MORTGAGE RATES AND INNOVATION

Do fluctuations in mortgage rates impact inventor mobility?

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I. Introduction

Innovation thrives on the dynamic exchange of ideas and collaboration of diverse minds. Central to this process is the mobility of inventors and scientists, whose ability to traverse geographic boundaries fosters the cross-pollination of knowledge and sparks novel breakthroughs. New products and processes are created by the combination of ideas, which are embodied in people. When individuals are tethered by constraints, the free flow of inventive talent becomes impeded, potentially stifling innovation. One of these potential constraints is high mortgage rates, which elevate the cost of moving. We utilize the historical decisions of the Federal Reserve on monetary policy, paired with information on inventor locations, to investigate the effects of changes in mortgage rates on inventor mobility.

When mortgage rates rise, the financial burden of relocating escalates, dissuading inventors and scientists from venturing beyond their current commuting zone. They may become less responsive to opportunities and collaborations. This is because high interest rates dramatically increase moving costs for people who already hold either an existing mortgage or lease at lower rates. Thus, this should minimize inventor mobility and reduce the creation of innovations made by people from geographically distant locations.

According to Fonesca and Liu (2023), for inventors who have "locked in low mortgage rates, these rate increases add a financial cost to the cost of moving, as moving requires prepayment of the current mortgage balance and remortgaging at significantly higher rates." Therefore, there is a widely cited concern in the existing literature that states the added financial cost may "lock in" households, reducing housing market transactions and labor mobility (Quigley, 1987; Ferreira et al., 2010; Fonseca and Liu, 2023). Moreover, the magnitude of the lock-in may impede geographic mobility (Ludwig et al., 2013; Chetty et al., 2014, 2018). Fonseca and Liu (2023) found

that such a mortgage "lock-in" reduces moving rates by 9%. We seek to expand upon this finding using data on the locations of inventors and scientists to investigate whether variation in historical interest rates has created a similar effect on inventors.

Several studies have also previously analyzed the relationship between mobility and productivity. Trajtenberg (2005, 2006) studied the relationship between mobility and labor productivity for R&D personnel, specifically. Per Hoisl (2007b), the study used data on "1,565,780 inventors listed on U.S. patent documents and [found] that mobility has a positive impact on work performance; in particular, patents of mobile inventors receive more citations." Hoisl (2007a, 2007b) also found the existence of a "simultaneous relationship between inventor mobility and inventor productivity: movers are more productive than non-moving inventors." We aim to expand on the finding of a relationship between inventor mobility and mortgage rates as a basis to ultimately determine the impact of volatility in mortgage rates on innovation.

The remainder of the paper is structured as follows. Section 2 discusses the data and methodology used to create the two unique data sets used for analysis. Section 3 provides the main results and section 4 discusses potential extraneous factors. Section 5 concludes.

II. Data and Methodology

i. Annual Mortgage Rates

As Kish (2022) found, the U.S. is the "only country in the world in which the 30-year fixed rate residential mortgage is the dominant home mortgage product." However, per Gustafson (2015), the 30-year term loan was not authorized by Congress until 1948 for new construction homes and 1954 for existing homes. As such, we sought to create a metric that would date back to the early 1900s and perform much like 30-year mortgage rates, had they existed back then. We took the following steps to create the unique data set.

The National Bureau of Economic Research ("NBER")'s Public Use Data Archive proved to house the most consistent historical data sets.[2] After analyzing all the data sets focused on interest rates within different contexts, two were deemed most relevant.[3] The first was a data set labeled as the U.S. Yield on Long-Term United States Bonds from 1919 to 1944, with a document ID of m13033a. The second was the same variable but from 1941 to 1967, with a document ID of m13033b. Upon closer investigation, the data sets contained information for bonds that were neither due nor callable for a minimum of ten years.[4] The two data sets were merged to create one cohesive data set from 1919 to 1967 with the yields of long-term U.S. bonds.

Next, market yields on 10-year U.S. treasury securities from 1962 to 2023 were collected from the Board of Governors of the Federal Reserve System.[5] To test the hypothesis that the two data sets from NBER functioned similarly to the 10-year treasury bonds, we analyzed the difference in the two rates from 1962 to 1967, which were the available overlapping years for both data sets. As shown in **Table 1**, the average annual difference between the 10-year treasury securities and the NBER yields on long-term U.S. bonds was only 0.10%.

Table 1. Comparison of NBER LT Yields and 10-YR Treasuries

Year Overlap	10-year Treasuries (%)	NBER LT Yields (%)	Difference (%)
1962	3.95	3.95	(0.00)
1963	4.00	4.00	(0.00)
1964	4.19	4.15	0.04
1965	4.28	4.21	0.07
1966	4.93	4.65	0.27
1967	5.07	4.85	0.22
Average			0.10

[2] https://www.nber.org/research/data?page=1&perPage=50
[3] https://www.nber.org/research/data/nber-macrohistory-xiii-interest-rates
[4] https://data.nber.org/databases/macrohistory/data/13/m13033b.db
[5] https://fred.stlouisfed.org/series/DGS10

The data on U.S. yields on long-term bonds from 1919 to 1961 was then combined with the data on U.S. 10-year treasury securities from 1962 to 2023, creating a clean and consistent data set from 1919 to 2023 for 10-year treasury securities. This data set was then transformed to perform like 30-year fixed mortgage rates through the use of an additive "mortgage rate premium".

