to actual tenure rules to predict (i) female representation in ten years, and (ii) the years it will take to achieve 50 percent representation. We parametrize our baseline model (P1) with the numbers we recovered from the data and then consider a counterfactual exercise (P2) in Section 5.

For all of our exercises, we treat the increase in hiring rates observed in the data as sustainable for extended periods.[23] We are assuming that whatever the explicit efforts to increase female representation have been, they can continue and will manage to increase hiring rates for as long as necessary at the same annual growth rate. We use the trend in hiring rates that we recovered from the data, g, starting from the true hiring rate at the end of our sample, π_{2017}, to produce a forecast

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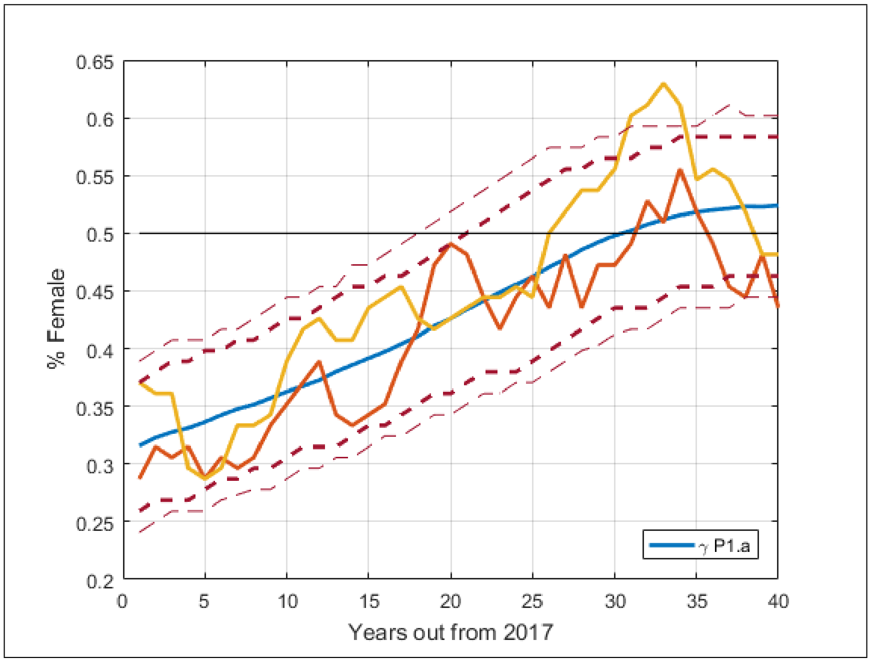
[21] Since most of the observed tenures comply with the recommended term structure for Class C directors that is currently in place, we report statistics about tenure including the few "outliers" where directors served more than seven years (one director served nine, and ten directors served eight years). However, we drop from our sample a few of the directors (twenty-nine) who change classes. Because total consecutive tenure is what matters for limits on service under the current rules, we would be misinterpreting the starting and end dates for these directors within a class.

[22] Details on tenure and term completion by gender and class are available upon request.

[23] We discuss potential determinants of the female hiring rate in Section 6.

Figure 5 Representation Projections and Paths



Note: Projected female representation. The blue line depicts the average, and dotted lines indicate the ninetieth and ninety-fifth percentile confidence bands. The light yellow and orange lines represent two of the 1,500 paths of realizations used to calculate the mean.

of hiring rates:

$$\pi_{2017+t} = \begin{cases} \pi_{2017} + gt & if\ \gamma_k < 50\ for\ all\ k < t \\ 50 & otherwise \end{cases} ;$$

that is, we assume the hiring rate increases at a growth rate g until representation reaches 50 percent for the first time, then it settles to 50 percent. As reported in Table 4, hiring rates increased over our sample period about half a percentage point per year ($g = 0.57$). Table 4 also shows that in the last ten years, the growth in the female hiring rate has been much faster ($g = 1.98$ percentage points); to consider the implications of maintaining this higher growth rate going forward, we conduct our forecasts using data for the whole sample (P1.a) and only for the last ten years (P1.b). For all the exercises we use the quitting rates by class, slot, and tenure found in the data during the subsample considered in the parametrization. For all parametrizations we start

Table 7 Numerical Results: Female Representation after Ten Years, and Years to Equal Representation

Specification		g	$\widehat{\gamma}_{2027}$	Years to $\widehat{\gamma}=.5$
P1. Baseline	a. whole sample	0.5	36.3	31
	b. 2008-2017	1.98	44.4	13
Common parameters: $\pi_{2017}=31.1$, $\gamma_{2017}=31.5$				

Note: Hats denote values found in each experiment, while no hats denote the value recovered from the data.

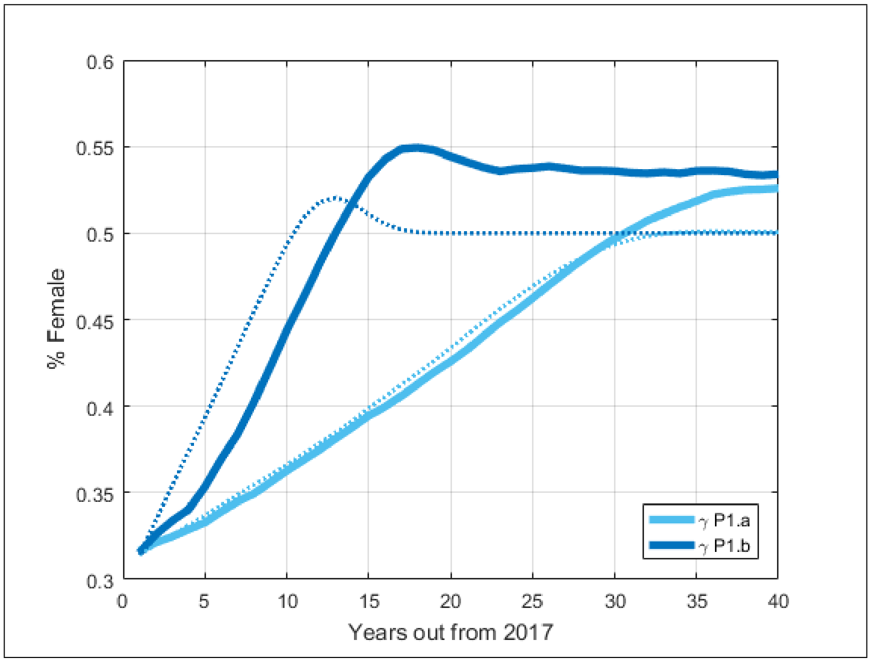
the simulation with the female representation across directors' slots that was observed in the data at the end of the sample (γ_{2017}= 31.5). We set the initial period hiring rate equal to the average rate in the data: $\pi_{2017} = 31.1$ *percent*. We assume all Banks are hiring according to HM2, since that is the recommendation of the Board going forward.

Figure 5 presents our forecast under the P1.a parametrization. We simulate the model 1,500 times, each draw recording the female representation across all Banks over time. To calculate the expected female representation, $E[\gamma_t]$, we compute the mean across all simulations at each point in time. We also track the ninetieth and ninety-fifth percentiles of the ordered draws at each point in time. In Figure 5, we plot two random paths of γ_t to illustrate the level of variation that can occur when the number of seats is so small.

Table 7 presents the results on representation in 2027 and on the time it would take to achieve equal representation of men and women. Figure 6 presents the average representation over time under the parametrizations P1.a and P1.b. In our baseline P1.a parametrization, we find that in ten years, i.e., by 2027, female representation is expected to reach about 36.3 percent. An equal representation of females and males under these parameters would occur thirty-one years out from 2017.[24] The faster growth in π in the P1.b parametrization translates into a representation of 44.4 percent in 2027 and equal representation being reached in only thirteen years. The graph also showcases the

[24] We also construct a counterfactual parametrization to evaluate the recommended change to allowing two–term tenures for all directors. We use all rates as in the baseline case and the actual hiring model that has been traditionally used for each bank. Although we expect the speed of refreshment to be slower, we find that the change in hiring model has negligible effects on the evolution of representation, and the two paths of representation coincide almost perfectly.

Figure 6 Representation Projections



Note: Projections under P1. Dashed line of corresponding color represents the path for the hiring rate π used in the projections.

effect on long-term representation of the slightly larger Δ in the P1.b case: it implies almost 4 percentage points higher representation for females.

5. HIRING BEYOND THE CEO

In this section, we discuss how expanding the pool of candidates from where directors are hired might affect female representation. This exercise is motivated by the recommendation a 2011 GAO report that boards tap executives below the CEO level as a way to consider more diverse candidates. Moreover, in a recent town hall meeting with Fed employees, President Esther George, from the Kansas City Fed, and President Loretta Mester, from the Cleveland Fed, mentioned that their

Table 8 Distribution of Fed Directors across Managerial Categories

	1990-2017			2008-17		
	% of all directors	% directors who are female (γ)	% of females with title	% of all directors	% directors who are female (γ)	% of females with title
E1	73.1	13.9	57.1	82.9	19.2	71.1
E2	6.4	41.4	12.7	7.6	51.2	13.1
NE	20.5	32.6	30.1	9.5	33.5	15.8

Banks had already been using this strategy in their hiring of directors with that objective.[25]

To evaluate the potential impact of this policy change, we use title information for directors in our sample to compile the gender composition among three different "hiring pools":

- "Tier 1" executive positions (denoted as E1), which includes mainly board chairs and/or CEOs,
- "Tier 2" executives (denoted E2), which include vice presidents, chief financial officers, and chief operating officers, and
- nonexecutives (denoted NE), which primarily include university deans, provosts, professors, and law firm partners.

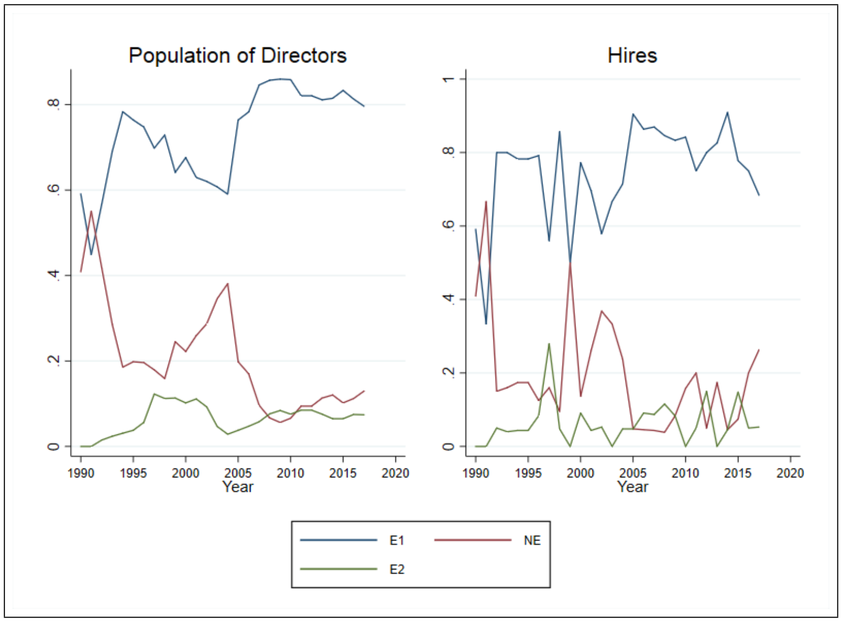
Our source for director data, the *Annual Report of the Federal Reserve System*, provides the titles and company information for directors starting in 1990.[26] We classify titles into the categories E1, E2, and NE, and we feed statistics constructed with this data into our model to construct a counterfactual (P2) that quantifies the potential effects of shifting the composition of the hiring pool away from E1 candidates.

Table 8 summarizes the composition of directors across the three hiring pools. As seen in the first column, during our title sample from 1990 to 2017, on average, 73.1 percent of the directors serving each year (male and female together) have an E1 title, while E2 titles represent 6.4 percent of the directors, and NE positions represent 20.5 percent. The fourth column reports these rates in the last 10 years of the data.

[25] We have anecdotal evidence that at the Richmond Fed this strategy has been more heavily used for recruitment of directors at the branches rather than in the main office. We do not look at branch directors in this study.

[26] For the statistics based on this data, we have omitted observations where the title was not recorded (N=42).

