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Violence and economic activity: evidence from African American patents, 1870–1940

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Abstract Recent studies have examined the effect of political conflict and domestic terrorism on economic and political outcomes. This paper uses the rise in mass violence between 1870 and 1940 as an historical experiment for determining the impact of ethnic and political violence on economic activity, namely patenting. I find that violent acts account for more than 1,100 missing patents compared to 726 actual patents among African American inventors over this period. Valuable patents decline in response to major riots and segregation laws. Absence of the rule of law covaries with declines in patent productivity for white and black inventors, but this decline is significant only for African American inventors. Patenting responds positively to declines in violence. These findings imply that ethnic and political conflict may affect the level, direction, and quality of invention and economic growth over time.

Keywords Growth · Conflict · Property rights · Institutions

Social instability and political conflict in a country are strongly associated with poor economic outcomes. A large literature has documented their effects on growth and development in both cross-country (Acemoglu and Robinson 2001; Alesina et al. 1996; Barro 1991; Mauro 1995) and within-country settings (Abadie and Gardeazabal 2003). Political unrest has been associated with reduced savings and investment (Alesina and Perotti 1996; Venieris and Gupta 1986), and property values suffer when civic strife breaks out (Besley and Mueller 2012). Likewise, Luigi et al. (2009) have shown that past warfare is negatively associated with international trade volume in the present.

One issue that has gone unexamined is the effect of violent conflict and social instability on inventive activity and the creation of intangible capital. While there is good experimental evidence that socioeconomic stress can lead to lower scores on cognitive tests

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(Duncan et al. 2011; Duncan and Magnuson 1998), and leads to poor economic decision-making (Shafir and Mullainathan 2012), the link with economically relevant intellectual output has not been made.

I show that patenting rates by African Americans in the 19th and 20th centuries systematically declined in areas affected by race riots and lynchings. Although violence might seem unrelated to the inventive process, it affected inventors and other economic agents. Between 1870 and 1940, race-related violence in the United States increased dramatically. Major race riots peaked in 1919 and 1921, lynchings in 1892 and 1893, and passage of state segregation laws in 1908, 1928, and 1933. These trends provide a natural experiment for testing the extent to which a shock to personal security and property rights can affect individual creativity and the production of economically intangible capital.

Using a novel data set and exploiting an historical experiment, I find that extrajudicial killings and loss of personal security depressed patent activity among blacks by more than 15 % annually between 1882 and 1940. In addition, productive activity increased after violence ceased. I also find that patenting was lower in states with more riots and laws promoting segregation than in other states and that these factors accounted for more than 1,100 "missing" patents (that is, patents that would have been applied for and obtained absent these factors) over the period compared to 726 actually obtained by African Americans. Finally, using a "placebo study," I find that a similar shock of increased hate-related violence to white inventors would have depressed U.S. patenting activity by nearly 40 % and ostensibly would have resulted in significantly greater volatility in technological change.[1] The economic significance of the findings in this paper implies that, then and now, conflict and hate-related violence, and the resulting uncertainty in property-rights enforcement, may substantially affect the level, direction, and quality of inventive activity and economic growth.

1 Violence and inventive activity, 1870–1940

1.1 Violence and segregation

Following the emancipation of slaves after the Civil War, race-related violence escalated in the South in the 1870s and spread to other parts of the country by the end of the nineteenth century. Such conflict was often related to the absence or diminished enforcement of the rule of law.[2]

Major race riots are one indicator of hate-related violence. As reported in Table 1, these events were occasionally politically motivated and were sometimes associated with mob

[1] Using data on major British firms, Bloom and Van Reenen (2002) show that higher uncertainty in the market for patents reduces productivity because of delayed investment.

[2] Economists and other scholars are increasingly interested in this period of conflict. Loewen (2005) finds all-white "sundown towns" emerged and were established using subtle intimidation and outright violence in nearly every state after 1890. Jaspin (2007) investigates sudden and dramatic shifts in racial composition in many U.S. counties. Using county-level census data between 1864 and 1923 and current census data, he finds that violent episodes of "racial cleansing" occurred throughout the United States and resulted in all-white or nearly all-white counties that have persisted. Norrell (2009) presents a new history of segregation in America with an emphasis on hate-related violence and the African American leader Booker T. Washington. Interest among policymakers and the popular press has also increased. Allen et al. (2000) chronicle the history of lynching through photographs and postcards, and their exhibit at the New York Historical Society and at other venues has received much attention (Smith 2000). In the last decade, a number of newspapers, such as the *Waco Tribune-Herald* (2006), have issued apologies for their role in fomenting riots and lynchings through "lynch journalism" during this period.

violence and election disputes; blacks were usually, but not always, the targets of race riots. This paper includes only riots that resulted in major violence and loss of life and property and that received national media coverage. There were many smaller riots. Yet, data have not been systematically collected on minor riots, and I exclude them from this paper. In the historical

Table 1 Conflict, rule of law, and segregation laws, 1870 to 1940

Decade	Major riots	Lynchings, black	Lynchings, White	New segregation laws				
				Total	Voting	Education	Public	Other
Panel A—riots, lynchings, new segregation laws, 1870–1940								
1870–1879	10	na	na	39	3	18	2	14
1880–1889	1	429	87	30	2	9	6	12
1890–1899	4	842	124	38	7	10	13	6
1900–1909	7	646	33	63	2	13	29	19
1910–1919	11	487	16	30	2	3	7	12
1920–1929	4	260	20	54	4	15	10	22
1930–1940	1	123	10	36	0	10	11	15
Year	Major riots	Lynchings, by year*	Location	Event				
Panel B—events related to conflict and rule of law, selected years								
1874	1	3.0	Vicksburg, MS	Election-related violence, KKK mob violence, deaths of civil-rights leaders				
1876	4	5.0	Cainhoy, SC; Charleston, SC; Charleston, SC; Ellenton, SC	Violence instigated by black Republicans after disputed election; murder of black public official; partisan fighting				
1878	1	8.0	Caddo Parish, LA	Election violence, KKK mob violence, 40–75 deaths				
1883	1	1.7	Danville, VA	Overthrow of democratically-elected, racially-integrated local government, 4 deaths (blacks)				
1895	1	4.0	New Orleans, LA	Attack on black workers, death of 6 blacks				
1898	2	2.0	Wilmington, NC; Lake City, NC	Assault on professional and working-class blacks following; Declaration of White Independence				
1900	1	0.0	New York, NY	Major race riot				
1904	1	0.3	Springfield, OH	Lynching, property destruction, mass exodus by black residents				
1906	1	7.0	Atlanta, GA	Major riot, election-related violence, massacre, property damage				
1906	1	0.3	Greensburg, IN	Major riot, mob violence, mass property damage				
1906	1	7.2	Brownsville, TX	Major riot, army-related violence				
1908	1	0.4	Springfield, IL	Lynchings				
1917	1	7.2	Houston, TX	Black officers' mutiny following WWI, 18 black soldiers hanged				
1917	2	0.1	Chester, PA;	Major race riots				