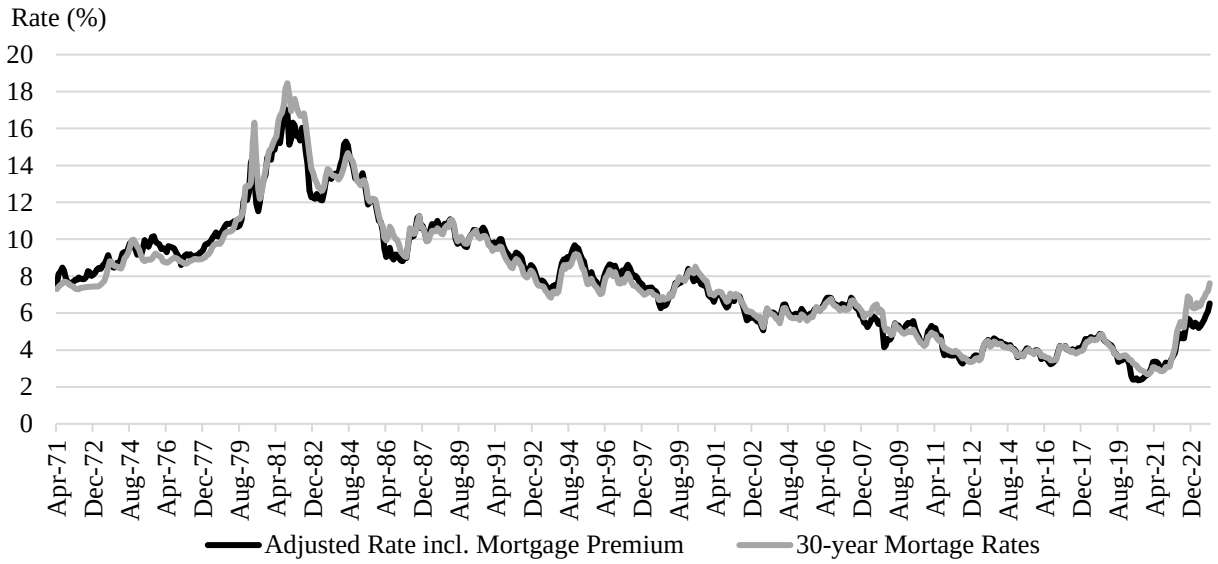
The yields on 30-year mortgage rates to those of the 10-year treasury securities from 1971 to 2023 were compared, and summary statistics for the yield differential were calculated, as shown in **Table 2**. The average rate differential between the 30-year mortgage rates and the 10-year treasuries for that fifty-year period was 1.73%, which we call the mortgage rate premium. **Chart 1** shows how the 10-year treasuries with the added mortgage rate premium, or the "adjusted rate", perform against the 30-year mortgage rates from 1971 to 2023.

In summary, to create this unique mortgage rate data set, NBER data on long-term yields from 1919 to 1961 were combined with the 10-year treasury yields from 1962 to 2023. Then, the 30-year mortgage rate premium was applied to the entire data set.

Table 2. Summary statistics for yield differential between 30-year mortgages and 10-year treasuries

Measure	Value (%)
Mean	1.73
Median	1.64
Minimum	-0.03
Maximum	5.66
Standard Dev	0.52
Variance	0.28
Bottom 25%	1.43
Top 25%	1.94

Chart 1. 10-year treasury yields plus mortgage rate premium versus 30-year mortgage rates



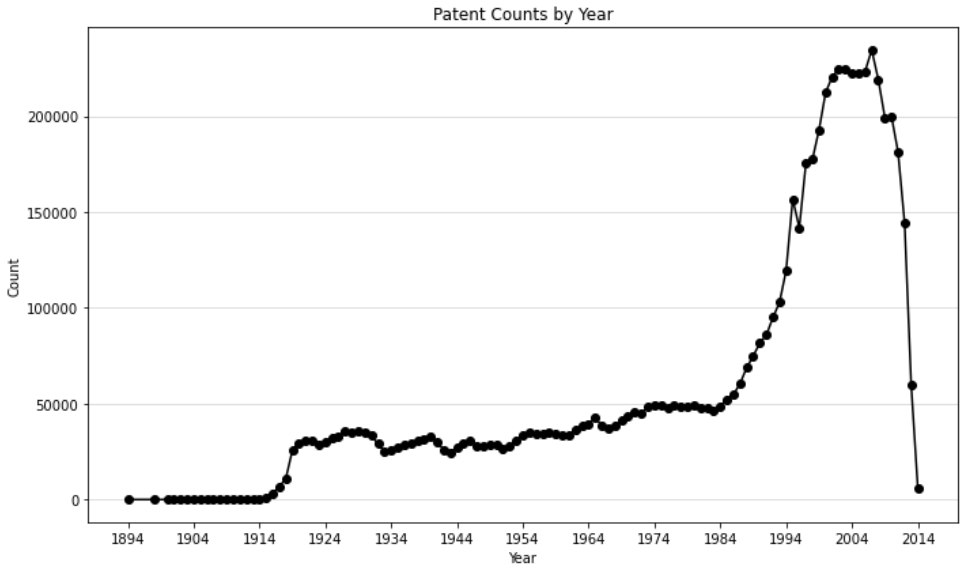
ii. Inventor Mobility

As this analysis focuses on understanding whether fluctuations in mortgage rates impact the propensity of inventors to move locations, a new variable to capture inventor mobility was created. The underlying data used to create the unique inventor mobility variable was U.S. patent data, particularly from 1919 to 2013, acting as a proxy for understanding innovation. Per Berkes (2018), since Hall et al. (2001), "patents have been the preferred measure of innovation in the literature." Thus, Berkes (2018) states they are commonly used as "the main source of data for empirical studies related to innovation and technological change." The data set created and cleaned by Berkes (2018), which includes all variables commonly used in the literature and also geolocates every investor reported in each patent grant, was utilized to create a measure of inventor mobility. The key variables used in this analysis include the inventor's name, location, and patent years.