Figure 7 Breakdown of the Population of Directors and the Hires into the Three Hiring Pools



These numbers, as well as the left panel of Figure 7, show that the importance of E1 in the composition of the population of directors has been higher in the last decade. The right panel of Figure 7 presents the evidence regarding *hiring* rates, showing that director (male and female together) hires from the E1 group have been the highest of the three and their importance has also increased slightly over time.

We use our title data together with our gender indicator to recover female-specific statistics within hiring pools. In what follows, abusing notation slightly, we use the subscript $h \in \{E1, E2, NE\}$ to indicate the corresponding statistics for each of the E1, E2, and NE hiring pools. We decompose female representation (γ), female hiring rates (π), and their growth (g) across the E1, E2, and NE categories.

First, we explore female representation. The second column of Table 8 reports that female representation is much higher outside of the E1 group: 41.4 percent and 32.6 percent for E2 and NE, respectively, compared with only 13.9 percent within E1. For reference, we compare these statistics to the representation of women in two private sector samples. The first sample is Execucomp, composed of the top 1,500

S&P firms.[27] Our own analysis of this data finds that 2.6 percent of CEOs are female, while for non-E1 positions it is 6.8 percent.[28] The second includes private employers within the financial system with 100 or more employees and federal contractors, which a GAO report uses as comparable to the pool of qualified candidates from where Fed directors are appointed.[29] Through years 2007-15, women held 29 percent of executive and senior-level management positions.[30] The report also indicates that in nonmanagerial positions female representation is 45.1 percent. These two samples, though not a perfect match to the pool from which directors are hired, provide suggestive evidence that it is easier to find females in E2 pools.

The GAO (2017) report also provides some evidence that female representation in executive positions (E1 and E2 combined) has been practically static over the past decade, around 28.6 percent for 2007. On the other hand, as we reported in Table 8, female representation among E1 and E2 directors (γ_{E1} and γ_{E2}) has increased in the last ten years, while γ_{NE} has remained around 33 percent. This suggests that efforts to increase the representation of women directors at the Feds may have been more important within the E1 and E2 pools. This is consistent also with the percent of female directors who have an E1 title being much higher in the last ten years (columns three and six in Table 8).

Next we document the decomposition of the female hiring rate (π) by hiring pool. Table 9 (columns two and four) shows the rates for the whole sample period and for the last ten years. For reference, in columns one and three, we report the fraction of all new directors (male and female together) hired from each pool (η). We see that η_{E1} has been the highest of the three and has also increased slightly in the last ten years. The evidence indicates that it is not the case that the Feds have shifted their hiring toward the E2 or NE hiring pools,

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[27] ExecuComp contains information on approximately 2,000 CEOs and 7,000 non-T1 executives per year. EEOC numbers are for financial firms only.

[28] Using data compiled from Standard and Poor's ExecuComp database for 1999-2006, Gayle et al. (2012) provide similar numbers. They find that only 1.5 percent of the equivalent to our E1 positions are held by women. Representation in positions equivalent to our E2 titles is about 6 percent. The database consists of 2,818 publically tradeable S&P 1000 firms, which have an average of 18,930 employees.

[29] According to data compiled by the Small Business Administration from the U.S. Census, in 2014, only 106,639 out of 5,825,458 (1.8 percent) firms had 100 or more employees. Available at: https://www.sba.gov/advocacy/firm-size-data.

[30] The statistics for this group come from their required reporting to the EEOC. The EEOC defines the category of executives and senior–level managers as consisiting of individuals who are "in the highest levels of organizations who plan, direct, and formulate policies, and provide overall direction for the development and delivery of products and services."

Table 9 Distribution of Fed Director Hirings across Managerial Categories

	1990-2017			2008-2017		
	% of dir. hired (η)	% of fem. within hires (π)	growth in π (g)	% of dir. hired (η)	% of fem. within hires (π)	growth in π (g)
E1	74.6	15.4	0.007	80.2	23.2	0.015
E2	6.2	42.6	0.014	6.9	51.0	−0.028
NE	19.2	29.5	−0.001	12.8	29.0	0.064
Overall	100		0.0072	100		0.0186

which typically have higher female representation. Instead, the Feds have managed over time to attract more females within the E1 hiring pool, which is reflected in the growth in female hires (g_{E1}) being twice as large in the last ten years than in the overall sample, as can be seen comparing columns three and six.

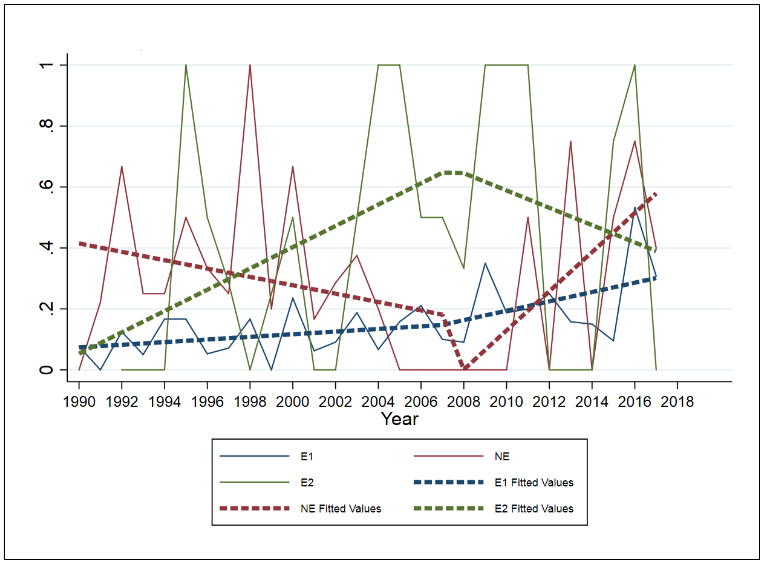
Figure 8 provides complementary evidence to Table 9. It shows the evolution over time in the proportion of female hires (π) from each of the three executive categories. The main takeaway is that the proportion of women out of E1 hires (the main source for director hires) has increased steadily over time. We fit a time trend on the three series allowing for a structural break in 2007 to construct a separate parametrization for the last ten years of the sample. The significant break suggests that a recent increase in the female-hiring rate among E1 directors has contributed to the increase in female representation over the last ten years. The trends for E2 and NE are less reliable due to the low numbers of observations per year.

When looking at the breakdown of female hires across hiring pools, we find that the shift toward E1 candidates has actually changed the composition of newer female directors to be fairly similar to that of the males (columns four and six in Table 8 are more similar than columns one and three).

Counterfactual exercise

To evaluate the effect of changing the relative importance of the three hiring pools, we use our statistical model. Since we only have information about the three pools since 1990, we create a new subperiod, denoted "c," which corresponds to the 1990-2017 year range. In each parametrization we use the growth rates of the female hiring rate by

Figure 8 Proportion of Female Directors Hired from Executive Level—Structural Break at 2007



Note: Evolution of female-hiring rate by hiring pool. Fitted values for growth rate g in dashed lines.

hiring sample (g_{E1}, g_{E2}, g_{NE}) that we reported in Table 9. In our baseline parametrizations, P2b and P2c, the overall g corresponds to the weighted-average growth in the proportion of females in hires using the true distribution of hires across pools ($\eta_{E1}, \eta_{E2}, \eta_{NE}$).[31] The initial hiring rate π is, as in our baseline parametrization, set to the hiring rate in 2017 ($\pi_{2017} = 31.1$ percent females). We compare this benchmark calibration to a counterfactual, denoted P2, of shifting two hires per year per regional Fed from the E1 to the E2 hiring pool. In this counterfactual we take as parametric the growth in the proportion of females across the hiring pools (i.e., we keep $g_{E1}, g_{E2},$ and g_{NE} fixed). We construct a counterfactual hiring rate π and overall growth g by changing the distribution of hires across the hiring pools (i.e., we com-

[31] This statistic will differ slightly from the g reported in Table 4 because here we construct it by Bank and average over individual Banks. This makes our counterfactuals more intuitive, since we switch two individuals by Bank from one hiring pool to another. We use a common set of η rates across the two subsamples since the actual numbers do not differ much and we have limited data.

Table 10 Numerical Results: Female Representation after Ten Years, and Years to Equal Representation

Specification		π_{2017}	η_{E1}	η_{E2}	η_{NE}	g	$\widehat{\gamma}_{2027}$	Yrs to $\widehat{\gamma} = .5$
P1. Baseline	b. 2008-17	31.1				0.0186	43.9	14
	c. 1990-2017	31.1	.8	.07	.13	0.0072	37.7	25
P2. Shifting 2 hires from E1 to E2	b. 2008-17	34.0				0.0133	43.8	15
	c. 1990-2017	34.0	.7	.18	.12	0.0078	40.7	21
Common parameters: $\gamma_{2017} = 31.5$								

Note: Hats denote values found in each experiment, while no hats denote the value recovered from the data.

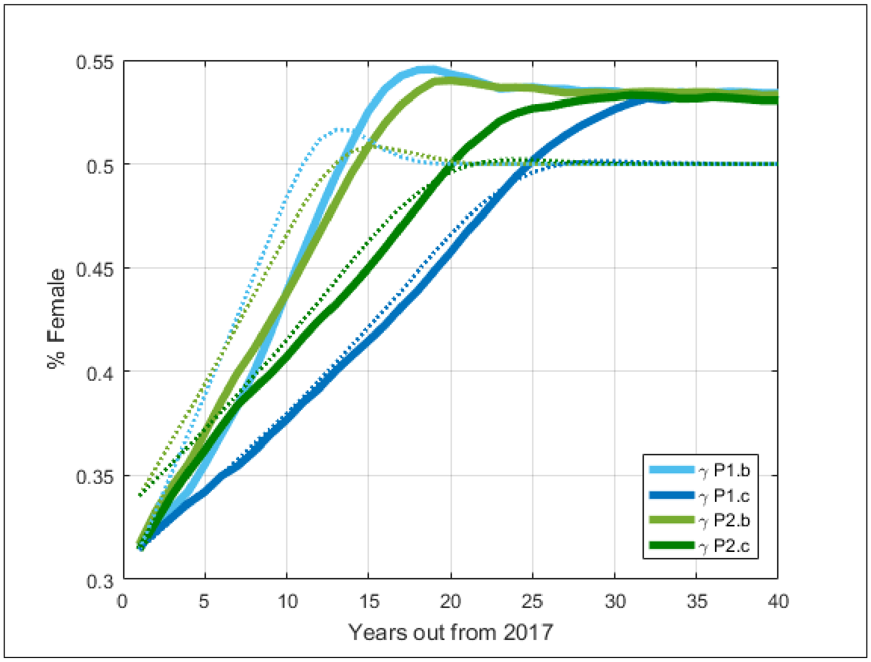
pute the implied $\eta_{E1}, \eta_{E2,}$ and η_{NE} of switching two hires from E1 to E2. We multiply these counterfactual weights times $[\eta_{E1}, \eta_{E2}, \eta_{NE}]$ in the year 2017). The resulting counterfactual π is 34 percent female hires and a g of 0.0133 when using growth data for the 2008-17 subperiod and of 0.0078 when using growth data for the 1990-2017 period.

The results of this counterfactual are presented in Table 10 and in Figure 9. The results we find depend importantly on whether we use the parameters from the last ten years (our (b) calibration) or those since 1990 (our (c) calibration). In our (b) calibrations, expanding to E2 hiring pools might be good for diversity in background or other dimensions, but it may not be good for female representation: Table 9 shows that even though the growth in female hiring within the E2 pool is higher than within the E1 pool over the period 1990-2017, in the last ten years this trend has reversed. Hence, if female rates within hiring pools represent the true rate of qualified and eligible females, then we should be careful about recommending this policy with the objective of increasing female representation. Of course, it may still be useful to expand outside of the E1 pool, provided it is done with the intention of hiring a female candidate (i.e., if you wish to hire a woman and there are no eligible candidates in the E1 pool).

6. WHAT IS DRIVING FEMALE HIRING RATES?

Our empirical analysis and the counterfactual exercises highlight the important role that changes in the hiring rate have (and can) play in female representation on the boards. In this section, we explore a

Figure 9 Representation Projections: Hiring Counterfactual



Note: Projections under P1 and P2. Dashed line of corresponding color represents the path for the hiring rate π used in the projections.