Table 1 continued

Year	Major riots	Lynchings, by year*	Location	Event
			Philadelphia, PA	
1919	1	0.4	Chicago, IL	Major race riot in reaction to rapid influx of black migrants
1919	1	1.0	Charleston, SC	Outbreak of violence among nearly 1,000 sailors; deaths
1919	1	0.0	Washington, DC	Major race riot
1919	1	1.0	Knoxville, TN	Lynching, deaths, injuries, army takeover of city
1921	1	0.8	Tulsa, OK	Mob violence, destruction of 1,256 homes and most businesses, 100–300 deaths, mass arrests; martial law imposed
1926	1	0.0	Carterer, NJ	Race riot and mass exodus of black residents
1929	1	0.1	Lincoln, NE	Mob violence, exodus by black residents
1935	1	0.0	New York, NY	Major race riot, police brutality, 3 dead, 60 injured, $200,000 property damage

* Lynching data are for the year and state given or earliest year available, 1882. Data for DC, NE, NJ, NY, OH, OK, PA, TX, and VA are expressed as an average of the years available. Panel B reports data on black victims only. Lynching data from 1930 to 1940 are extracted from the Tuskegee file only. Segregation laws are new state laws designed to restrict movement or activities of minorities and not overturned within 3 years. Not all categories of laws are included separately, but the total includes all laws. See Data Appendix for sources

literature there is no universally-accepted set of sufficient conditions that would predict race riots during this period. Race riots frequently had legal and political consequences, such as the imposition of martial law and the ousting of democratically elected black and moderate white officials, along with economic consequences, such as looting of black business districts and destruction of entire black farms, firms, and residential neighborhoods.[3] Riots were largely concentrated in the South before 1900 and in the North after 1900. The effects of violence on black economic activity would have been both direct—for example, black inventors' workshops were located in the affected business districts—and indirect—for example, riots lower the value of commercial and residential property (Collins and Margo 2003), which would reduce financing opportunities and increase operating costs.

Riots often had consequences far beyond their cities and states of origin. The East St. Louis race riots in May and July 1917 involved a mob of nearly 3,000 white men, several lynchings, as many as 150 black deaths, and extensive damage to black homes and white firms, including a warehouse of the Southern Railway Company (Garvey 1917/1983; *New York Times* 1917). In support of the victims and in protest of the failure of East St. Louis and other authorities to protect their citizens, the National Association for the Advancement of Colored People (NAACP) organized a "silent march" of 15,000 people down Fifth Avenue in New York City in late July 1917. Historian John Hope Franklin writes, "It was the epidemic of race riots that swept the country early in the century that aroused the greatest anxiety and

[3] Although negative effects of race riots during this period were disproportionately concentrated among African Americans, there were also negative spillovers reported for whites. O'Dell (2001) analyzes claims against the city for property damage and other data related to the Tulsa riot in 1921 and identifies whites who incurred riot-related losses due to theft from businesses and losses associated with real-estate transactions in black neighborhoods. Martial law was imposed on the entire city of Tulsa following the riot, which would have affected all city residents. Mixon and Kuhn (2005) cite several newspaper accounts reporting the death of a white woman who had a heart attack at the sight of the mob near her home during the Atlanta riot in 1906.

discomfort among the African-American population.… Riots were perceptibly increasing, and their dramatic nature had the effect of emphasizing the insecurity of blacks throughout the country" (Franklin and Moss 1994, p. 313).

Lynching also may be considered a proxy for absence of the rule of law.[4] Whereas race riots involved opposing groups, lynchings typically involved a group taking action against a specific individual or individuals. In addition to killing the victim, often a secondary objective was the externality a lynching produced—to intimidate the victim's family, community, or ethnic or racial group.[5] A lynching signaled that personal security—and with it the freedom to work and innovate—was not guaranteed.[6]

Table 1 shows that lynchings peaked for black and white victims in the 1890s.[7] Most lynchings occurred in the South, and most victims were African American. As the table indicates, the average number of lynchings with African American victims each year varied greatly. Although data on lynching are recorded through 1968, the practice had largely stopped by 1930. Media coverage of lynchings spread awareness of the violence. For much of the nineteenth century, lynchings received local coverage in black- and white-owned newspapers, and nationally through newspapers in major urban areas and publications of the NAACP, other national civil rights organizations, and nascent anti-lynching movements.[8] International attention grew through newspapers and organizations, including the British Anti-Lynching Committee formed in 1894 to protest the lynchings of southern blacks. Although the direct effect of lynching was likely primarily local, its indirect effect—a growing and general sense of diminishing protection in the courts and among law-enforcement bodies—was national.[9]

Other measures associated with violence are the timing and extent of Jim Crow legislation, which often legitimated acts of violence and created or reflected the social and political environment of the day. A flurry of laws promoting segregation followed the period of Reconstruction. As Table 1 shows, laws advancing segregation were primarily related to education

[4] There is some debate in the literature about whether the motives for lynching were relatively more political or economic. See Darity and Price (2003) for an extensive discussion of this debate.

[5] Many scholars argue that the 1955 lynching of Emmett Till, the motive for which was to intimidate northern and southern blacks, was a catalyst for the civil rights movement. See Mettress (2002) and U.S. Department of Justice (2004).

[6] Although there are no reports of lynchings of inventors in the biographical data collected, there is anecdotal evidence that arsonists and firebombers more often targeted African American inventors, particularly those who manufactured their inventions. For example, Haber (1970) includes an account of two fire bombings at the home of Percy Julian, a black chemist. The direct and indirect effects of arson and fire bombing are likely equivalent to those of riots (through property destruction) and lynching (personal security threats and the rule of law).

[7] Historical American Lynching (HAL) Data Collection Project data on lynchings are often used in empirical studies. These data are based on and nearly identical to the Tolnay and Beck (1995) data. Because the data Tolnay and Beck (1995) used are limited geographically and temporally (1882–1930), the lynching series used here combines the Tolnay and Beck (1995) data for selected southern states and lynching data collected by Tuskegee Institute (2004) and Ginzburg (1962) for non-southern states. Both black and white lynchings, especially in northern states, are undercounted. Data on white lynchings report victims who are of all racial groups other than black, including those of Chinese and Mexican descent.

[8] In 1892, Ida B. Wells (later Wells-Barnett), an early civil rights and anti-lynching activist who helped found the NAACP, published the *Red Record*, which contained the first systematic data on lynchings in the United States, and in 1895. *Southern Horrors: Lynch Law in All Its Phases*, both of which were nationally and internationally circulated. See Wells-Barnett (1892, 1895). By the early 1900s, regional and national, including congressional, debates on lynching were also receiving attention across the United States and beyond.