The original data set contains 14,726,777 entries, inclusive of patents from 1894 to the beginning of 2014. After dropping duplicate entries, the remaining data contained 14,726,141 patent entries. As the analysis focuses on U.S. inventors, all foreign inventors were removed,

leaving 8,260,424 patent entries. Certain entries did not contain valid inputs for the U.S county, so those entries were removed, leaving a clean data set of 8,155,073 patent grants. The full distribution of yearly patent grants is shown in **Chart 2**.

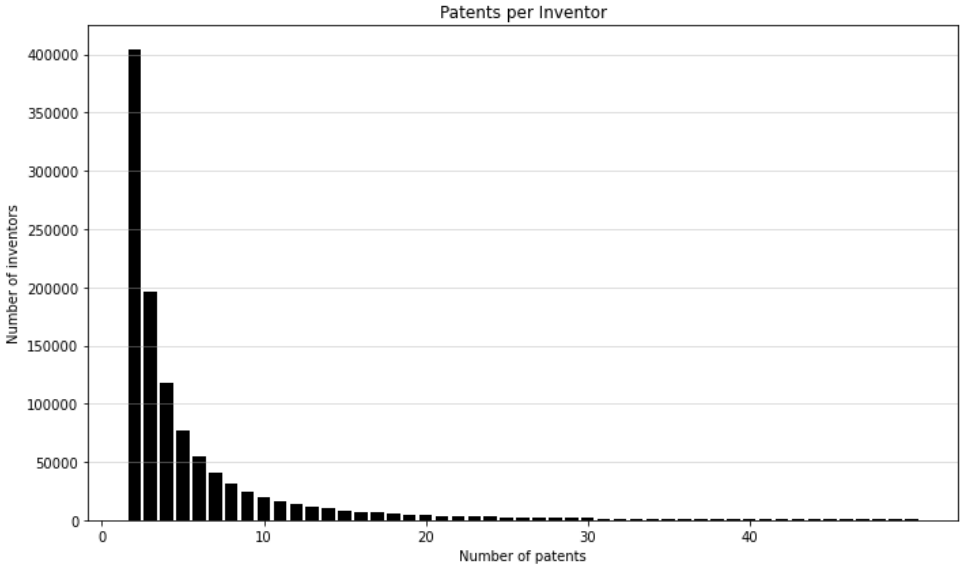
Chart 2. Total U.S. Patent Counts per Year from 1894 to Early 2014



From this cleaned subset of data, every inventor was assigned a unique ID. Then, the number of patents per inventor was aggregated, the output for which is shown in **Chart 3**. An additional subset of the data was created, leaving only those inventors who have been issued more than one patent. As the goal is to track when an inventor moves locations, such a metric could only be created with inventors who have at least two patent grants. However, as an extrapolation, a very small proportion of the U.S. population holds patents. **Appendix 1** demonstrates the number of patents divided by the number of persons, in thousands, residing in each state in 2019. Massachusetts had the highest with 1.31 patents per 1,000 residents.[6] Additionally, the number of patents per inventor decreases exponentially beyond the first patent.

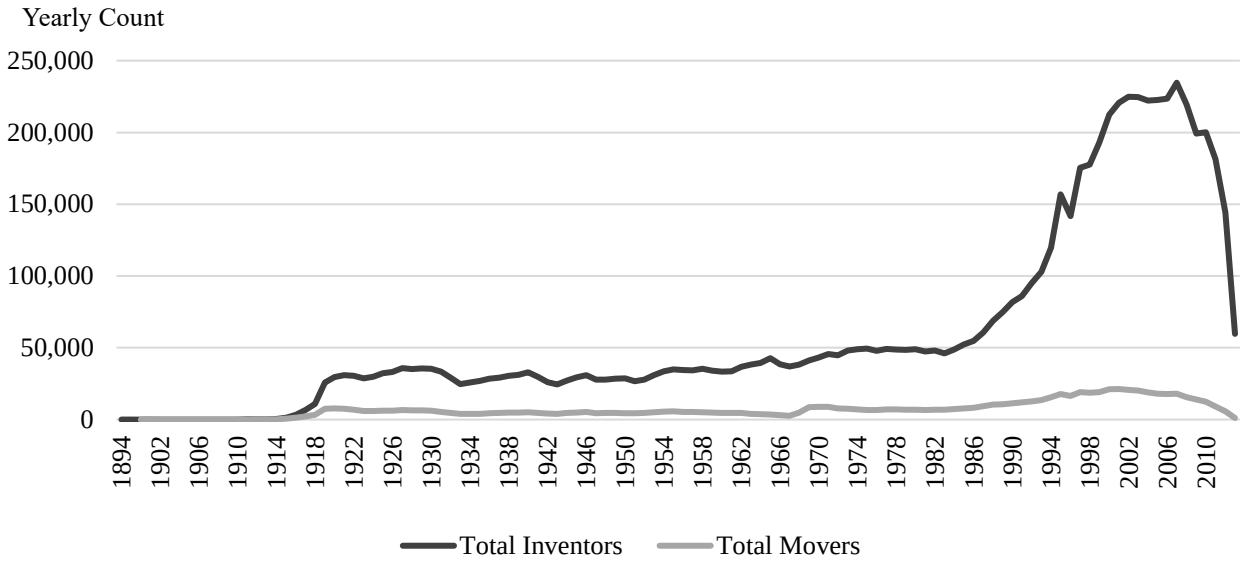
[6] https://fredblog.stlouisfed.org/2021/05/the-distribution-of-patents-across-u-s-states/