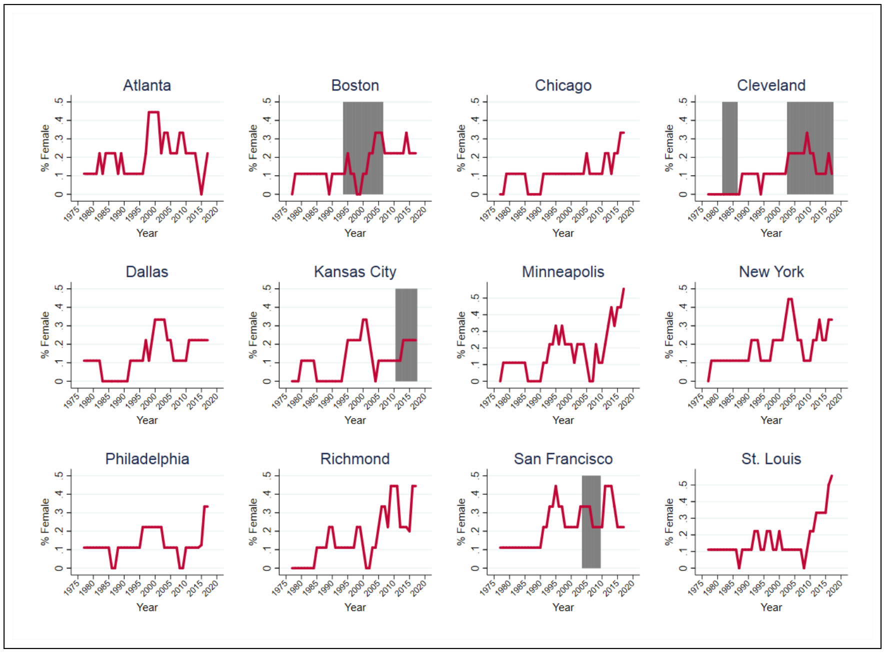
few possible determinants of the female hiring rate. First, we check the hypothesis that females tend to hire more females by studying the effect of female Fed presidents on the number of females on their own boards.[32] Second, we explore whether female hiring rates vary with the number of female directors already on the board or depending on whether one of those females just left the board.

Female Fed presidents

Figure 10 documents the actual series of representation, by Bank, with shaded areas representing the tenure of female presidents. One obvious takeaway from the series is that, despite a general increasing trend for

[32] Kunze and Miller (2017), using data from private employers in Norway, find higher promotion rates for females who have female managers.

Figure 10 Representation of Female Board Members over Time



Note: Proportion of female board members over time (red line) and tenure of female Fed presidents (shaded in grey).

all Banks, given the small number of slots by Banks and the tenure limits, representation can change drastically for a given Bank in a few years.

Using panel data (each of the Feds over time), we can check whether female Fed presidents recruit more women for their boards. This could arise if female Fed presidents appointed more women to their boards or if the presence of a female Fed president encouraged other women to accept offers to serve on the board. Because we do not observe offers and acceptance rates for directors, we cannot distinguish between the two explanations.

Tables 11 and 12 list the Fed presidents, the year they were appointed, the number of female directors in the previous year (when their election is likely to have taken place), and the number of women directors hired under each president, along with the proportion of new hires that they represent.

Table 11 Statistics on the Hiring of Female Directors and First VPs during Fed Presidents' Tenures—Part 1

Tenure	Bank	Name	Hired fem. VP	Female on BoD in $t-1$	Total fem. director hires	Total director hires	Female directors as % of hires
1968-79	Atlanta	Kimbrel, Monroe	0	0	1	19	5
1968-88	Boston	Morris, Frank	0	0	2	44	5
1970-80	Philadelphia	Eastburn, David	0	0	1	24	4
1970-80	Chicago	Mayo, Robert	0	0	1	19	5
1971-81	Cleveland	Winn, Willis	0	0	0	22	0
1972-85	San Francisco	Balles, John	0	0	3	25	12
1973-92	Richmond	Black, Robert	0	0	2	45	4
1974-80	Dallas	Baughman, Ernest	0	0	1	11	9
1975-78	New York	Volcker, Paul	0	0	1	9	11
1976-90	Kansas City	Guffey, J. Roger	0	0	1	27	4
1976-82	St. Louis	Roos, Lawrence	0	0	2	11	18
1977-79	Minneapolis	Willes, Mark	0	0	1	5	20
1979-84	New York	Solomon, Anthony	0	1	0	10	0
1980-82	Atlanta	Ford, William	0	1	1	5	20
1980-84	Minneapolis	Corrigan, E. Gerald	0	1	0	11	0
1981-90	Dallas	Boykin, Robert	0	1	0	14	0
1981-94	Chicago	Keehn, Silas	0	1	1	21	5
1981-99	Philadelphia	Boehne, Edward	0	1	4	38	11
1982-86	**Cleveland**	**Horn, Karen**	**0**	**0**	**0**	**7**	**0**
1983-84	St. Louis	Roberts, Theodore	0	1	0	2	0
1983-95	Atlanta	Forrestal, Robert	0	2	4	21	19
1985-2007	Minneapolis	Stern, Gary	1	1	6	48	13
1985-93	New York	Corrigan, E. Gerald	0	1	3	20	15
1985-97	St. Louis	Melzer, Thomas	0	1	3	22	14
1986-2003	San Francisco	Parry, Robert	0	1	7	30	23
1987-91	Cleveland	Hoskins, W. Lee	0	0	1	11	9
1989-93	Boston	Syron, Richard	1	1	1	11	9
1991-2010	Kansas City	Hoenig, Thomas	1	0	5	35	14
1991-2004	Dallas	McTeer, Robert	1	0	4	24	17
1992-2002	Cleveland	Jordan, Jerry	1	1	2	17	12
1993-2003	Richmond	Broaddus, J. Alfred	0	1	3	22	14
1994-2002	New York	McDonough, William	0	2	4	19	21
1994-2006	**Boston**	**Minehan, Cathy**	**0**	**1**	**5**	**27**	**19**

(Continued on next page)

Table 12 Statistics on Fed presidents who have hired female directors during their tenure—Part 2

Tenure	Bank	Name	Hired fem. VP	Fem. on BoD in $t-1$	Total fem. hires	Total hires	Fem. as % of hires
1995-2006	Chicago	Moskow, Michael	0	1	4	19	21
1996-2006	Atlanta	Guynn, Jack	0	1	5	19	26
1998-2008	St. Louis	Poole, William	0	2	2	21	10
2000-05	Philadelphia	Santomero, Anthony	0	2	1	12	8
2003-08	New York	Geithner, Timothy	1	3	3	11	27
2003-13	**Cleveland**	**Pianalto, Sandra**	**0**	**1**	**4**	**20**	**20**
2004-16	Richmond	Lacker, Jeffrey	1	1	9	29	31
2004-09	**San Francisco**	**Yellen, Janet**	**0**	**3**	**2**	**10**	**20**
2005-15	Dallas	Fisher, Richard	0	2	3	19	16
2006-15	Philadelphia	Plosser, Charles	0	1	3	19	16
2007-17	Chicago	Evans, Charles	0	1	4	18	22
2007-17	Boston	Rosengren, Eric	0	3	5	20	25
2007-16	Atlanta	Lockhart, Dennis	0	2	3	17	18
2008-15	Minneapolis	Kocherlakota, Naryana	1	0	7	17	41
2009-17	New York	Dudley, William	0	1	4	14	29
2009-17	St. Louis	Bullard, James	0	0	7	16	44
2010-17	San Francisco	Williams, John	0	2	3	11	27
2011-17	**Kansas City**	**George, Esther**	**1**	**1**	**5**	**16**	**31**
2014-17	**Cleveland**	**Mester, Loretta**	**0**	**1**	**2**	**8**	**25**
2016-17	Minneapolis	Kashkari, Neel	0	4	1	2	5
2016-17	Philadelphia	Harker, Patrick	0	1	2	2	100
2016-17	Dallas	Kaplan, Robert	1	2	1	1	100
2017-17	Atlanta	Bostic, Raphael	0	1	1	3	33
2017-17	Richmond	Mullinix, Mark	0	4	0	3	0
Average for Male Fed Presidents			0.18	1.02	2.61	17.94	19
Average for Female Fed Presidents			0.17	1.17	3.00	14.67	19

We find that there is no difference between the average proportion of females hired during the tenure of male Fed presidents and that of female presidents, with the proportion equal to 0.19 in both cases. To consider another, related, form of female representation, we also report whether each president ever appointed a woman as first vice president. The first woman appointed to the post of first vice president of one of the regional Feds was Cathy Minehan, at the Boston Fed, in 1991. Minehan was also the second woman ever appointed to the post of president, also at the Boston Fed, in 1994. We find that the proportion of females who appointed a female vice president is 17 percent, while for males it is 18 percent.

These data also beg the question of whether the probability of appointing a female Fed president increases with the number of women on the Bank's board the year before the president started, when the appointment of the female president by the board likely took place. We find that the average number of directors who are female the year before the election of a female Fed president is 1.17. For male presidents, this number is 1.02, a small difference that disappears if we restrict the calculation to the years after the first female president's appointment.

Replacing females and informal quotas

We find much stronger and intriguing results when we check to see whether hiring practices seem geared toward replacing female directors with other females or toward maintaining a minimum female representation. Table 13 reports the probability of a Fed hiring at least one female in the next year by whether or not a female on that Bank's board left this year (either because she quit or because she completed her maximum tenure).[33] We find an important and statistically significant (at 5 percent confidence level) difference: Banks that had at least one female leave are twice as likely to hire at least one female (43.6 percent versus 21.5 percent).[34]

To complement this evidence, Table 14 reports again the probability of having at least one female hire for Banks that had a female leave, but now conditioning on the current number of female members on those boards. The evidence in this table suggests that hiring is affected by gender balance concerns. First, the probability of at least one new director being a female when there are no females on the board is

[33] To estimate the significance on these conditional means, we run a logit regression. The specification is spelled out in the Appendix.

[34] Note that these numbers are consistent with the female hiring rate of 16.6 percent for our sample, since the 43.6 percent of banks that hire females have, most of the time, more than one opening that year.

Table 13 Probability of Hiring a Female in Year t+1, Conditional on Whether at Least One Female Quit in Year t

$\Pr(female\ hired)_{t+1}$					
Not conditioned on female quits		One or more female quit in t		No females quit in t	
26.9*** (2.1)	$n = 445$	43.6*** (4.7)	$n = 110$	21.5*** (2.2)	$n = 335$

Note: Data cover entire sample except for the year 1977, when the first five female hires happened. *** Indicates significance at the 5 percent level.

equal to 31.3 percent, much larger than when there is one woman and she does not leave (16.7 percent). Second, the probability of hiring at least one female is larger when at least one female left in the previous period, for any number of current female directors, but this difference is much larger when the remaining number of females is smaller. For example, in the case where there is only one woman on the board and she leaves, the probability of hiring a woman is 50 percent versus 16.7 percent if only male directors leave; when there are four females on the board, this comparison is 28.6 percent versus 18.2 percent.

To summarize the evidence on the willingness of boards to replace female directors, we can calculate the female hiring rate for Bank-year combinations in which a female left the board: 23 percent of new hires are women. In contrast, the rate is 12 percent when no females left.[35]

It seems reasonable to hypothesize that when the Feds are in search of a "female replacement," as suggested by these data, they might be more likely to consider hiring outside of their usual hiring pool of E1. We can tie the evidence we collected on titles for our P2 counterfactual to check this hypothesis. We check the distribution across hiring pools of female hires at $t + 1$ when the only female on the BoD left at t. There are nineteen such events in our 1990-2017 sample containing title information. We know from Table 14 that, in the full sample, 50 percent of the Feds looking to hire following such an event bring at least one female onto their board. The percentage of these female hires coming from each hiring pool is reported in Table 15, together with the corresponding composition of female hires for the whole 1990-2017 sample. The numbers should be taken with caution due to the small

[35] This pattern underlies the unconditional female hiring rate of 16.6 percent reported in Table 4.