[9] This is a negative externality cited in apologies for lynching by both U.S. Houses of Congress in 2008 and 2009.

and public facilities.[10] Segregation laws had two direct effects. First, and most important, they were proxies for latent violence. Jim Crow legislation formalized customary practices and allowed few legal safeguards for minorities. Residents of a given state understood that violence would occur if the laws were not obeyed. Litwack (1998) argued that lynch mobs and the courts were the de facto enforcers of Jim Crow laws.[11] In explaining "racial cleansings" in which blacks were abruptly driven out of counties both North and South, Jaspin (2007) offered an additional direct effect of segregation laws. He argued that the greater the number of and adherence to Jim Crow laws, the fewer the encounters between African Americans and whites and the greater the degree of anxiety, mistrust, and suspicion between the races, which could lead to spontaneous outbreaks of violence.[12] In this paper, the number of segregation laws was included to capture the taste for and degree of segregation and latent violence across states.

Passage of segregation laws also decreased access to patenting institutions and to social networks and institutions that support invention and innovation.[13] The offices of patent attorneys (all white at the time) were in "white-only" commercial districts, hindering African American inventors from applying for patents.[14] With little recourse to the courts, African Americans would have found it nearly impossible to fight patent infringement, even if they had been represented by white attorneys.[15] Networking opportunities were also limited. Segregation of public buildings led to "Negro Day" during major scientific fairs or "Negro fairs" that were completely separated from major exhibitions.[16] Unequal access to education,

[10] It is anticipated that data on passage of segregation laws may understate the extent of racial segregation and isolation and their effect on property-rights enforcement. Supreme Court rulings and local, including residential, segregation laws are excluded from the data. For example, using census data, Cutler et al. (1999) develop indices of segregation and isolation from 1890 to 1990 and consider the importance of residential segregation in explaining the variation in segregation over time. Legislation related to miscegenation and employment is included in the "other" category in Table 1. As well, policies, customs, and practices will not necessarily be fully captured by state legislation.

[11] Specifically, he argues, "Once previous customs became lodged in the statute books, it was imperative that any breaches be swiftly punished as examples to others of how the new order would be implemented.…To forestall lynch mobs, courts often speeded the conviction and execution of black defendants, distorting whatever semblance of constitutional protection remained for them" (256-57).

[12] See Jaspin (2007), p. 8. Data on racial cleansings were unavailable and, hence, are beyond the scope of the current paper.

[13] See Thomson (2009) for a rich discussion of the importance of social ties and networks for invention and patenting in the nineteenth century.

[14] Loewen (2013) notes that there were also entire towns, including three in Illinois, which barred African Americans during the day.

[15] Suing a white person was one of the offenses reported for victims in the HAL lynching data set. Also, anecdotal evidence suggests that abrogation of intellectual property rights was not unusual. A letter in the Carter G. Woodson Papers contains testimony from the son of an African American inventor whose patent rights were illegally assumed by a firm when his father was temporarily sent on assignment abroad. However, to my knowledge, no systematic evidence of such abrogation exists. Similarly, there is anecdotal evidence concerning greater rejection rates of patents received from applicants suspected of being African American. There is only one instance of this behavior in the literature, and a comparison of a sample of similar patents obtained by white and African American inventors shows that the time between patent application and grant for the two groups was not significantly different, 1.4 years in each case. The implication is that patent examiners did not treat patent applications from the two groups of inventors differently once the decision to grant the patent was made. Application rejection rates would need to be analyzed to examine Patent-Office behavior more fully, which is beyond the scope of the current paper.

[16] For example, Foner (1978) reports that Joseph H. Dickinson, a prolific inventor of musical and mechanical instruments, could only display his inventions and view other exhibits at the Centennial Exposition in Philadelphia in 1876 in the "Negro building." As a result, there were extra costs associated with marketing his inventions.

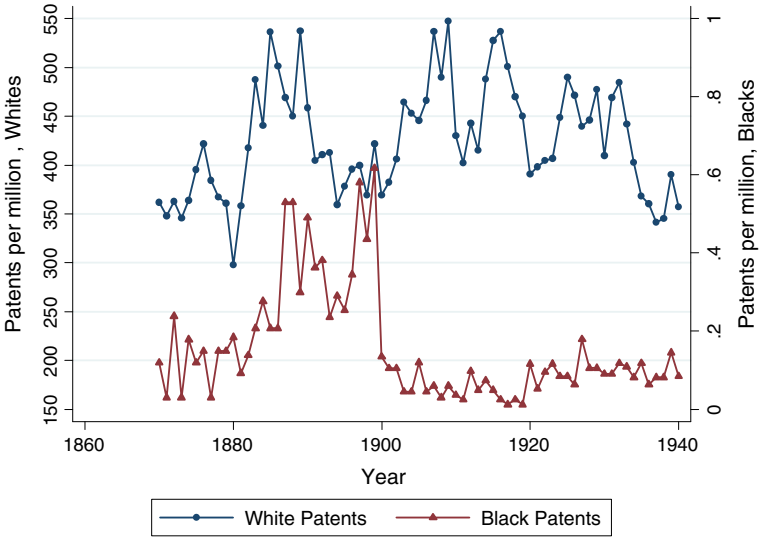

Fig. 1 Black and white utility patents, per million, 1870–1940

which became increasingly important to patenting over the course of the twentieth century, also likely deterred patenting.

1.2 Patenting activity, 1870–1940

Figure 1 shows that, before the early 1900s, patenting rates among African Americans followed a pattern increasingly similar to that of the larger inventor population, albeit at a much lower level. Like overall patent rates, African American patent rates were procyclical, increasing with economic booms.[17] Black patent activity became countercyclical at the turn of the century. As Fig. 2 suggests, black inventors began responding to incentives or conditions that did not affect other inventors. Specifically, a rise in race-related violence coincided with greater divergence in patenting rates between black and white inventors. I test the validity of this apparent correlation statistically using new data on African American inventors as described below.

2 Data

Race is not recorded in patent records. Therefore, my first task was to identify African American inventors. I collected data from little-known surveys that Henry E. Baker conducted on behalf of the U.S. Patent Office in 1900 and 1913. He sent surveys to 9,000 of the 12,000 patent attorneys and agents in the United States asking if they had African American clients or if they knew of any African American patentees. Data collected from these surveys constitute

[17] Throughout the paper, I use the terms "patent" and "utility patent" interchangeably. A utility patent is issued for any new and useful process, machine, manufacture, composition of matter, or any new and useful improvement thereof. From 1995, utility patents are effective for 20 years from the date of application. Utility patents constitute more than 95 % of all patents granted to African Americans. Although it is standard to use patents as a proxy for innovation and inventive activity, this measure has limitations as, for instance, not all inventions are patentable or patented. However, direct measurement of invention is not generally possible and, in particular, not available, given the limitation of historical data needed for this study.