Chart 3. Distribution of Patents per Investor from 1894 to Early 2014



We then analyzed the total number of movers each year versus the total number of inventors to see if there was a visible trend between the two. See **Chart 4**. The count of inventors who moved since their last patent grant were considered as a yearly mover for the year in which their new patent grant was received. For example, if an inventor received their first patent in 1960 when they were living in California, and received their second patent in 1964 when they were living in New York, they are considered an annual mover in 1964. **Chart 4** further shows that even though the number of inventors receiving patents each year generally increased, the number of yearly movers stayed relatively constant. Potential factors for why this may be the case are further discussed in *Section IV*.

Chart 4. Total Number of Inventors vs. Movers per Year from 1894 to Early 2014



The number of total yearly movers was then divided by the total number of inventors who received patent grants in that year to create the percentage of annual inventor movers. This was the new key variable used in the analysis, as evident in **Chart 5**.

III. Results

This analysis centers around data from 1919 to 2013. The time period was selected because the earliest data available for the re-creation of 30-year mortgage rates was dating back to 1919 and the last full year of patent data with the geolocations for inventors is 2013. Thus, 1919 to 2013 provides for the most comprehensive data set for both variables used in this analysis.

After plotting the four key variables, as shown in **Chart 5** and **Chart 6**, no trends between the variables were easily visible and identifiable.

Chart 5. Annual Mortgage Rates and Percentage of Annual Inventor Movers from 1919 to 2013

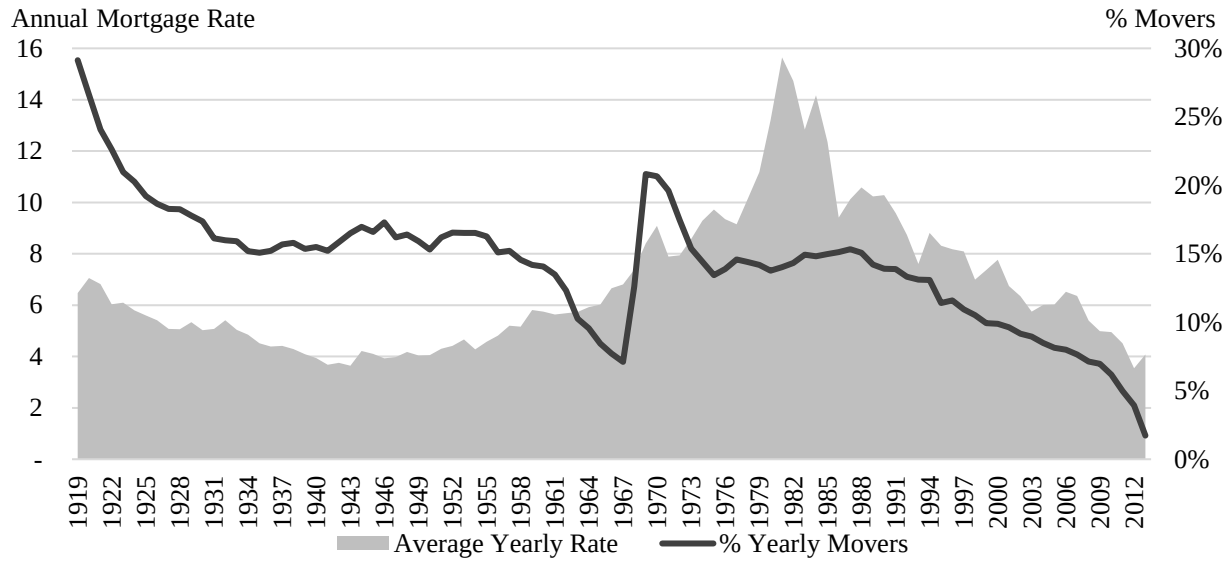
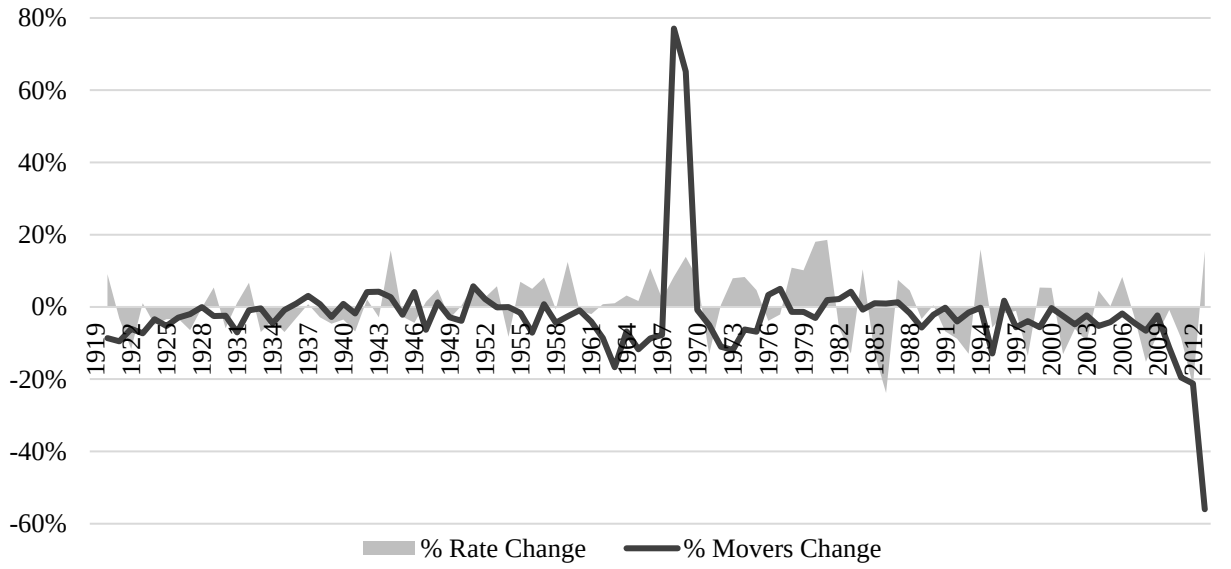