Table 14 Probability of Hiring a Female in Year t+1 by Number of Females on the Board in Year t, Conditional on Whether at Least One Female Quit in Year t

	$\Pr(female\ hired)_{t+1}$					
Number of females in t	Not conditioned on females leaving		One or more females leave in t		No females leave in t	
0	31.3*** (5.7)	$n = 67$	n/a		31.3*** (5.1)	$n = 67$
1	22.6*** (2.9)	$n = 212$	50.0*** (8.1)	$n = 38$	16.7*** (2.8)	$n = 174$
2	31.0*** (4.3)	$n = 113$	42.9*** (7.6)	$n = 42$	23.9*** (5.1)	$n = 71$
3	34.3*** (8.0)	$n = 35$	39.1*** (10.2)	$n = 23$	25.0** (12.5)	$n = 12$
4	22.2** (9.8)	$n = 18$	28.6* (17.1)	$n = 7$	18.2 (11.6)	$n = 11$

Note: *** Indicates significance at the 5 percent level.

number of observations, but they suggest that indeed the E2 pool may be tapped in a targeted way to find females, even more so than the NE pool: while the rate of E1 hires is almost equal to the unconditional mean, the importance of NE decreases, and the probability of hiring from the E2 pool is 3.1 percentage points larger when the only female director leaves and she is replaced by another female than in a random female hire.

Given current practices, it is not unreasonable to think about hiring from E2 as more of an exception than from the NE pool. If the targeted use of E2 is indeed driving the data, this qualifies our conclusion in the counterfactuals of Section 5: the decrease during the last ten years in the proportion of women hired from E2 that is driving our simulation results could be due to fewer situations (such as having the only female member leave) that merit "exceptions" and not indicative of how likely female hires would be if using the E2 pool regularly. Indeed, twenty-four of the total thirty-eight instances of the only female director leaving happen after 1990.

7. CONCLUSION

Female presence on the boards of directors of the Feds has been steadily increasing since the first female director was appointed in 1977. This increase has been due mainly to more female directors being recruited,

Table 15 Distribution of FRB Directors across E1, E2, and NE Titles (1990-2017)

	% of females from pool (η)	% of female hires from pool after the only female quits
E1	57.1	57.9
E2	12.7	15.8
NE	30.1	26.3

since, in fact, quitting rates for female and male directors are very similar. Among the boards of directors of the Feds, because complete refreshment happens in at most seven years due to maximum tenure rules, seven years after a change in hiring policies, the expected female representation would be equal to the prevailing female hiring rate, regardless of quitting rates. This means that drastic changes to the hiring rate would be very effective in increasing female representation in less than a decade. Despite the low female presence in executive positions, which sometimes is blamed for the low number of women serving on the boards of the Feds, we find that in cases when female representation is at risk of decreasing significantly, the Feds implement hiring strategies that double the odds of hiring a female director. Though these strategies may not be sustainable for each and every hire, learning about the particular efforts implemented in these instances could be useful in increasing female hires.

Using a statistical model of hiring for boards of directors, we evaluate the effect of a change in hiring practices that would shift some of the hiring from CEOs to non-CEO executives, as suggested by a report by the GAO in 2011. Our exercise highlights the importance of recruitment efforts in attracting females. Using data from the last twenty-seven years, we document that directors recruited from lower-ranked executive positions have been more likely to be female than those recruited from the very top executive ranks (CEOs). However, we also uncover a reversal in the trends in the last ten years, with the proportion of females increasing for the CEO pool while decreasing for hires from executives in lower ranks. These trends may reflect the effectiveness of recruitment efforts across the two pools (for example, networks of current female directors with other CEOs may being stronger than with non-CEOs). If we expect them to continue as in the last ten years, a recommendation to hire more often from non-CEO positions may not be a very effective way to increase female representation.

The data presented in this article are limited to public information on the serving directors. We do not know which candidates were approached nor the takeup rates of offers. Such data would likely help us understand better the reasons behind the limited increase in female hires over time, which we conclude is the main driver of the limited representation of females on the boards of directors of the Federal Reserve Banks.

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APPENDIX

Algorithm for the numerical model

The simulation returns a $(3\times3\times12)\times T$ matrix. In each period t, each column contains the characteristics of the director occupying a seat for each of the three seats, in each class, in each of the twelve Banks, for each period $t = 1,\ldots,T$. Within a class and Bank, the order of the seats reflects the three slots (seats with assigned terms within a class), denoted $s \in \{1,2,3\}$. Within a class, directors are identified by characteristics (s,τ,f): the slot they are occupying, their total tenure ($\tau \in \{1,2,...7\}$), and the indicator for their gender, $f \in \{1,0\}$, which takes a value of 1 if they are female. Quit rates in the simulations are contingent on class.

The law of motion for f depends on both the law of motion for s and τ and their values, as there are differential average quitting rates depending on where the director is in his or her career and depending on their gender. Denoting with γ', s', τ', and f' the variables for next period,

- Law of motion of s :

$$s' = \begin{cases} s+1 & \text{for } s = 1,2 \\ 1 & \text{for } s = 3. \end{cases}$$

- Law of motion of τ :

$$\tau' = \begin{cases} \tau+1 & \text{for eligible directors} \\ 1 & \text{for noneligible directors.} \end{cases}$$

  An "eligible" director is one who qualifies for an additional year of service, according to the rules of maximum tenure and the hiring model. To determine eligibility we create an indicator of the "replacement" status of directors:

$$r = \begin{cases} 0 & if\ s = 1 \\ 3-(s-1) & if\ s > 1 \end{cases}$$

  That means that if a director quits in the second year of their term, then the replacement director enters into slot 3 and is assigned $r = 1$ (they can serve an "extra" year). If a director leaves at the end of his or her first year in the term, the replacement enters into a slot 2 and is assigned $r = 2$ (the replacement can serve two "extra" years). Directors who begin their tenure in slot 1 have $r = 0$ and go by the usual term rules. This variable allows us to write the rule for maximum tenure compactly in the code. Let Y be the maximum number of terms allowed by a given hiring model (f.e., $Y = 2$ if a Bank is using HM2). For a director to be eligible for an additional year of service, it must be the case that

$$\tau < 3Y + r,$$

and

$$3Y + r < 7.$$

In our simulations, the gender of the initial set of directors at $t = 1$ is determined by current female representation, or γ_{2017}. These directors randomly inherit a tenure $\tau \in (s, s+3)$, and all are of replacement status $r = 0$.[36] An eligible current director faces a quitting rate $q_{s,\tau}$ if $f = 1$ and a quitting rate of $q_{s,\tau} + \Delta_{s,\tau}$ if $f = 0$. A noneligible director is forced to separate from his or her seat: $q_{s,\tau} = 1$. If a director is separated, then he or she is replaced by a female director with probability π, where this probability grows over time according to

$$\pi_{2017+t} = \begin{cases} \pi_{2017} + gt & if\ \gamma_k < 50\ for\ all\ k < t \\ 50 & otherwise \end{cases};$$

where g is the empirical growth rate of π corresponding to the time period used for setting the parameters.

The law of motion for f takes the form

$$\begin{bmatrix} \gamma', & 1-\gamma' \end{bmatrix} = \begin{bmatrix} \gamma, & 1-\gamma \end{bmatrix} \Pi(s,\tau),$$

where $\Pi(s,\tau)$ is the gender transition matrix:

$$\Pi(s,\tau) = \begin{bmatrix} \Pr(f' = 1|s,\tau,1) & \Pr(f' = 0|s,\tau,1) \\ \Pr(f' = 1|s,\tau,0) & \Pr(f' = 0|s,\tau,0) \end{bmatrix}.$$

These transition probabilities take different forms, according to the laws of motion of s and τ, and the probability of hiring a female, π. For eligible directors, this matrix can be written as

$$\Pi(s,\tau) = \begin{bmatrix} [1 - q_{s,\tau}] + q_{s,\tau}\pi & q_{s,\tau}(1-\pi) \\ [q_{s,\tau} + \Delta_{s,\tau}]\,\pi & (q_{s,\tau} + \Delta_{s,\tau})(1-\pi) + (1 - q_{s,\tau} - \Delta_{s,\tau}) \end{bmatrix}.$$

For noneligible directors, it simplifies to

$$\Pi(s,\tau) = \begin{bmatrix} \pi & 1-\pi \\ \pi & 1-\pi \end{bmatrix}.$$

[36] We do not use the true tenures in the data because there are several exceptions to the rules of maximum tenures that we are using in the model.

Derivation of long-term female representation without term limits

In what follows, we derive the expression in equation 1 in Section 3. In this simple model without tenure limits, we drop the dependence of the quitting rates q and Δ on s and τ, and we assume π does not grow over time. Hence the gender transition matrix is independent of s and τ.

The law of motion for gender is equal to:

$$\left[\gamma', \quad 1-\gamma'\right] = \left[\gamma, \quad 1-\gamma\right]\Pi.$$

One period ahead, this gives us the following expressions:

$$\begin{aligned} \gamma' &= \gamma\left[(1-q)+q\pi\right]+(1-\gamma)(q+\Delta)\pi, \\ 1-\gamma' &= \gamma\left[q(1-\pi)\right]+(1-\gamma)\left[(q+\Delta)(1-\pi)+1-q-\Delta\right]. \end{aligned}$$

Thus, if there is a female in a given seat, i.e. $\gamma=1$, we have

$$\left[\gamma', \quad 1-\gamma'\right] = \left[(1-q)+q\pi, \quad q(1-\pi)\right].$$

Female representation after n periods is

$$\left[\gamma_n, \quad 1-\gamma_n\right] = \left[\gamma_0, \quad 1-\gamma_0\right]\Pi^n,$$

with

$$\begin{aligned} \Pi^n &= \frac{1}{q+\Delta\pi}\begin{bmatrix} (q+\Delta)\pi & q(1-\pi) \\ (q+\Delta)\pi & q(1-\pi) \end{bmatrix} \\ &\quad + \frac{(1-q-\Delta\pi)^n}{q+\Delta\pi}\begin{bmatrix} q(1-\pi) & -q(1-\pi) \\ -(q+\Delta)\pi & (q+\Delta)\pi \end{bmatrix}, \end{aligned}$$

or, expanding the product, we can write this expression as

$$\Pi^n = \frac{1}{q+\Delta\pi}A,$$

where A represents the following matrix:

$$\begin{aligned} &\begin{bmatrix} (q+\Delta)\pi+(1-q-\Delta\pi)^n q(1-\pi) & q(1-\pi)-(1-q-\Delta\pi)^n q(1-\pi) \\ (q+\Delta)\pi-(1-q-\Delta\pi)^n(q+\Delta)\pi & q(1-\pi)+(1-q-\Delta\pi)^n(q+\Delta)\pi \end{bmatrix} \\ = &\begin{bmatrix} (q\pi+\Delta\pi)+(1-q-\Delta\pi)^n q(1-\pi) & q(1-\pi)(1-(1-q-\Delta\pi)^n) \\ (q\pi+\Delta\pi)[1-(1-q-\Delta\pi)^n] & q(1-\pi)+(1-q-\Delta\pi)^n(q\pi+\Delta\pi) \end{bmatrix}. \end{aligned}$$

The probability of having a female in a seat after n periods, γ^n, given an initial state of representation γ_0, is given by:

$$\begin{aligned} \gamma^n &= \frac{1}{q+\Delta\pi}\{\gamma_0\left[(q+\Delta)\pi+(1-q-\Delta\pi)^n q(1-\pi)\right] \\ &\quad + (1-\gamma_0)\left[(q+\Delta)\pi-(1-q-\Delta\pi)^n(q+\Delta)\pi\right]\} \\ &= (1-q-\Delta\pi)^n\gamma_0+\left[1-(1-q-\Delta\pi)^n\right]\frac{q\pi+\Delta\pi}{q+\Delta\pi}, \end{aligned}$$

where $\frac{q\pi+\Delta\pi}{q+\Delta\pi}$ is the probability of having a female in a given seat when n is very large.[37]

Quitting rates

The quitting rates in the table included in Figure 11 were used in all the (a) parametrizations (corresponding to the whole sample). Because we include replacement directors in this table, for any given slot (which determines years left in current term) more than two tenure values are possible. Hence separate quitting rates, according to slot and tenure, and the numbers speak to the effect of tenure separately.

In the model, for tenure and slot combinations where there are no observations for a particular class, we impute the quitting rate as the average quitting rate for that tenure and slot combination across all classes. The imputed rates are displayed here as well for rows with $\omega_f = 0$.

The quitting rates in Table 16 were used in all the (b) parametrizations (corresponding to data in the last ten years). Because there are fewer observations when we restrict the sample to the last ten years, we exclude from the table the replacement directors. This means that for any given slot (which determines years left in current term) only two tenure values are possible.

[37] For a textbook treatment of these transition dynamics, see Hamilton (1994).