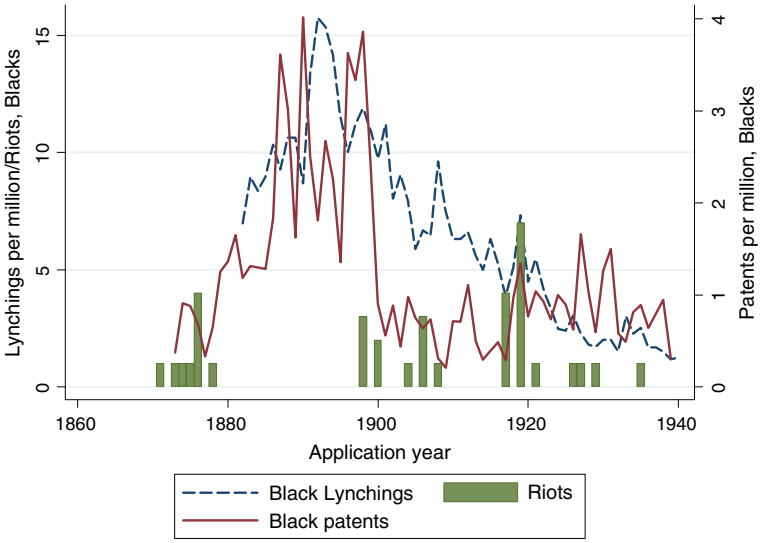

Fig. 2 Conflict and black inventive activity, 1870–1940. *Source* Cook (2004), EPO, Tolnay and Beck (1995), Tuskegee Institute (2004), USPTO. *Note* Patent data in Fig. 1 are presented by grant year and in Fig. 2 by application year

approximately 65 % of the data set. The Baker data, however, are only partially helpful to my study. He mistakenly identified the first African American known to receive a patent, and the data end in 1914, 26 years short of the period of interest.[18]

To fill the data gap, I matched patent records to census data. While matching nearly two million patents to census records is an onerous task, it is more onerous to distinguish African American from non–African American patentees. First, as is evident from Table 2, African Americans obtained patents outside the South, even though only a small percentage of the African American population lived outside the South. Second, with the exception of a few famous inventors, African American inventors' names were indistinguishable from those of other American, particularly British-born, inventors.[19] Addresses were often limited to just the city or town of residence, which added further difficulties in identifying individuals. Appendix II describes other approaches, including those exploiting the recent literature related to "black names," such as in Bertrand and Mullainathan (2004) and Fryer and Levitt (2004).

The best strategy was to identify African Americans among the population of inventors and likely inventors from other sources and to match them to patent records. I accomplished this by collecting names from several sources including modern and historical directories of African American scientists, engineers, and medical doctors; archives, including correspondence of the noted African American historian Carter G. Woodson and the Garrett Morgan

[18] The 1843 patent of Norbert Rillieux was the only patent record Baker observed with the term "colored" next to the name of the patentee. It was the earliest patent he identified with an African American named as the patentee, but subsequent research would show that an 1821 patent obtained by Thomas Jennings was the earliest known to have been obtained by an African American. See the data appendix, Appendix I, for an explanation of approaches for identifying African American inventors, including the Baker surveys.

[19] The easily identifiable names were based on the post-slavery practice of adopting the names of American presidents as first and middle names. The inventors using this convention were Andrew Jackson Beard, George Washington Carver, and George Washington Murray.

Table 2 Total and African American patentees, 1870–1940

Utility patents	All	African American
Geographic distribution (%)		
Mid-Atlantic	40.5	30.3
Midwest	26.5	34.0
New England	24.2	7.6
South	6.6	22.9
West	n/a	5.2
Sectoral distribution—panel A (%)		
Agriculture	1.2	6.0
Construction	7.8	0.7
Electricity, communications	23.5	11.9
Manufacturing	37.6	17.9
Transportation	15.3	35.6
Miscellaneous	14.6	27.8
Sectoral distribution—panel B (%)		
Chemical	n/a	5.1
Communications	n/a	1.4
Drugs, medical	n/a	1.5
Electrical, electronic	n/a	10.3
Mechanical	n/a	34.6
Other	n/a	43.8
Average patents/patentee	10.6	2.2
Patentees with 1 career patent (%)	33.2	67.8
Patentees with 4 or 5 career patents (%)	10.3	4.4
Patentees with 10 or more career patents (%)	25.0	3.0
Patents assigned at issue (%)	50.1	36.9
Total patents	2,127,079	726

Source Cook (2004), author's calculations; Sokoloff (1988), Khan and Sokoloff (1993, 2004), Sokoloff and Lamoreaux (2003), and Lamoreaux et al. (2008). Sectoral distribution data for all patentees are for 1866–1885 (Sokoloff and Khan 2004); geographic data are for 1846–1865 and were obtained from Khan and Sokoloff (1993). Midwest and West data are combined, and Mid-Atlantic includes NY and PA for all. Data in Panel A are organized according to the classification of technological field in Sokoloff (1988); in Panel B, in Hall et al. (2001). Data in Panel A for African Americans are for 1870–1930. Average patents/patentee for all inventors are for 1910–1911 from Lamoreaux et al. (2008) for careers of 6–10 years. Average patents/patentee for African American inventors are for all inventors in Cook (2004) between 1870 and 1930 whose patenting careers spanned at least 10 years. Career patent data for all inventors are for 1790–1911 from Lamoreaux et al. (2008); data for African American inventors are for 1870 to 1930 from Cook (2004). Percent patents assigned at issue for all are a weighted average of percent assigned in 1890–1891 and 1910–1911 in Sokoloff and Lamoreaux (2003)

Papers; obituaries in local newspapers; published biographies and collections of biographies; programs from the "Negro Building" or "Negro Day" at fairs and exhibitions related to science and invention before 1940; census data; and online company-history searches. A more detailed description of these sources appears in Appendix II. I obtained additional patents of inventors appearing in the Baker data by searching USPTO (2004) and EPO (2004) databases.

The data set I constructed extends from 1870 to 1940 and includes 726 utility patents granted to African Americans during this period. The data comprise the patent number; inventor's full name, full names of co-inventors, and order of appearance of names of inventors; location of the inventor; title of the patent; dates of application and issue; assignment status; assignee's name and location; current USPTO patent class and subclass; and NBER-Hall, Jaffe, and Trajtenberg two-digit technological class.[20]

As Fig. 1 shows, despite the difference in levels, trends in inventive activity by race were roughly similar before the early 1900s.[21] Until 1930, two of the three major fields in which the two groups patented were the same: manufacturing and transportation. Table 2 reports other data on invention by technological category.