Chart 6. Percent Change in Mortgage Rates vs. Percent Change in Movers from 1919 to 2013



To further explore the possibility of a relationship, we performed two simple linear regressions to measure the relationship between mortgage rates and inventor mobility. Control variables were not included in the regression analysis. However, extraneous factors contributing to the findings that there is no discernible relationship between mortgage rate volatility and investor mobility are further identified and explained in *Section V*.

Table 3 shows the correlation between the variables used in the analysis. Here, we observe preliminary indications of the weak correlation between annual mortgage rates and the percent of inventor movers, and a similarly weak correlation between the percent change in the annual mortgage rate and the percent change in the annual mover rate.

Table 3. Correlation table demonstrating correlations between dependent and independent variables

	Annual Mortgage Rate	% of Annual Movers	% Change in Annual Mortgage Rate	% Change in % of Annual Movers
Annual Mortgage Rate	1.00			
% of Annual Movers	0.02	1.00		
% Change in Annual Mortgage Rate			1.00	
% Change in % of Annual Movers			0.12	1.00

Table 4 shows the output data of models 1 and 2, which use the nominal values and then the percentage change in the nominal values and the two dependent and independent variables. Model 1 shows the regression results of the annual mortgage rates and percent of inventor movers each year. Model 2 shows the regression results of the percent change of the annual mortgage rates and the percent change in the percent of inventors movers for a given year. Both models indicate that there is no statistical significance between the changes in mortgage rates and inventor mobility, having *p*-values of 0.8604 and 0.2317, respectively.

Table 4. The relationships between annual mortgage rates and inventor mobility

Variables	(1) % of Annual Movers	(2) % Change in % of Annual Movers
Annual Mortgage Rate	0.0003 [0.0017]	
% Change in Annual Mortgage Rate		0.1959 [0.1627]
Observations	95	94
R-squared	0.0003	0.0115
Adjusted R-squared	-0.0104	0.0048

Standard errors in brackets
*** p < 0.01; **p < 0.05; *p < 0.1

IV. Extraneous Factors

Even as the number of inventors who filed patents per year continued to rise for most of the period from 1919 to 2013, except for the dip in number of patents filed post-global financial crisis, the total number of movers per year tended to remain relatively constant. There are several factors that may be playing into the equation as to why we do not see concrete evidence of a relationship between fluctuations in annual mortgage rates and inventor mobility. Spring et al. (2016) found a steady decrease in one-year mobility in the U.S. from 1948 to 2011. On a five-year basis, residential mobility was also significantly down in 2011 as compared to 1948.

Moreover, the age of the inventors plays an important role in their propensity for mobility. Spring et al. (2016) found that those with "professional or graduate degrees are slightly less mobile than [those in] other [educational] categories." According to the U.S. Census Bureau in 2010, only 3% of the "adult U.S. population has a professional or doctoral degree, but 45[%] of patent holders hold a degree at that level."[7] Similarly, Walsh and Nagaoka (2009) also found that 46% of U.S.

[7] https://www.hamiltonproject.org/publication/economic-fact/eleven-facts-about-innovation-and-patents/#:~:text=Patent%20holders%20are%20substantially%20more,a%20degree%20at%20that%20level.

inventors have a doctorate and tend to be older, on average, than in other countries.[8] Walsh and Nagaoka (2009) account for this difference due to U.S. inventors "taking longer to begin inventing." Per Nager et al. (2016), Walsh and Nagaoka (2008) conducted a survey of 1,919 U.S. patent holders that established an age profile of U.S. inventors. They found that "American inventors average 47 years of age, with roughly equal proportions of inventors below the age of 40 and above the age of 50." Moreover, Spring et al. (2016) found that age is the factor that is "most strongly and consistently associated with the likelihood of moving." Thus, Spring et al. (2016) concluded that propensity for migration and mobility sharply decline after reaching a peak in the young-adult ages.