Figure 11 Statistics for Quits Used in (a) Parametrizations

	Slot	Tenure	Number of directors Fem.	Male	All q	All Δ	Class A HM1 q	Δ	ω_f	ω_m	Class A HM2 q	Δ	ω_f	ω_m	Class B q	Δ	ω_f	ω_m	Class C q	Δ	ω_f	ω_m
r=0	1	1	100	595	.03	.01	.07	−.01	.15	.24	.00	.01	.08	.25	.05	−.01	.40	.30	0	.06	.37	.21
	2	2	89	580	.03	−.01	.00	.03	.15	.24	.00	.03	.08	.26	.06	−.05	.39	.29	.03	.02	.38	.21
	3	3	71	433	.23	−.02	–	–	0	0	.38	−.13	.11	.25	.29	−.07	.44	.30	.13	0	.45	.26
	1	4	54	348	.02	.04	–	–	0	0	.00	.05	.09	.33	.00	.04	.41	.38	.04	.05	.5	.29
	2	5	50	440	.08	−.02	–	–	0	0	.00	.04	.1	.32	.10	−.05	.40	.40	.08	.02	.31	.28
r=2	2	1	14	72	0	0	0	0	0	.15	0	0	0	.11	0	0	.36	.28	0	0	.64	.46
	3	2	13	76	0	.28	0	.64	0	.14	0	.38	0	.11	0	.38	.31	.28	0	.08	.69	.47
	1	3	11	53	0	.13	0	.50	0	.08	0	.20	0	.09	0	.31	.36	.25	0	0	.64	.58
	2	4	11	48	.09	−.01	.09	−.09	0	.04	.09	−.09	0	.08	0	0	.36	.21	.14	−.02	.64	.67
	3	5	10	52	.50	−.17	.50	−.17	0	.10	.50	−.25	0	.10	.5	−.05	.40	.26	.5	−.20	.60	.64
	1	6	5	29	.40	.05	.40	.05	0	.10	.40	−.17	0	.10	0	.14	.40	.24	.67	−.09	.60	.66
r=1	3	1	22	53	.05	.03	.05	−.05	.11	.08	1	−.88	.05	.15	0	0	.45	.26	0	.12	.50	.47
	1	2	20	48	.05	.03	.05	.04	0	.13	.05	-.05	0	.15	0	.14	.50	.29	.10	0	.50	.44
	2	3	18	43	.06	−.06	.06	−.06	.1	.14	.06	−.06	0	.16	.1	−.1	.50	.30	0	0	.5	.40
	3	4	17	55	0	.29	0	.29	0	.14	0	.17	0	.16	0	.29	.47	.37	0	.33	.53	.47
	1	5	16	26	0	.04	0	.04	0	0	0	0	0	.15	0	0	.5	.38	0	.08	.50	.46
	2	6	16	23	.25	−.12	.25	−.12	0	0	.25	−.25	0	.17	.13	−.13	.5	.39	.38	−.08	.50	.43

Note: We include replacement directors, which means that for any given slot more than two tenure values are possible.

Table 16 Average Quitting Rates Using Data from the Last Ten Years

Slot	Tenure	Number of directors		All		Class A HM1		Class A HM2		Class B		Class C	
		Female	Male	q	Δ	q	Δ	q	Δ	q	Δ	q	Δ
1	1	36	107	0.03	0.01	0.17	−0.12	0.00	0.03	0.00	0.00	0.00	0.09
1	4	15	66	0.00	0.06			0.00	0.04	0.00	0.08	0.00	0.06
2	2	28	110	0.04	0.01	0.00	0.04	0.00	0.03	0.09	−0.09	0.00	0.14
2	5	15	63	0.07	0.04			0.00	0.11	0.14	0.03	0.00	0.12
3	3	21	21	0.24	−0.10			0.50	−0.34	0.22	−0.05	0.13	-0.07

Estimation of conditional hiring rates in Tables 13 and 14

To estimate the conditional hiring rates in Table 13, we use observations at the year (t) and Bank (i) level for which we observe a hire. These observations always follow a separation in $t-1$, either due to a quit or because of the end of allowed tenure. We construct the variable f_hire_{ti}, which takes a value of 1 if at least one female was hired at Bank i in year t, and 0 if only males were hired. We also construct the variable $f\_quit_{t-1,i}$, which takes a value of 1 if at least one female director left Bank i in year $t-1$. We are interested in the marginal effects of having at least one female quit last year from Bank i's board ($f\_quit_{t-1,i} = 1$) on the probability of hiring a female this year to Bank i's board ($f\_hire_{ti} = 1$). We run a logit regression with the following functional form:

$$\Pr\left(f\_hire_{tij} = 1\right) = f\left(\alpha_0 + \zeta_i f\_quit_{t-1,i} + \varepsilon_{ti}\right).$$

Using the estimates from this regression, we recover the corresponding marginal effects. Predictive margins for f_quit are equal to the difference in the predicted probability of a female hire under the counterfactual of all banks having a female quit and the counterfactual of all Banks not having any female quits. That is, counterfactuals are computed by switching every observation in the sample to $f\_quit_{ti} = 1$ (or $f\_quit_{ti} = 0$, correspondingly), calculating the predicted probability of hiring a female next year for each observation, and taking the average of these predicted probabilities.

To obtain the predictive margins of whether a female quit *by number of females currently on the board* (denoted N_{ti}) on the probability of hiring a female in the next year (margins of $N_{ti} * f\_quit_{ti}$ as shown in Table 14), we estimate a logit regression of this probability, including on the right-hand side whether a female quit in time t, the number of females on the board in time t (denoted N_{ti}), and the *interaction* of these two variables:

$$\Pr\left(f\_hire_{tij} = 1\right) = f\left(\alpha_0 + \sum_{i=1}^{12} \alpha_j N_{ti} + \zeta_i f\_quit_{t-1,i} + \sum_{i=1}^{12} \beta_{ij} N_{ti} * f\_quit_{t-1,i}\right).$$

Each observation in the data can be identified by a (N_{ti}, f_quit_{ti}) pair, and taking the mean hiring probability of observations identified by a particular (N_{ti}, f_quit_{ti}) is equivalent to computing the predictive margins on the corresponding $N_{ti} * f\_quit_{ti}$ dummy, since there are no more additional variables in our equation that could affect the predicted probabilities for each (N_{ti}, f_quit_{ti}) group. Similarly as before, predictive margins for a given (N, f_quit) pair are computed by switching every observation in the sample to that given value of (N, f_quit), calculating the predicted probability of hiring a female next year for each observation, and taking the average of these predicted probabilities. The difference between the margins of one or more female quitting and no female quitting is interpreted as the *marginal effect* of a female quit in t, for each possible value of females on the board in t.

Further, we can compute predictive margins for only N_{ti} without conditioning on the quit, in other words asking what is the effect of having exactly N females on the board in time t. These margins are obtained by estimating the following regression:

$$\Pr(f\_hire_{t+1,i}) = f(\alpha_0 + \sum_{i=1}^{12} \alpha_j N_{ti} + \varepsilon_{ti}),$$

and for each level of N, switching every observation in the sample to the given N, and calculating the average predicted probability. Similarly, this is equivalent to slicing the data by observations with each value of N at t and calculating the average of f_hire in $t + 1$.

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Recent Borrowing from the U.S. Discount Window: Some Cases

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Federal Reserve Banks, through their respective discount window facilities, make loans to depository institutions on a regular basis. The main purpose of the discount window is to serve as a backup source of short-term funding for banks. When a bank finds itself short of reserves on any given day, the discount window can provide that liquidity at short notice, as long as the bank has entered the necessary lending agreements with the corresponding Reserve Bank. In general, discount window loans are provided at a rate that is higher than market rates and, in consequence, are not expected to constitute a regular source of funding for banks.

The discount window can play a critical role during periods of general financial distress. For example, the Federal Reserve used the discount window to grant substantial amounts of credit to financial institutions during the 2008-09 financial crisis (see Berger et al. 2017). This role of the central bank as lender of last resort during crises has been a topic of debate since the times of Henry Thornton and Walter Bagehot (see Humphrey 1989). Much less studied is the role of the discount window during normal times, outside of crises.

The Fed's discount window is open at all times. Two common objectives attributed to the discount window during normal times are (1) increasing interest rate control in a system of monetary policy implementation based on targeting an interbank rate; and (2) emergency

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funding for banks suffering a purely idiosyncratic, adverse liquidity event. The first objective is mostly muted in a period when the banking system is operating with very large quantities of excess reserves, as has been the case in the U.S. since 2009. The second objective is much more difficult to evaluate given the idiosyncratic nature of the phenomenon and the well-known complications associated with distinguishing liquidity from solvency events. The material discussed in this paper is intended to provide a forensic perspective on the issues associated with evaluating the second objective described above.

Since 2010, the Federal Reserve makes public every transaction at the discount window after a two-year delay. This newly available information provides an opportunity to better understand the reasons why banks borrow from the discount window during normal times. Understanding the needs that the discount window fulfills is important to assess the various features in the organization of the facility and, ultimately, whether such a facility is needed in the first place. A high-level review of the transactions data reveals that there is a lot of variety among discount window loans in the recent past. Taking an individual-loan perspective and looking at the specific conditions under which some of those loans happened, then, seems a promising avenue for improving our understanding of the role of the discount window during normal times.

In this article, we review the details of several loan events that occurred between July 2010 and March 2017. We select which loans to review based on some basic criteria: size of the loan, size of the borrower (measured by assets), frequency of lending by the borrower, and other similar characteristics. We further investigate the conditions under which the loan took place, reviewing the financial statements of the borrower around the time of the loan and its pre- and post-loan performance based on publicly available information.

The approach we take in this article is inspired by the idea of "forensic finance" pioneered by Stephen Ross (2002) (see also King [2018] for a recent paper following this approach). Basically, we focus on specific cases of loans at the discount window to try to learn about and better understand the role that this important public program is playing in the financial system. The ultimate objective would be to determine whether the current system serves us well or if there are changes that could be implemented to improve the way public provision of liquidity is handled in financial markets.[1] We intend to provide evidence

[1] For a recent detailed proposal of reform, see, for example, Selgin (2017).

that can aid that evaluation, but we do not intend to provide definitive answers to the broader questions.

Given the limited information available, it is not possible for us to be sure of the reasons that motivated the borrowing in each of the specific cases we study. Instead of speculating on the possible ultimate reasons in each case, our objective is to gain perspective from the combination of all the cases. We summarize this perspective in the following general patterns based on the idea that different banks use the discount window for different reasons and in different ways. Some large healthy banks borrowed from the discount window in amounts that, while large in absolute value, were small relative to the size of the banks. Given the lack of any sign of distress or urgency, the reason for those loans appears to be mainly a matter of convenience: the discount window was readily available and not terribly expensive during that time.

Some banks borrow repeatedly from the discount window for a relatively brief period of time and then stop. In these cases, the discount window appears to have been part of a model for managing liquidity that eventually was discarded—suggesting that the alternatives to using the discount window were not particularly onerous. Finally, using the discount window to lend to banks in poor financial conditions seemed to have exposed the Fed to dealing with institutions that eventually ended up failing and in many cases were later discovered to be associated with fraudulent activities.

The paper is organized as follows. In the next section, we cover some basic facts about discount window policy and the data. In Section 2, we discuss five important cases concerning primary credit loans. Section 3 looks at four of the most important cases associated with the secondary credit program in our sample period. Finally, Section 4 offers some concluding remarks.

1. THE FED'S DISCOUNT WINDOW

There are three programs for making loans via the discount window. The primary credit program is the most widely used and is restricted to well-capitalized institutions. It is mainly a no-questions-asked standing facility that charges a fixed penalty of 50 basis points over the policy-target interest rate.

The secondary credit program is available to those institutions that do not qualify for primary credit. It is associated with a higher level of scrutiny by the Fed, and the interest rate is generally 50 basis points higher than the primary credit rate.

The seasonal credit program is aimed at satisfying some seasonal demands for liquidity by banks with a particular exposure to such fluctuations. It is fundamentally different from primary and secondary credit in that it is offered for longer terms and not at a penalty rate. A bank borrowing from the seasonal credit program can, in principle, also borrow from another discount window program (primary or secondary, depending on eligibility status) to cover short-term funding needs.