Each patent-holder was issued approximately two patents, on average, which is consistent with the findings of Hall et al. (2001) for the entire population of utility-patent-holders from 1963 to 1999, but it is much lower than the average that Khan and Sokoloff (1993) computed for patentees up to 1846.[22] Two-thirds of black patentees have one patent. However, 4 % have four or five patents, and 3 % have ten or more patents. Table 3 contains examples of patented inventions in the data set. This sample reflects the significant variation across technical classes and geography among African American inventors of this era. Although patent activity was evident in all regions of the country, the Midwest and Mid-Atlantic states, including New York and New Jersey, accounted for 64 % of this activity, which mirrors general patterns among white inventors at this time. Consistent with the practice of the day, African American inventors were largely individual inventors, but a number of patent-holders were members of well-known research teams.[23]

One problem in the data is the potential undercount during the period when African Americans relied heavily on patent intermediaries. Baker's task of verifying patentees was complicated by a widespread perception that African American patents might be undervalued if the inventor's race were revealed.[24] Truncation due to undercounting would be difficult to measure and to account for in estimation. Nonetheless, the number of "missing blacks" would have to be large to obtain the magnitude of decline apparent in Fig. 1. Further, prolific inventors entered and exited the data set throughout the period of study. Because inventors with one

[20] Biographical data, including patentee education, training, and property-ownership status, are only available and have been collected for a group of 26 prolific inventors before 1930. This group is the subject of Cook (2011). Application data were not recorded for patents obtained between 1870 and 1873. Technological classes created by Hall et al. (2001) are designed as an alternative to the USPTO technical classification to capture broad technological categories of innovation. Patents collected are matched to broad one-digit categories and more specific two-digit subcategories. Citations, a typical measure of quality of invention, are only publicly available from 1975. Patents granted between 1870 and 1930 and cited from 1975 will be rare, because older inventions will have been incorporated into newer inventions. Therefore, I do not use citations in the present analysis.

[21] To determine the number of patents granted to white inventors, I subtracted the patents obtained by black inventors from total patents granted. Any nonblack patent-holders will therefore be included among white inventors. Although the precise ethnic composition of patent-holders is unknown, it is reasonable to assume that the majority of nonblack patent-holders are white.

[22] The average is two per patentee from 1821 to 2004. The Hall et al. (2001) sample is drawn between 1963 and 1999. During the same period, the average for African American patentees is 6.2, and the median is 2.

[23] Lewis Latimer was a member of Thomas Edison's research team, the "Edison Pioneers." Granville T. Woods, who obtained 45 patents mainly related to electricity and transportation, was asked by Edison to join Edison's Pioneers but declined and preferred to invent alone or with his brother.

[24] This was likely more broadly observed than just among inventors. There is anecdotal and empirical evidence during the period of heightened racial tension that race may have been endogenized, if physically possible. See Jaspin (2007) for an account of blacks who left counties owing to "racial cleansing," who migrated to different counties, and who appeared in subsequent census years as white.

Table 3 Patented inventions by African Americans, selected, 1870–1940

Year	Patentee	Inventions	Location
1870	Harde Spears	Improvement in portable shields for infantry	Snow Hill, NC
1872	Elijah McCoy	Automatic lubricator cup	Ypsilanti, MI
1875	Alexander P. Ashbourne	Method of preparing coconut	Oakland, CA
1878	Benjamin H. Taylor	Improvement in rotary engine	Rosedale, MS
1881	Lewis H. Latimer	Carbon filaments for electric incandescent lamp	New York, NY
1883	Jan Ernst Matzeliger	Automatic method for lasting shoes	Lynn, MA
1884	Judy W. Reed	Dough kneader and roller	Washington, DC
1887	Alexander Miles	Elevator	Duluth, MN
1887	Granville T. Woods	Telephone system, electro-mechanical brake, railway telegraphy, third rail	Cincinnati, OH
1890	Frank J. Ferrell	Steam trap, apparatus for melting snow, valve	New York, NY
1894	George W. Murray	Fertilizer distributor, planter, cotton chopper	Sumter, SC
1897	Andrew Jackson Beard	"Jenny" coupler (for train operators), rotary engine	Eastlake, AL
1899	George F. Grant	Tapered golf tee	Boston, MA
1907	Clara C. Frye	Timing device	Tampa, FL
1908	Shelby J. Davidson	Paper-rewind mechanism for adding machines	Washington, DC
1909	Joseph Hunter Dickinson	Motor drive for phonographs, player piano	Larchmont, NY
1914	Oscar Robert Cassell	Flying machine, angle indicator	New York, NY
1915	Garrett A. Morgan	Gas mask, traffic light	Cleveland, OH
1918	Madeleine Turner	Fruit press	Oakland, CA
1919	Clarence Gregg	Machine gun	Pitt Bridge, TX
1924	Charles V. Richey	Spark plug, railway switch	New York, NY
1925	George Washington Carver	Process of producing paints and stains	Tuskegee, AL
1928	David Nelson Crosthwaith, Jr.	Method and apparatus for setting thermostats	Marshalltown, IA
1930	Richard E. S. Toomey	Airplane appliance to prevent ice formation	Miami, FL
1938	Lloyd Augustus Hall	Curing of meats and the like, sterilizing foodstuffs	Chicago, IL
1940	Percy L. Julian	Cortisone, recovery of sterols	Maywood, IL

Source Baker (1917), USPTO, EPO, Cook (2004). Year reported is for at least one of the inventions patented by the inventor. All patents obtained by inventors are not necessarily reported, and co-inventors are not reported

patent dominate the data set (unlike the U.S. data for this period), several prolific inventors would have had to die or retire simultaneously to account for such a large and sustained decline, but the data do not bear this out. Finally, the population of inventors is heterogeneous and extends beyond those who are highly skilled and in the sciences, particularly in the period before the early twentieth century when specialized skills became more useful. As a result, the data set likely underrepresents inventors with fewer or different skills. Upon inspection

Table 4 Baseline characteristics, 1870

	Black	White	Gap
Patents, per million	0.119	361.811	361.692
Labor force participation, by industry (share)			
Agriculture	0.624	0.521	−0.103
Transportation, communications, public utilities	0.087	0.082	−0.005
Non-durable manufacturing	0.026	0.047	0.021
Durable manufacturing	0.098	0.075	−0.023
Occupation (share)			
White Collar	0.027	0.163	0.136
Skilled Blue Collar	0.038	0.095	0.057
Semi-skilled Blue Collar	0.049	0.057	0.008
Service	0.042	0.015	−0.027
Unskilled non-farm laborer	0.223	0.081	−0.142
Farm operator	0.376	0.442	0.066
Farm laborer	0.231	0.415	0.184
Illiteracy (share)	0.787	0.155	0.683
School attendance, 10–14 (share)	0.153	0.713	0.560
Population by Region (share)			
Mid-Atlantic	0.071	0.250	0.179
Midwest	0.056	0.378	0.322
New England	0.006	0.103	0.097
South	0.865	0.213	−0.652
West	0.001	0.027	0.026

Source Cook (2004), black patents; USPTO, patents; Margo (1990), industry and occupation data; Gibson and Jung (2002), population; Ruggles et al. (2007), illiteracy; Collins and Margo (2003), school attendance. Industry data are for 1910; occupation data are for 1900. The gap is (white–black)

of related data, such as Sluby (2004), these potential problems appear to be minor and should not significantly affect results from estimation.

3 Estimation

This section assesses the economic impact of conflict and violence on innovative activity, as measured by patents. Specifically, it explores whether economic activity, namely the level of innovative output, changes in response to changes in hate-related violence, or whether the quality and direction of economic activity change in response to changes in property rights resulting from hate-related violence.