Independent of the mortgage rate environment, there are several reasons as to why people tend to move less as they age – established roots, familial considerations, and financial stability. As people age, they tend to become more rooted in their communities due to established social connections, routines, and familiarity with local amenities. They often have more familial ties and responsibilities, such as caring for children or grandchildren, which anchor them to their current location. Furthermore, older individuals typically enjoy greater financial stability, including homeownership and retirement savings, which can make the idea of moving less appealing due to the investments made in their current home and community.

Moreover, although concrete data is not publicly available on this specific topic, it is possible that inventors are largely renters as opposed to homeowners. People who are renters versus homeowners have different propensities for mobility. Nakagami and Pereira (1989) found that "residential mobility rates for homeowners rose sharply during the 1970s when inflation-adjusted mortgage rates were low and housing prices were appreciating rapidly." After 1980, they

[8] https://www2.itif.org/2016-demographics-of-innovation.pdf

rapidly fell as interest rates soared and residential appreciation slowed. However, Nakagami and Pereira (1989) also found that "in the same period, mobility rates for renters were relatively stable." These findings showcase the different reactions homeowners and renters have to a changing interest rate environment. Moreover, if inventors secure a mortgage at a high rate and then rates decline, they have the option to refinance the mortgage. This incentivizes them to stay in the same location, even with a change in mortgage rates, and thus, minimizes inventor mobility.

Another factor may be the vast technological advancements that facilitated cross-location communications with greater ease. Technological developments have made it possible for individuals to fulfill various aspects of their lives remotely, reducing the necessity for physical mobility and enabling people to stay in their current locations for longer periods. With the development and expansion of electronic mail in the 1970s to video conferencing in the early 1990s, collaborations with colleagues and teammates no longer required face-to-face interactions. That is even more so the case today with the wide prevalence of Zoom, Google Meet, Microsoft Teams, and other videoconferencing and chat platforms that have made collaboration around the world a much more seamless process.

Time may also have impacted the results of this analysis in several ways. First, the time lag between mortgage rate change and when inventors moved was not directly accounted for. It is possible that there was a one-to-three-year lag between when the interest rate environment experienced volatility to when inventors made the decision to move. This is due, in part, to various financial, contractual, and other practical considerations. Many individuals may be bound by contractual agreements, such as rental leases or mortgage contracts, that impose penalties or restrictions on moving before a certain period has elapsed. Even if interest rates change, individuals may need to wait until they are able to fulfill these contractual obligations before

considering a move. LaCour-Little and Holmes (2008) found that prepayment penalties in residential mortgage contracts can impose a very high cost on borrowers. Therefore, if a time lag variable was included in the regression analysis, the results may have differed. Moreover, it is not possible to determine exactly in which year the inventors moved if their additional patents were linked to a different address from their previous patents. As aforementioned, the inventor was said to have moved in the year the new patent was granted with a different address. However, it could be the case that the inventor moved several years prior to receiving the new patent grant. Further research should consider including a time variable in the analysis.

Moreover, it is possible that inventors are already located in a geographic area with high innovation rates. As evidenced in **Appendix 2**, patent grants are heavily concentrated within a few states and regions in the U.S., such as NY, PA, CA, TX, and FL. This may also be a factor of the size of the population; however, population is adjusted for in **Appendix 1**. Hoisl (2007a, 2007b) found that "more productive inventors are less likely to move." Therefore, if inventors are already in a geolocation with many other inventors, they may be less likely to relocate. As such, we find less evidence of annual movers in the data.