In this paper, we will focus mainly on primary and secondary credit loans, since those are the loans directly associated with the role of the discount window as a backup source of short-term funding for banks. Between July 2010 and March 2017, there were 15,774 primary credit loans and 732 secondary credit loans. Many of these loans are for small amounts and are likely to constitute "test" loans, where the borrowing institution submits a request for a small loan to test the processes involved, with the purpose of ensuring operational readiness. If we take as a threshold that all loans for $1 million or lower constitute test loans, then we are left with 3,443 (nontest) primary credit loans and twenty-seven (nontest) secondary credit loans (the last of these secondary credit loans was in February 2015).[2]

Most nontest loans are overnight, but there are some three-day loans that involve weekends, some four-day loans that involve holidays, and some loans of longer maturity, although those are very rare (see Ackon and Ennis 2017, Table 6). In particular, 83 percent of primary credit loans greater than $1 million are overnight loans. For secondary credit, that percentage is somewhat lower but still very high (70 percent). Interestingly, many of these overnight loans are rolled over several times. In those cases, it seems more appropriate to consider a sequence of consecutive loans a single "loan event." This is the approach we will take here.

Table 1 shows the number of loans and the total amount lent per year, from 2011 until 2016 (the six complete years in our sample). We also present the total amount lent expressed in overnight equivalents (OEs). This adjustment is intended to make a term loan taken for several days equivalent to several overnight loans taken on those same days. The numbers are not very different because most term loans are relatively small and, overall, there are not that many of them.

Ackon and Ennis (2017) provide a more detailed overview of the general features of the transaction data using the subsample that runs from July 2010 until June 2015. The distribution of loan sizes, the

[2] There are probably some loans smaller than $1 million that are not tests. Still, given their (very) short-term nature, loan amounts smaller than $1 million are relatively insignificant, which limits their interest.

Table 1 Discount Window Lending (Loans Greater than $1 million)

	Primary Credit			Secondary Credit		
Year	No. of loans	Total amt lent ($mm)	Total amt lent (OE) ($mm)	No. of loans	Total amt lent ($mm)	Total amt lent (OE) ($mm)
2011	550	5,458.12	9,045.04	15	48.5	69.00
2012	575	5,759.42	7,384.47	2	6.00	6.00
2013	554	3,413.82	4,335.69	1	3.50	3.50
2014	465	3,032.71	4,310.22	2	3.50	3.50
2015	443	4,297.92	6,075.72	1	1.20	4.80
2016	357	3,881.34	6,030.91	0	0.00	0.00

Note: Overnight equivalents (OEs) adjust the data so that term loans lasting for several days are equivalent to a comparable sequence of one-day loans.

term to maturity of loans, the time of the month, quarter, and year when most loans happen, and other features of the data are thoroughly discussed there. Furthermore, Ackon and Ennis (2017) provide an overview of the collateral pledged by borrowing banks and the patterns of utilization of that collateral during the sample period. One lesson that comes through from the inspection of the cross-sectional data is that there is a lot of heterogeneity across these discount window loans and much of the variation does not seem to involve clear common patterns. Idiosyncratic factors, the focus of this paper, seem to matter a lot.

To borrow at the primary credit program, a depository institution needs to be in generally sound financial condition. Reserve Banks review institutions on a regular basis, assessing capital adequacy, asset quality, management, liquidity and other general aspects of bank health. As a result of the supervisory examination, each institution is assigned a rating called the CAMEL rating. A rating of 1 is the strongest qualification, and a rating of 5 is the weakest. To be eligible to borrow at the primary credit program, an institution has to be adequately capitalized, with a CAMEL rating of 1, 2, or 3 (unless supplementary information indicates that the institution is not generally sound). CAMEL ratings are confidential, but to gain some insight on the financial conditions of the banks in our cases, we will often report the capital ratios and how those compare with regulatory requirements at the time.

The provision of credit at the discount window needs to be secured with eligible collateral pledged at the corresponding Reserve Bank. Most performing assets held by institutions are acceptable as discount window collateral but are assigned a lendable value, which often involves appropriate discounts, or haircuts. The published transaction data include the amount and composition of the collateral pledged by the borrower at the time when the loan happens. We will discuss this information below for the cases (loans) that we study.

2. PRIMARY CREDIT LOANS

Primary credit loans are the most common discount window loans. As these loans are granted to depository institutions in good financial condition, several of them are relatively large banks. For the same reasons, some of the primary credit loans tend to be much larger than the ones granted through the other two discount window programs. Here, we will discuss five lending events: the first involves the largest primary credit loan in our sample. After that, we discuss two loans taken by relatively large depository institutions. Finally, we deal with two prominent repeat borrowers (i.e., banks that took a large number of loans in a given period).

The largest primary credit loan in the sample

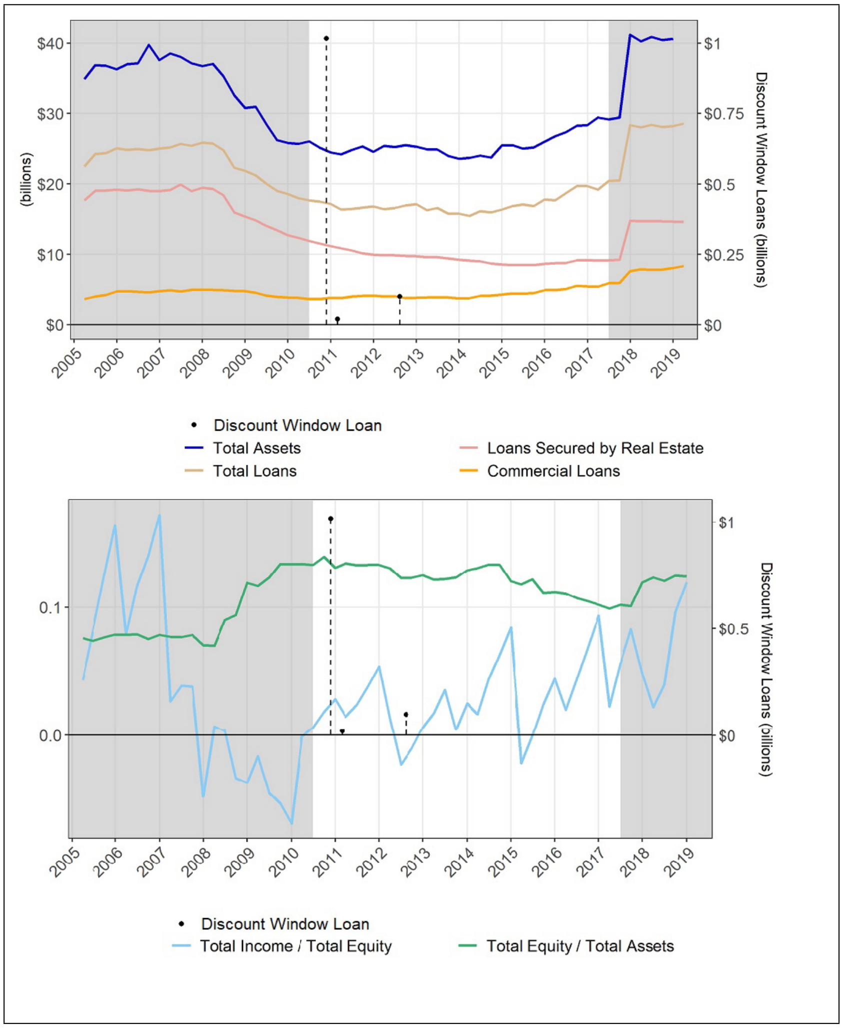
Case 1. On November 24, 2010, First Tennessee Bank of Memphis, Tennessee, borrowed $1.017 billion from the primary credit program at the St. Louis Fed. The term of the loan was two days, as November 25, 2010, was the Thanksgiving holiday in the U.S. The amount of the loan was equal to 42 percent of the pledge collateral that First Tennessee had at the discount window.

Aside from this large loan, First Tennessee took two other smaller nontest loans at the discount window during our sample period: one in February 2011 for $20 million, and one in August 2012 for $100 million (see the black dots in Figure 1, with the corresponding scale in the right axis; the shaded area indicates time outside of our sample period, which starts in July 2010 and ends in March 2017). Finally, there is only one more loan from First Tennessee in our data. This is a small loan for $1 million in September 2015—likely to be a "test" loan and hence not a loan we want to focus on.

The collateral available to First Tennessee was plentiful in all cases. In terms of the composition of the pledged collateral, around 60 percent was in the form of commercial loans and 40 percent was in commercial real estate loans, with only a small proportion left to consumer loans in some instances. This is similar for all four transactions in our dataset.

First Tennessee is a regional bank operating mainly in the southeast area of the U.S. It is the main bank subsidiary of First Horizon National Corporation (FHNC), a bank-holding company that in 2010 had over

Figure 1 First Tennessee Bank



Note: The unshaded area represents the period of time covered by our sample.

$24 billion in assets (as of December 2018, the asset-size of FHNC was $40 billion). After the financial crisis, First Tennessee moved to refocus its strategic direction away from mortgage banking and toward more traditional lending and deposit-taking services aimed at consumers and businesses. This reorganization was well underway when the bank took the large loan at the discount window in November 2010.

In Figure 1, we can see that First Tennessee's reaction to the crisis was to become smaller and to refocus.[3] By mid-to-late 2010, when the large discount window loan happened, First Tennessee had returned to positive profitability, increasing its lending and securities operations. That period in late 2010 was also an important time for First Tennessee because they issued equity and long-term debt and used the proceeds to redeem roughly $850 million in TARP money, which they had received during the height of the financial crisis. In the available public information we have reviewed, we were not able to find any specific event that could be directly linked to the large discount window loan of November 2010.

Large-bank borrowing

Case 2. Barclays Bank of Wilmington, Delaware, borrowed $50 million from the primary credit program of the Philadelphia Fed on July 17, 2014. In April of the previous year, Barclays Bank of DE also borrowed $10 million from the same program. Both loans were overnight, and in both cases the collateral the bank had pledged at the discount window was orders of magnitude larger than the amount borrowed ($6 billion and $4.7 billion, respectively). There are two other loans from Barclays in our dataset, one in August 2015 and one in October 2016, but they are both for $10,000 and, in all likelihood, given the small amount, just for the purpose of testing the operational readiness of the systems involved.

Barclays Bank of DE provides consumer and small-business credit programs in the U.S., including credit cards and personal loans. It is part of Barclays Corporation, a U.K.-based global financial firm. Barclays bank in the U.K. also owns a foreign branch in New York that is separate from the Delaware operations. Within our sample, there is actually one loan for $1 million taken by the New York branch of the U.K. bank in November 2016.

In 2014, when the loans under consideration happened, the U.S. credit card portfolio of Barclays Bank of DE was quite large, with around $20 billion in assets.[4] In July 2016, the Delaware bank became an operating subsidiary of the newly created international holding company under which Barclays moved to consolidate all its operations in the U.S. At least since then, the bank has been subject to numerous

[3] By 2016, the bank had resumed growth and, in November 2017, it completed the acquisition of Capital Bank, a North Carolina bank with $10 billion in assets.

[4] At the time of writing (December 2018), Barclays Bank of DE was still a large credit card provider in the U.S. with nearly $35 billion in assets. The U.S. operation amounts to around 2 percent of Barclays Corporation's total global assets.

regulations aimed at "large" bank holding companies, such as umbrella supervision by the Federal Reserve, stress testing, and the regular submission of resolution plans (living wills).

At the time of the discount window loans in 2014, Barclays, like many other large banking corporations operating in the U.S., was undergoing significant changes in its legal structure in a move to ring-fence some of its critical operations. Still, in its 2014 resolution plan, Barclays reported that they had a centralized management structure to deal with capital and liquidity needs across the global corporation. For a company the size of Barclays Corporation, with over a trillion dollars in global assets, the amounts borrowed at the discount window were, relatively speaking, very small.

Case 3. The New York branch of Banco Bilbao Vizcaya Argentaria (BBVA) took two $100 million loans from the New York Fed's primary credit program in October 2010 and then another loan for the same amount in November 2011. Aside from those (more significant) loans, the branch has taken several (much) smaller loans over the years that are likely to constitute test loans. For the three large $100 million loans, such amount was over 70 percent of the pledged collateral that the branch had at the discount window, with the lion's share of the collateral (over 92 percent of the total) in the form of international securities.

BBVA is a Spanish multinational banking organization and one of the largest financial institutions in the world. The N.Y. branch of BBVA is a direct subsidiary of the global international bank. Aside from the foreign-bank branch, the BBVA Group also owns a commercial bank operating in the U.S., BBVA Compass, with significant presence in the Sunbelt states.[5]

In other words, the N.Y. branch of BBVA, which took the discount window loans we are discussing, is part of a much larger banking organization with, at the time of the loans, over $500 billion in total assets and large cash reserves (around $20 billion). These facts suggest that the overnight loans taken by the BBVA N.Y. branch may have been the result of relatively small, urgent (short-term) demands for cash and that the bank considered the discount window the most convenient avenue to fulfill them.