Table 4 reports values of variables typically associated with innovative activity at the beginning of the period to establish a baseline. Table 5 reports the means and standard deviations of variables for blacks and whites jointly and separately.[25] Much of the increase in productivity in the mid-nineteenth century occurred in the manufacturing and transporta-

[25] Other potential explanatory variables, such as wage differentials and quality of schooling, are also not available for the entire period or for all regions. Margo (1990) uses earnings data for blacks and whites from 1900 to 1940 in the South. State school-quality data as used in Card and Krueger (1992) are available from 1919. Rates of illiteracy are available throughout the period of interest and are included in the estimation. Other potential indicators, such as socioeconomic status, are highly correlated with race in the period 1870–1940 and would be dropped because of multicollinearity in estimation.

Table 5 Descriptive statistics

Aggregate data, annual, 1870–1940					State data, 1870–1940		
		Black	White	All			
Patents, per million	Mean	0.1560	425.1963	212.6761	Lynchings, per 100,000	Mean	0.2015
	SD	(0.1433)	(57.1635)	(217.0424)		SD	(1.1962)
	Year = 1882	0.1382	417.6903	208.9143			
	N	71	71	142	Patents	Mean	1.6332
Major riots	Mean	0.4930	0.4930	0.4930		SD	(1.3186)
	SD	(1.1817)	(1.1817)	(1.1775)			
	Year = 1882	0	0	0	Mechanical patents	Mean	0.5837
	N	71	71	142		SD	(0.8143)
Lynchings, per million	Mean	6.5884	0.3007	3.4446			
	SD	(3.9203)	(0.1710)	(4.1954)	Electrical patent	Mean	0.1744
	Year = 1882	6.9898	0.5599	3.7748		SD	(0.5198)
	N	59	59	118			
Lynchings, (BT) per million	Mean	5.8838	0.3821	3.1329	Assigned patent	Mean	0.6279
	SD	(4.0548)	(0.5026)	(3.9884)		SD	(1.0449)
	Year = 1882	5.7105	0.8526	3.2816			
	N	59	59	118	Southern patents	Mean	0.3884
Segregation laws (1)	Mean	4.0845	4.0845	4.0845		SD	(0.7605)
	SD	(3.1385)	(3.1385)	(3.1273)			
	Year = 1882	3	3	3	Illiteracy rate	Mean	0.2390
	N	71	71	142		SD	(0.1973)
Segregation laws (2)	Mean	2.6197	2.6197	2.6197			
	SD	(2.0309)	(2.0309)	(2.0237)	Industry Share, Blacks	Mean	0.1074
	Year = 1882	2	2	2		SD	(0.1307)
	N	71	71	142			
Illiteracy rate	Mean	0.4458	0.0860	0.2659	Multiple-patent inventor, share	Mean	0.3708
	SD	(0.2158)	(0.0376)	(0.2375)		SD	(0.4566)
	Year = 1882	0.6494	0.1200	0.3847			
	N	71	71	142			
U.S. population in the south, share	Mean	0.8478	0.2277	0.5378	Black population, share of total U.S. in state	Mean	0.0229
	SD	(0.0324)	(0.0086)	(0.3120)		SD	(0.0261)
	Year = 1882	0.8690	0.2230	0.5460			
	N	71	71	142			
					N		430
					Number of states		49

Source See data appendix. Aggregate data are annual. Lynching and Lynching (BT) data range from 1882 to 1940. State data are for black patents and grouped by state and year

tion sectors. According to Margo (1990), African Americans were represented in greater proportions in durable manufacturing and in transportation employment relative to whites, as was the case in agriculture. Illiteracy and school-attendance gaps were large, a fact that may have become more relevant when patenting began to require better education and more specialized skills in the early 1900s. Literacy improved (as measured in the data by illiteracy rates) between 1870 and 1940. In 1870, 68 % more African Americans were illiterate than whites, while in 1940, the gap was only 12 % (Ruggles et al. 2007). In general, patenting activity occurs in regions with relatively more robust economic activity and with significant urban populations.[26] Blacks were concentrated in rural areas and the South, which were the least productive areas for patented innovation. As Table 2 shows, however, three-quarters of black patent activity took place *outside* the South.

My analysis employs three different empirical strategies. First, with time-series data, I use state and federal practices promoting segregation and condoning violence as a natural experiment to estimate the effects of changes in hate-related violence on patenting outcomes.[27] Second, I account for regional heterogeneity by estimating the effects of increased violence on state-level data for African American inventors. Third, a placebo of white inventors is randomly drawn, and I examine the "counterfactual" effect on patenting among whites.

3.1 Difference-in-differences estimation

Did the difference in patent productivity between blacks and whites change over time? The first part of the estimation strategy uses the implementation of state and federal policy as a natural experiment to estimate the effects of racial conflict. We can use patent data to explore more precisely changes in patenting rates by race following acts of violence that would differentially affect inventors, if not all economic agents. That is, significant changes arise not as a result of violence per se but out of a sense that these hate-related acts could be carried out with impunity.

To capture the direct and indirect effects of hate-related acts, I include two specific years, 1900 and 1921, in which state and federal changes in policy would have increased the indirect effects of violence—that is, years in which policy changes would have signaled that local, rather than state or federal, legal remedies would be final. I include the year 1900 to capture the *Plessy v. Ferguson* decision, which was implemented with a lag. I include 1921 because this was the year of the Tulsa, Oklahoma, race riot, the largest race riot in American history, and the response to which signaled a major change in government policy.[28] This event was considered so grave and alarming that it was the first time the head of the NAACP, the nation's largest and oldest civil rights organization, appealed directly to and met the President of the

[26] This observation is consistent with the findings of economists who have examined the relation between innovation and expected profits and demand, e.g., Gilfillan (1930), Griliches (1957), Schmookler (1962, 1966), Sokoloff (1988), and Khan and Sokoloff (1993).

[27] In this paper, I use the term "natural experiment" in reference to the orthogonality of violent events to patenting, because traditional models of patent activity do not include measures related to violence. For example, seminal work by Griliches (1957) and related subsequent work relate patent activity to demand and R&D spending. Factors like violence and rule of law are not included in these traditional models. The term is also used interchangeably with "historical experiment."

[28] The year 1921 was also determined statistically to be the break year. The Chow F-statistic for the year 1921 was computed, and the Quandt Likelihood Ratio statistic, or maximal Chow statistic, was also computed to confirm that the maximum Chow F-statistic was selected from a range of potential break years 8 years before and after 1921, 1913–1929.

United States to request that the federal government intervene.[29] However, this appeal to the President was rebuffed, and there was no federal intervention. The Oklahoma Commission to Study the Tulsa Race Riot of 1921 roundly criticized responses to the riot: "Stand back and look at those deeds now. … In none did government prevent the deed. In none did government punish the deed" (Oklahoma Commission to Study the Tulsa Race Riot of 1921 2001, p. 20). The Tulsa riot of 1921 followed a rash of major (and smaller) race riots throughout the country in 1919.