V. Conclusion

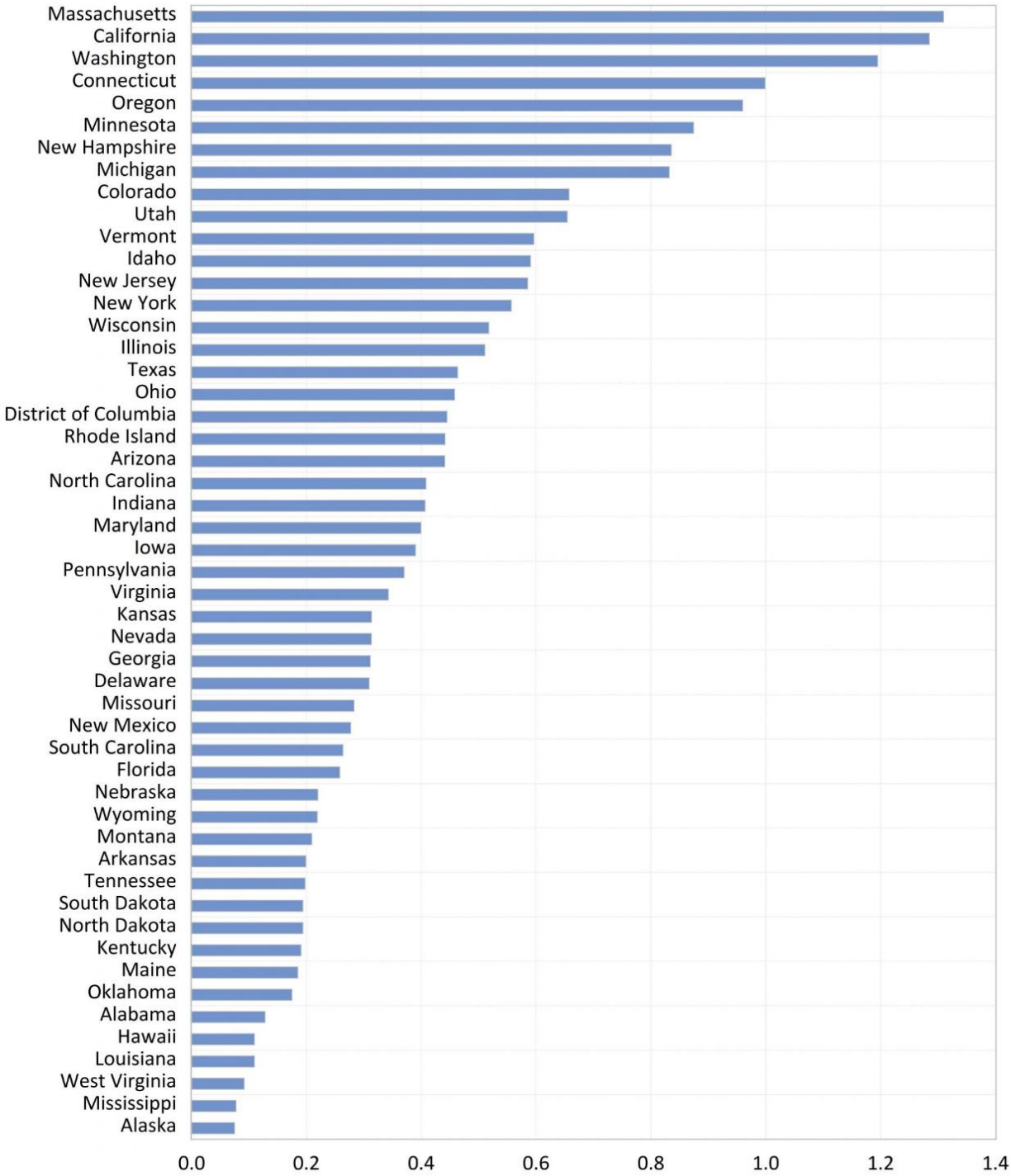
In this paper, we investigated the intricate dynamics between mortgage rates and inventor mobility, seeking to uncover the relationship that governs these variables. Innovation, as we have emphasized, flourishes through the exchange of ideas and collaboration, both of which are facilitated by the mobility of inventors. However, when inventors face constraints such as high mortgage rates, their ability to move freely and engage in collaborations beyond their current geographic confines becomes restricted, potentially hampering innovation.

Our study contributes to the ongoing discourse on the drivers of innovation and the role of mobility in shaping the innovation landscape. By deepening our understanding of the relationship between mortgage rates and inventor mobility, we can inform policymakers and stakeholders in fostering an environment conducive to creativity, collaboration, and sustained innovation.

Through several regression analyses, we have found no significant statistical relationship between fluctuations in mortgage rates and inventor mobility. This underscores the multifaceted nature of mobility decisions and the need for a nuanced understanding of the factors at play. While our findings provide insights into the dynamics of inventor mobility, further research is warranted to explore additional factors and their implications for innovation, such as the age of investors, homeownership rates, and introduction of technological advancements. Limitations in data analysis, including the absence of a time lag variable and potential misalignment between inventor movements and patent grants, underscore the need for further research in this domain.

VI. Appendix

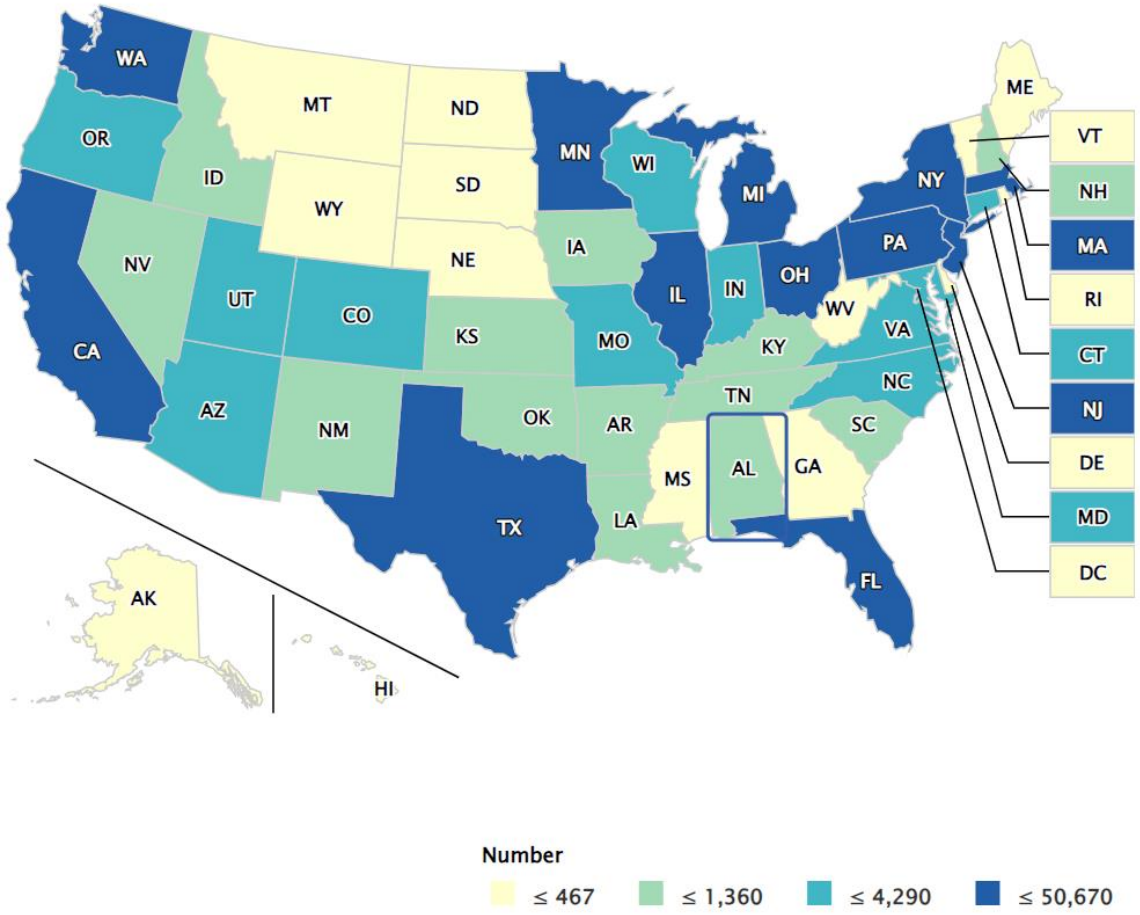
Appendix 1. Patents per thousand persons in 2019[9]