These loans are particularly interesting in view of the fact that around that time the business models of many U.S. branches of foreign banks were shifting toward high participation in the intermediation of

[5] The BBVA Group had also a bank subsidiary in Puerto Rico that actually took a $5 million overnight loan from the primary credit program at the New York Fed in March 2011.

interest on reserves (Goulding and Nolle 2012). Branches of foreign banks have a comparative advantage, relative to more heavily regulated commercial banks, in the process of taking deposits from private investors and holding them as interest-paying reserves in their accounts at the Federal Reserve. This activity results in branches holding large quantities of reserves (and liquidity), which would tend to make the need for a discount window loan very rare.

Repeat borrowers

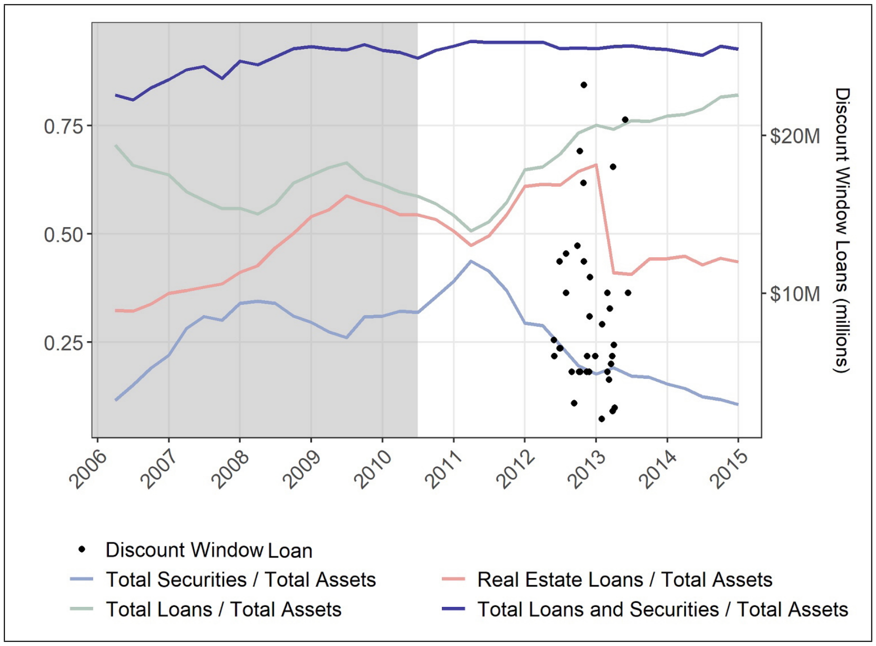
Case 4. From October 2010 until July 2013, ViewPoint Bank of Plano, Texas, borrowed thirty-nine times from the primary credit program at the Dallas Fed. Loan amounts range from $2 million to $35 million, which is a large sum for a discount window loan but still relatively minor for a midsize bank with around $4 billion in assets and $500 million in equity capital, as ViewPoint was at the time.

While many of the loans taken by ViewPoint were in consecutive days (about half of them), it is hard in this case to characterized consecutive loans as the same loan event because the loan amounts were generally very different (sometimes larger and sometimes smaller than the preceding day's loan). Many of the loans happened toward the end of the month, but not always. The pattern of borrowing suggests that the bank might have been using the discount window as a regular source of short-term funding.

When ViewPoint took its largest discount window loan (for $35 million) in July 2011, all its collateral was in the form of mortgage-backed securities (MBS). This large overnight loan used 93 percent of the total pledged collateral (a relatively high utilization rate) and was fully repaid at maturity (overnight). After that event, ViewPoint increased the amount of collateral pledged at the discount window significantly, but the composition did not change—all MBS. The thirty-seven loans that came after the July 2011 loan were all much smaller, and none of them amounted to more that 25 percent of the collateral available to ViewPoint at the discount window.

ViewPoint started as a credit union and became a bank in 2005. At the time when the bulk of the discount window loans happened (2011-12), the bank was undergoing significant transformations. The proportion of loans in assets was increasing and the proportion of securities decreasing (see Figure 2). Similarly, loan concentration in real estate started to decrease in 2012 from levels close to 90 percent of total loans in 2011. During the first quarter of 2013, the amount of loans secured by 1-4 family residential properties in ViewPoint's balance sheet fell by over a billion dollars. At the same time, loans to nondepository

Figure 2 ViewPoint Bank



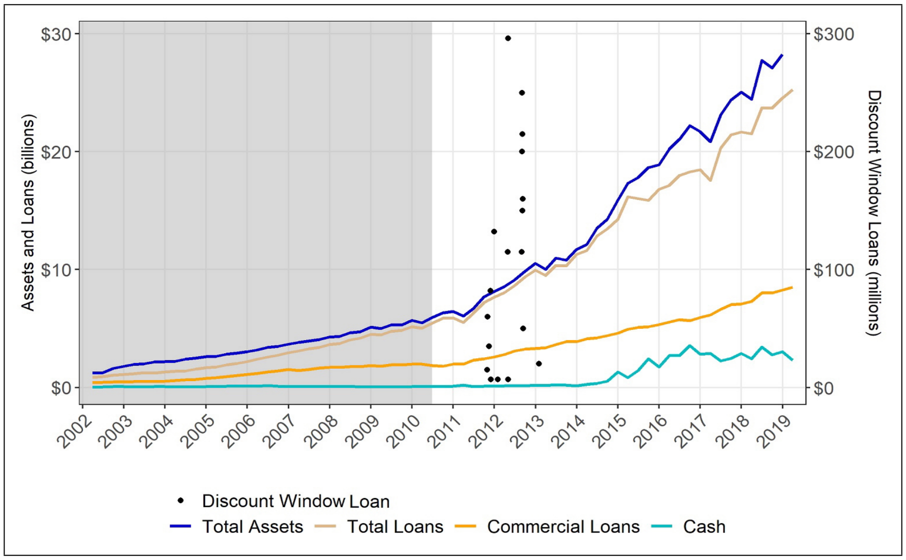
financial institutions increased by $750 million. In principle, this move should have reduced ViewPoint's exposure to real estate risk, although possibly not for the whole amount of the change.

Late in 2013, ViewPoint announced plans to merge with LegacyTexas bank and become part of LegacyTexas Financial Group, a publicly traded company. The merger was completed in the first months of 2015. The time of the announcement of the merger is interesting because it was only a few months after ViewPoint took the last discount window loan (as reported in our sample). This suggests, perhaps, that in the process of arranging the merger, a determination was made to no longer use the discount window on a regular basis.[6]

Case 5. Between October 2011 and January 2013, Texas Capital Bank of Dallas, Texas, borrowed thirty-five times from the discount window primary credit program of the Dallas Fed. After January 2013, the bank never borrowed again from the discount window until the end

[6] It could of course be the case that the prospects of a beneficial merger also improved ViewPoint's access to short-term funding, helping the bank to stay away from borrowing at the discount window.

Figure 3 Texas Capital Bank



of our sample period. Many of the discount window loans by Texas Capital were significant: ten of the thirty-five loans were for over $100 million and four were for $200 million or more, with the maximum loan amount being $296 million (see the black dots in Figure 3, with the corresponding scale in the right axis). These amounts make it one of the banks that borrowed the most from the discount window during our sample period.

Texas Capital had abundant collateral pledged at the discount window over the period under consideration. In all cases, the discount window loans amounted to less than 20 percent of the pledged collateral, and in most cases this ratio was below 10 percent. All pledged collateral came from their commercial and industrial loans portfolio.

Texas Capital was founded in 1998 with a focus on business lending and has grown consistently since its creation (see Figure 3). In 2003, the bank had its IPO, and, since then, it has been listed in the NASDAQ exchange. Most of the bank's assets are loans and leases, with commercial and industrial loans accounting for over a third of the total. The bank was profitable during the period of our sample and was growing particularly fast in the years when it took the bulk of the discount window loans under consideration. At the same time, the bank had a relatively low cash-to-assets ratio, which suggests that some of the discount window loans might have worked as a backup source of funding in the process of expanding its operations. The bank's cash holdings increased considerably after 2013, and it is likely that this change in their balance sheet made borrowing at the discount window much less relevant (see Figure 3).

3. SECONDARY CREDIT LOANS

Since secondary credit loans are, in principle, subject to much more scrutiny from the Fed and, during the period under consideration, the number of banks that do not qualify for primary credit is much smaller than the ones that do, there are a lot fewer secondary credit loans in the sample. We concentrate attention in the two most important loan events (by borrowed amount) and the main two repeat borrowers (by number of loans taken).[7]

The largest secondary credit loans in the sample

Case 6. In the final week of 2010, Nova Bank of Berwyn, Pennsylvania, borrowed two consecutive loans for $17 million from the secondary credit program at the Philadelphia Fed's discount window. This was the loan event involving the largest borrowed amount from the secondary credit program during our sample. In October 2012, Nova Bank was liquidated and closed. Later investigations revealed fraudulent behavior by Nova's managers between 2009 and 2010.

The first loan was taken on Friday, December 24, 2010, for four days at an interest rate of 1.25 percent, which was 100 basis points higher than the target policy rate at the time. On December 28, 2010, Nova renewed the loan for a period of two days, but this time the reported interest rate was 6.25 percent, an unusually high number. On December 30, Nova repaid the loan and never borrowed any significant amount again at the discount window.[8]

[7] Aside from the four banks involved in our Cases 6 to 9, there are ten other banks that took loans (thirteen) from the secondary credit program in our sample. Most of those banks are relatively small. Some are still in operation and some have merged or closed.

[8] Within our sample, there is one other discount window loan by Nova for the small amount of $10,000, likely to be a test at the secondary credit program during February 2012.

At the time of the borrowing, Nova had $30 million in pledged collateral at the discount window, 96 percent of which was in the form of MBS. This is indicative of a more general fact: Nova's focus on real estate lending.

Nova Bank was a relatively small institution that originated from the reorganization of a troubled banking institution in 2002. Even after significant restructuring during the 2000s, of the 60 percent of assets that Nova held in loans at the time of the discount window event, over 40 percent were in commercial real estate (CRE). Compared with the average of 20 to 25 percent for all commercial banks, this can be seen as high concentration in CRE. Furthermore, at the time of the discount window event, 20 percent of Nova's assets were MBS. Adding up these two components showcases Nova's high exposure to real estate risk.

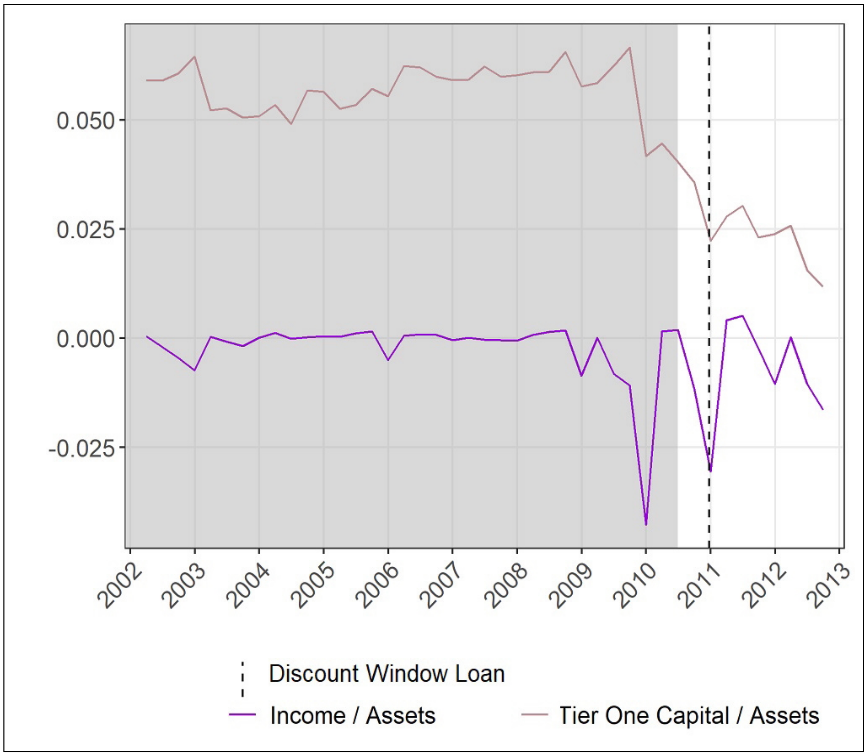
Since its beginnings, Nova never managed to become a profitable enterprise (see Figure 4). Badly hit by the 2008 financial crisis, their regulatory capital position began to deteriorate, and by the time they took the two large discount window loans under consideration, they were clearly undercapitalized. Indeed, in May 2010, the FDIC issued a consent order requiring Nova to meet and maintain an 8 percent minimum tier 1 capital ratio within 180 days from the issuance of the order. Call report data suggest the bank never managed to comply with the order.