According to the historical literature, before 1921 potential victims implicitly believed that, if implored, the federal government would act. The response to the Tulsa riot was considered a major policy shift in favor of nonintervention by federal and state governments. Accounts of the Tulsa riot suggest that many at the time believed that government failed at all levels, that this was a turning point in federal policy and national practice related to property-rights protection, and that the country was likely headed toward racial warfare.[30] Consistent with historical analysis and the sense of heightened national anxiety concerning racial conflict, a search of the terms "race riot" and "race war" in Google Books Search between 1880 and 1930 shows that these terms peaked in 1921.[31]

To begin statistical inference on the impact of hate-related violence on inventive activity, the basic equation follows Gilfillan (1930), Griliches (1957), Schmookler (1962, 1966), and Sokoloff (1988), all of whom find a relation between economic activity and innovation, and includes positive and negative correlates of innovation—industrial production and unemployment.[32] To this model I add the following conflict-related indicators:

$$\begin{aligned}\Delta\log(patents_{it}) = {} & \delta_1 + \beta_1\Delta\log(lynch_{it}) + \beta_2\Delta riot_t + \beta_3\Delta seglaw_t + \delta_2 race_i \\ & + \alpha_2 d1921_t + \alpha_3 race * d1921_t + \Delta z_{it}\gamma + \Delta u_{it}, \end{aligned} \quad (1)$$

where the observation $patents_{it}$ is total utility patents per capita applied for in year t and granted to individuals of race i; $lynch_{it}$ is lynchings per capita by race of victim in year t; $riot_t$ is number of major riots in year t; $seglaw_t$ is total new state segregation laws passed by year t or total new state and federal segregation laws related to education, housing, and public accommodations passed by year t; z_{it} is a vector of controls; and u_{it} is a stochastic error term.[33] The elements of z_{it} are year dummies for peaks and troughs of economic activity, a year dummy for the structural break that occurs in 1900 ("year $\geq$ 1899"), $unem_t$ is the Lebergott (1964) unemployment series in year t, and $indprod_t$ is the Miron–Romer index of industrial production in year t.[34] Aggregate and race-specific time effects are included

[29] *The Crisis* (1999). Given the significant carnage and damage from the riot, this is also only the second instance in which the NAACP sent an official from the organization to examine and report on events. See White (1921).

[30] See *New Republic* (1921) and *New York Times* (1921a, 1921b) for extended coverage the riot received.

[31] Data from Google Books Search/Ngram are from April 2012, when more than 20 million books had been scanned.

[32] In estimation, formal inclusion of specific determinants of the knowledge production function used by these and similar researchers will not be possible in this study. For example, Griliches (1957) and Kortum (1997) posit a relation between patenting and R&D expenditure. Many studying the modern era test this relation. Using R&D spending data would be outside the scope of this research, because the National Science Foundation did not collect such data until 1940, which is the last year of the period under review in this paper.

[33] In estimation, the Wilson Administration's segregation of the civil service in 1913 is considered a state law affecting Washington, DC, although its effects were likely more geographically extensive. It is the only federal law included among the segregation laws used in this analysis.

[34] Statistical identification of a structural break in 1900 (and in 1921 below) is the result of estimating time-specific effects across all years in the sample, including adjacent years. These breaks are the most significant in the period of study.

Table 6 Difference-in-differences regressions dependent variable: log patents per capita

Explanatory variable	Full	Whites	Blacks
Lynchings per capita, log	−0.342	0.136**	−0.908**
	(0.216)	(0.069)	(0.461)
Major riots	−0.085***	−0.021***	−0.132*
	(0.021)	(0.007)	(0.070)
Segregation laws (1)	0.013	−0.003	0.036
	(0.010)	(0.004)	(0.026)
Race	−0.141		
	(0.284)		
Year = 1921	0.172	−0.002	−0.538***
	(0.114)	(0.038)	(0.180)
Race × Year = 1921	−0.829***		
	(0.076)		
R^2	0.153	0.308	0.283
N	112	56	56
Year ≥ 1899	Yes	Yes	Yes
Additional controls	Yes	Yes	Yes

All models are estimated as pooled OLS models in first differences. Driscoll–Kraay standard errors are in parentheses in Column 1. Heteroscedasticity-robust standard errors are in parentheses in Columns 2 and 3. A linear control for the break year is included in each model. Additional controls for peak and trough years and economic activity, the Miron–Romer Industrial Production Index (log), are included in each model. The sample period is 1882–1940. See data appendix for variable descriptions. Coefficients marked with an asterisk (***) are significant at the 1 % level of significance, (**) at the 5 % level, and (*) at the 10 % level

in estimation. Because of persistence in the patent series, the basic model is estimated in first differences.[35] Table 6 reports the estimated effects from this estimation, along with Driscoll–Kraay standard errors.[36]

The overall effect of the year 1921 is mixed in these regressions, but the interaction for 1921 is negative and significant in the full sample.[37] Adjusting for other observables, annual patenting by African Americans was lower by a factor of 2.2 on average than for whites because of events in 1921. Coupled with the introduction of federal anti-lynching legislation in 1921, there was a heightened sense among African Americans that personal security and

[35] Zivot and Andrews (1992) and Perron (1989, 1990) tests are used to determine the presence of a unit root with a structural break and intercept (optimal lag lengths from minimized AIC scores). As Eq. (1) implies, all regressors should be first-differenced, as well. However, there are many zeroes in the segregation-law and riot series, and they are essentially count variables, which should not be differenced. I report estimated coefficients for these variables for the estimated level coefficients.

[36] I use the unemployment and industrial-production series alternately in estimation because of the high degree of correlation between them. Estimates obtained using each series are nearly identical, and only those using the industrial-production series are presented in Table 6. See Driscoll and Kraay (1998) for an explanation of Driscoll-Kraay standard errors.

[37] Given the inherent noisiness of historical data, the significance levels attained should be considered a strict lower bound on the true values in all regressions. We may expect a negative effect from the interaction of riots and lynchings on patenting by African Americans because of the magnified sense of insecurity among African Americans and because of the occasional close proximity of these two events (see Table 1). Although these results are not reported, I added the interaction term $riot_t * lynch_{it}$ to the models estimated, and reported results are robust to inclusion of this additional control.

other property-rights protections were being markedly eroded, and this was the basis upon which Secretary Johnson of the NAACP met President Harding. This suggests, like the *Plessy v. Ferguson*, U.S. Supreme Court. (1896) decision, that federal action or inaction with respect to hate-related violence may generate significant declines in security and economic activity, as measured by inventive activity.

From the pooled regression, I tested for differences between coefficients on lynching and riots for blacks and whites. The difference in coefficients is significant at the 0.01 level.[38] These differences are evident in results from estimation of the baseline regression in the black and white subsamples reported in Table 6. For whites, major riots are correlated with a decline in patenting of 2 % per year, and there is no correlation between the year 1921 and patenting activity.[39] For blacks, the estimated effect of the policy shift in 1921 is negative and significant. A 1 % increase in the growth rate of lynchings per capita is associated with 0.9 % lower growth rate in black patent activity, and major riots are associated with 13–14 % lower rate of growth in black patent activity.