Source: FRED | U.S. Patent and Trademark Office, Census Bureau

[9] https://fredblog.stlouisfed.org/2021/05/the-distribution-of-patents-across-u-s-states/

Appendix 2. Total patents originating and granted by state in 2019[10]



Source: FRED | U.S. Patent and Trademark Office

[10] https://fredblog.stlouisfed.org/2021/05/the-distribution-of-patents-across-u-s-states/

VII. References

Berkes, E. (2018): Comprehensive Universe of U.S. Patents (CUSP): Data and Facts, https://assets.pubpub.org/zlwqau96/51606362190691.pdf.

Chetty, R., N. Hendren, P. Kline, and E. Saez (2014): "Where is the land of opportunity? The geography of intergenerational mobility in the United States," The Quarterly Journal of Economics, 129(4), 1553–1623.

Chetty, R., J. N. Friedman, N. Hendren, M. R. Jones, and S. R. Porter (2018): "The opportunity atlas: Mapping the childhood roots of social mobility," Discussion paper, National Bureau of Economic Research.

Ferreira, F., J. Gyourko, and J. Tracy (2010): "Housing busts and household mobility," Journal of Urban Economics, 68(1), 34–45.

Fonseca, J. and L. Liu: "Mortgage Lock-In, Mobility, and Labor Reallocation," Jacobs Levy Equity Management Center for Quantitative Financial Research Paper, http://dx.doi.org/10.2139/ssrn.4399613.

Gustafson, S. (2015): "Housing Finance Fact or Fiction? FHA Pioneered the 30-Year Fixed Rate Mortgage during the Great Depression?," American Enterprise Institute, www.aei.org/housing-center/housing-finance/housing-finance-fact-or-fiction-fha-pioneered-the-30-year-fixed-rate-mortgage-during-the-great-depression/.

Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2001): "The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools," NBER Working Paper No. 8498.

Hoisl, K. (2007a): "Tracing mobile inventors - The causality between inventor mobility and inventor productivity," Research Policy, 36(5), 619–636.

Hoisl, K. (2007b): "Does mobility increase the productivity of inventors?," The Journal of

Technology Transfer, 34, 212–225, https://doi.org/10.1007/s10961-007-9068-5.

Kish, R. J. (2022): "The Dominance of the U.S. 30-Year Fixed Rate Residential Mortgage," Journal of Real Estate Practice and Education, 24(1), 1–16, https://doi.org/10.1080/15214842.2020.1757357.

LaCour-Little, M. and C. Holmes (2008): "Prepayment penalties in residential mortgage contracts: A cost-benefit analysis," Housing Policy Debate, 19:4, 631-673, https://doi.org/10.1080/10511482.2008.9521651.

Ludwig, J., G. J. Duncan, L. A. Gennetian, L. F. Katz, R. C. Kessler, J. R. Kling, and L. Sanbonmatsu (2013): "Long-term neighborhood effects on low-income families: Evidence from Moving to Opportunity," American Economic Review, 103(3), 226–231.

Nager, A., D. M. Hart, S. J. Ezell, and R. D. Atkinson (2016): "The Demographics of Innovation in the United States," SSRN Electronic Journal, https://doi.org/10.2139/ssrn.3066060.

Nakagami, Y. and A. M. Pereira (1991): "Housing appreciation, mortgage interest rates, and homeowner mobility," Journal of Urban Economics, 30(3), 271-292, https://doi.org/10.1016/0094-1190(91)90050-H.

Quigley, J. M. (1987): "Interest Rate Variations, Mortgage Prepayments and Household Mobility," The Review of Economics and Statistics, 69(4), 636.

Spring, A., S. E. Tolnay, and K. Crowder (2016): "Moving for opportunities? Changing patterns of migration in North America," International handbook of migration and population distribution, Dordrecht: Springer Netherlands, 421-448.

Trajtenberg, M. (2005): "Recombinant ideas: The mobility of inventors and the productivity of research," CEPR-Conference, Munich, May 26–28, 2005.

Trajtenberg, M., G. Shiff, and R. Melamed (2006): "The ''names game'': harnessing inventors'

patent data for economic research," NBER WP No. 12479, Cambridge, Mass.

Walsh, J. P., and S. Nagaoka (2009): "Who invents? Evidence from the Japan-US inventor survey," RIETI Discussion papers 24.