The FDIC consent order also included a requirement to develop a plan that would reduce the bank's exposure to CRE. Quarterly balance sheet data suggest that the bank was not very successful in implementing such a plan. If anything, the bank's asset concentration in real estate increased (moderately) after 2010.

At the time of the discount window loans, the bank had only $14 million in tier 1 capital, so the amount of the loans ($17 million) was actually larger than the amount of capital at the bank. This suggests that Nova was over-reliant on short-term funding when they accessed the discount window.

Funding issues were not a new development for Nova Bank. In June 2009 (a year and a half before the discount window loans), the bank was approved to receive $13.5 million from the Troubled Asset Relief Program (TARP). The TARP funds were contingent on Nova's ability to raise an extra $15 million of private capital. It was later discovered that the bank's chairman and the bank's CEO engaged in fraudulent activity in order to obtain the additional private capital. Ultimately, the bank did not receive the money from TARP, and in 2016, both executives were fined and received prison sentences.

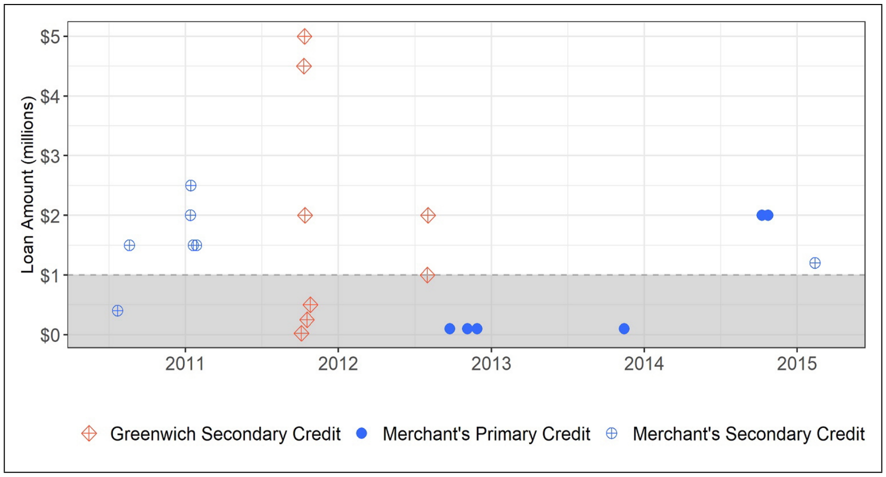
Figure 4 Nova Bank



Case 7. In the spring of 2011, Country Bank of Aledo, Illinois, took two consecutive overnight loans for $9 million from the secondary credit program at the Chicago Fed's discount window. This was the second largest loan amount for a loan event in our sample of secondary credit transactions. Country Bank had $10.3 million in pledged collateral at the time, with 23 percent being commercial loans, 33 percent CRE loans, and 43 percent consumer loans.

Country Bank was a small bank with approximately $200 million in assets in 2011. The bank was founded in 2000 and performed relatively well until the financial crisis. The bank had some significant losses in 2010 associated with its MBS portfolio and a significant loss associated with its lending activities in early 2011. Eventually, in October 2011, Country Bank was closed by state regulators for following unsafe and unsound banking practices, with Blackhawk Bank and Trust acquiring $113 million of Country Bank's assets and the remaining problem loans

Figure 5 First Bank of Greenwich and Merchant's Bank discount window loans



Note: The shaded area indicates loans under $1 million, which are likely to be tests.

transferred to the FDIC. At the time of the failure, the FDIC estimated that the cost to the Insurance Fund would be over $66 million.

It was later revealed that Country Bank had a significant exposure to a real estate developer who had misrepresented financial statements and eventually defaulted on the loans. The bank filed foreclosure claims for multiple properties associated with that individual developer but was not able to recoup the money. The developer had other loans, including one large loan from the U.S. Department of Agriculture for which he was indicted after providing false information.

Repeat borrowers

Case 8. First Bank of Greenwich of Cos Cob, Connecticut, borrowed eight times from the secondary credit program of the New York Fed during our sample period, six times in October 2011 and two more times in August 2012. Three of the loans in October 2011 were back-to-back but involved different loan amounts, first higher and then lower than the initially borrowed amount (which suggests a gradual pay down of the loan). All of Greenwich's collateral at the discount window was in the form of Treasury securities.

As a local community bank with under $100 million in assets at the time, the First Bank of Greenwich was hit hard by the financial crisis in 2008-09 and was starting its recovery by the time we find it in our dataset. In fact, in May 2010, the FDIC demanded First Bank of Greenwich submit a management and capital plan that required a significant increase in the bank's capital level. In late 2010 and early 2011, the bank received substantial capital injections from private investors and a new CEO arrived at the bank in April 2011. Since then, the bank has experienced steady asset growth, reaching over $350 million in assets by the end of 2018.

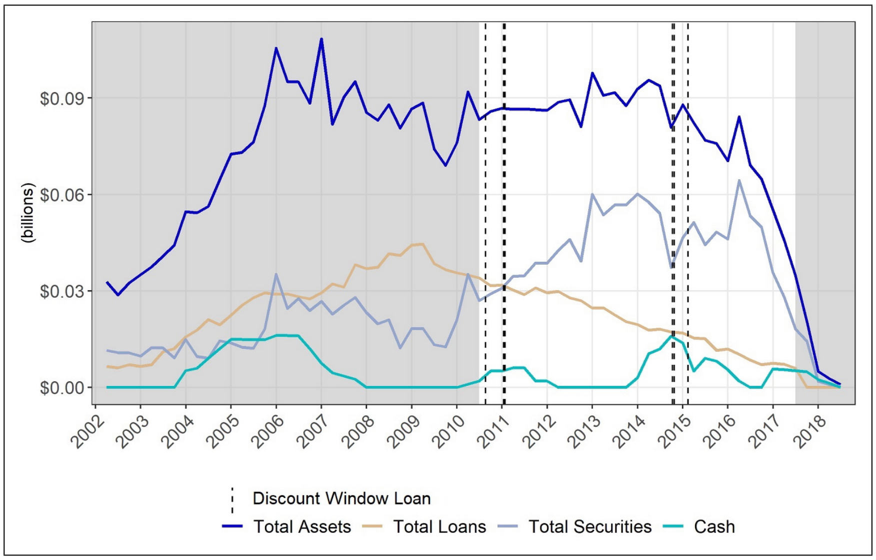
An interesting fact in this case is that the First Bank of Greenwich borrowed from the discount window during a time when it was being closely monitored by regulators—as the management and capital plans were in the early stages of implementation. Many of the discount window loans were relatively large for a small bank the size of First Bank of Greenwich (see Figure 5; the shaded area indicates loans under $1 million, which are likely to be tests) but all of them were overnight loans backed by very high-quality collateral (Treasuries). Furthermore, after 2012, the First Bank of Greenwich does not borrow again from the discount window (at least until after the end of our sample period in 2017).

Case 9. Between July 2010 and January 2011, Merchants Bank of California took six discount window loans at the secondary credit program of the San Francisco Fed. Sometime before September 2012, the bank switched to being well-capitalized and hence able to borrow at the primary credit program. For the next two years, the bank borrowed six more times from the primary credit program—although only the last two, which happened in October 2014, were for amounts larger than $1 million (in both cases the loans were for $2 million). Finally, in February 2015, the bank reappeared at the secondary credit program with a loan of $1.2 million, the last loan from this bank in our sample (see Figure 5). This discount window activity by Merchants Bank makes it the second most frequent borrower at the secondary credit program (after First Bank of Greenwich, our Case 8 above) during the sample period.[9]

Merchants' collateral pledged at the discount window was mainly composed of commercial and CRE loans, so the bank was not using the discount window to monetize Treasury securities (as, for example, the First Bank of Greenwich was doing in our Case 8). Instead, the dis-

[9] Most loans by Merchants were overnight, although a few were three-day loans over a weekend and two were four-day loans involving a weekend followed by a U.S. holiday.

Figure 6 Merchants Bank



count window was monetizing loans that in all likelihood were relatively illiquid.

Merchants was a small bank (around $100 million in total assets) located in Carson, California, that specialized in banking for money services businesses such as check cashers and money transmitters (which provide money transfers and other payment services to their customers). Merchants' main business required the handling and administration of large volumes of cash. For example, Merchants had over 150 check-cashing customers (see FinCEN 2017). Volatile cash flows naturally require a significant buffer of cash, and this is reflected in Merchants' balance sheet (see Figure 6). It is interesting, however, that even with a relatively large proportion of assets in the form of cash and balances (i.e., reserves and deposits in other banks), Merchants still needed to tap the discount window as a backup source of cash. Of course, the data plotted in Figure 6 represent end of the quarter conditions and it is entirely possible that Merchants experienced large fluctuations in its cash account within the quarter, which could have resulted in shortages and the need to tap the discount window.

In 2016, Merchants' financial conditions deteriorated markedly and, eventually, the bank was closed and liquidated in late 2017. In the last years of its life, Merchants was being investigated for unsafe banking practices in the period between 2012 and 2016, which includes the time when the bank was able to borrow from the primary credit program. The investigations revealed that Merchants had been in violation of the Bank Secrecy Act for not properly controlling money-laundering risks. For example, Merchants failed to detect and report suspicious activity related to remittances to and from high-risk jurisdictions (such as Honduras, Romania, Mexico, and Somalia). In the end, the investigation resulted in a $7 million fine imposed on Merchants by the U.S. Treasury Department.[10]

The investigation also revealed that Merchants had a very low degree of sophistication in monitoring and documenting account behavior and in performing cash-flow analysis to better understand the way its customers were funding their check-cashing operations. These poor practices may also help explain Merchants high exposure to borrowing from the discount window, as the bank seems to have been ill-equipped to predict its short-term liquidity needs.

4. CONCLUSION

For a long time, individual transactions at the discount window were kept confidential. It was hard (if not impossible) for policymakers and academics to get a comprehensive view of the role of the discount window. Even Fed officials were not regularly exposed to a full picture but rather mainly just saw what their individual Reserve Banks were experiencing. The periodic publication (with two-year delay) of transactions data, which started in June 2010, is an opportunity to change that state of affairs.

This paper exploits that opportunity in one particular way. We study transactions or sets of transactions that could be considered especially relevant: the largest; the ones involving repeat borrowers; the ones involving relatively large banks. The transactions analyzed in this paper all occurred during a time of relative calm in financial markets.

The reasons why banks borrow from the discount window appear to be highly idiosyncratic and not a matter of "life or death." Large healthy banks sometimes borrowed significant absolute amounts, but those dollar amounts are relatively small compared with the size of the banks' operations. In those cases, the discount window appears to have been just one of the many ways banks could handle a particular short-term funding event. Healthy repeated borrowers seem to use the discount window more as part of a global funding strategy and in

[10] For further details on the investigations and Merchant's activities, see FinCEN (2017). The Somali connection was reported by Reuters in February 2015.

general only temporarily. In summary, healthy banks seem to access the discount window mostly for convenience.

The borrowing from the discount window by unhealthy banks appears to be one more manifestation of the inappropriateness of their managerial practices. Such banks are often closed down after some time or are reorganized, at which point they stop using the discount window. Many of those banks that were ultimately closed down seem to have exposed the Fed to dealing with clearly (ex post) undesirable counterparties.

To assess the social value of having a discount window open at all times, it is necessary to understand the benefits of having such a facility open during periods of financial calm. This paper is an attempt to provide a better sense of where those benefits might be and their relative size. Our preliminary conclusion is that in the cases we have studied those benefits do not seem particularly large. It seems likely that with no access to a discount window the banks in our "cases" would have found other ways to deal with their specific funding needs without major implications for relevant economic outcomes.

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