Aggregate data in this instance may bias the coefficients on segregation laws toward zero. While laws instituting racial segregation are not significant, the structural break in the black patent series, foreshadowed by Fig. 1, may suggest otherwise. Implemented with a lag in nonsouthern states, *Plessy v. Ferguson* allowed states to adopt rules that would disrupt previously integrated economic ties and activities.[40] Nonsouthern states, including Illinois, Ohio, New Jersey, and New York where much of the inventive activity among blacks was taking place, adopted 145 new Jim Crow laws between 1896 and 1940, more than two and a half times the number passed by these states between 1870 and 1895. As I mentioned above, increasing formal race-based restrictions in the workplace and in everyday life may have limited blacks' access to patent agents and attorneys and to patent-related resources such as patent journals at public libraries. Therefore, inventors' ability to collaborate, register patents, conduct patent searches, and defend their patents against infringement would have become a binding constraint on patenting activity.[41] Other economic ties were broken, such as property

[38] Another approach for the baseline regression is to instrument for riots. I use three instruments that are correlated with riots and inventive activity but are uncorrelated with other regressors: the unemployment rate from Lebergott (1964), changes in industrial production from the Miron–Romer index of industrial production, and fraction of the population living in the South (see data appendix for descriptions of data used as instruments). Although the instruments are valid, they are weak, as were other instruments tried, such as weather patterns, and this approach does not change the fundamental results.

[39] In addition to the aforementioned Southern Railway example, deaths of whites, and other quantified ways in which whites were affected by riots, they were also affected in broader ways. The Tulsa Riot of 1921 was targeted at African Americans, but the declaration of martial law to quell the violence would have affected all residents of, workers in, and economic activity in the city. Many white families had black domestic servants, and, according to historical accounts, e.g., Ellsworth (2001), they were accosted to turn over black workers so they could be taken to detention centers like the other 6,000 arrested. From a more contemporary example, although the riots in Los Angeles in 1992 occurred mainly in predominantly black neighborhoods, the entire city was affected by the curfew, the reassignment of police officers to riot-related duty, the investigation of the police department, the negative national and international publicity brought to the city, and so on. Matheson and Baade (2004) estimate that the entire city of Los Angeles lost $3.8 billion in taxable sales and $125 million in direct sales tax revenue losses.

[40] Similar to *Brown v. Board of Education* in 1954, *Plessy* and other Supreme Court rulings are implemented with a lag as legislatures, courts, and other entities determine appropriate mechanisms for compliance. Barth (1968) and Shapiro (1971) contain rich discussions of Supreme Court decisions and their implementation.

[41] Fouché (2003) recounts in detail the deterioration of the professional inventive career of Shelby Davidson, an African American inventor and official in charge of technology design, maintenance, and procurement at the U.S. Postal Office Division in Washington, D.C. Like other African Americans in the Treasury and Post Office Departments, he was removed from his supervisory position following President Wilson's segregation

ownership and whites patronizing black-owned businesses.[42] This evidence supports the view that the aforementioned congressional apologies reflect the intuition of black inventors, and other economic agents of the time, that the federal government had been tacitly condoning race-related violence or actively promoting blockage of federal anti-lynching legislation and erosion of legal protection generally.[43] The implication of this finding in the patent data is that official legitimation of hate-related acts can permit their proliferation and produce long-term declines in inventive and economic activity.

When variation across states and technological category are exploited below, estimated coefficients related to Jim Crow laws not only have the predicted sign, they are significant.

3.2 State regressions

Do these results vary geographically? Variation in the institutions and opportunities related to patent activity and in patent activity itself, in the rule of law, and in violence was significant across regions between 1882 and 1940. Without state controls, parameter estimates may be biased, picking up the influence of omitted region variables that are not explicitly included. Another advantage of more refined data on state patents is that they may be evaluated along technological, geographic, and economic dimensions. Therefore, the second prong of the empirical strategy is to estimate a model using panel data containing state-level characteristics of patents (and inventors) that therefore allow me to account better for observed heterogeneity than if I were to rely on the aggregate data. I organize patent data by state-year and fit them to a random-effects model.[44]

In this model, $patents_{st}$ is the total number of utility patents granted to African American inventors in state s in year t. Applying random effects to Eq. (1) implies:

$$\begin{aligned} patents_{st} = {} & \beta_1 lynch_{st} + \beta_2 riot_{st} + \beta_3 seglaw_{st} + \beta_4 firms_{st} \\ & + \beta_5 illit_{st} + \beta_6 particip_{st} + z_{st}\gamma + \varepsilon_s + u_{st}, \end{aligned} \tag{2}$$

where ε_s is the state-specific error component of the composite error term.

of the civil service in 1913. He resigned from government service and inventive activity after this event (see pp. 173–176).

[42] Kusmer (1976) reports that, like those in many northern cities, nearly all black-owned firms in Cleveland lost their white clients. As seen in many industrial cities in the North adopting segregationist laws and practices, between 1890 and 1910, the percentage of black residents who owned property in Cleveland fell from 14.8 to 10.9 %. Kusmer also finds that, by 1930, the percentage of African Americans who were property owners in Cleveland had not recovered its 1890 level. Consistent with the evidence from patent data, Higgs (1982, 1984) and Margo (1984) also find patterns of rapid increases in black wealth, as measured by property ownership in southern states, from the 1880s to the mid-1890s and a marked decline beginning around 1896. Unlike black property accumulation during this period, which resumed rapid growth between 1900 and 1905, entrepreneurial and economic activity did not recover quickly. Because these white consumers were wealthier than the black consumers to whom black firms were newly confined and because access to white suppliers was now limited or eliminated altogether, many black-owned firms faced rising cost, falling revenue, and bankruptcy.

[43] Anti-lynching legislation, including the Dyer Anti-Lynching Bill of 1921, was introduced and passed several times in the House of Representatives but rejected by the Senate in the 1920s and 1930s.

[44] Selection of the random-effects estimator is based on Hausman and robust Hausman tests to compare the random- and fixed-effects estimators, as suggested in Hausman (1978), Wooldridge (2002), Baltagi (2008), Cameron and Trivedi (2005), and Greene (2011). From these tests, we fail to reject the null hypothesis that the preferred model is the random-effects model, which suggests that the differences in the random- and fixed-effects coefficients are systematic. The random-effects model is consistent and is the more efficient of the two, which is anticipated since the random-effects estimator uses information from both the within and between estimators, rather than just the within estimator like the fixed-effects estimator, and is consistent with the findings of Taylor (1980).

In Eq. (2), lynchings are per 100,000 residents in state s in year t. Additional covariates of patenting can be included in the state regressions: $illit_{st}$ is the illiteracy rate in state s in year t, and $particip_{st}$ is an average over state s and year t of the percentage of blacks represented in the industry with which patents are associated from Margo (1990). Instead of industrial production and unemployment, the number of firms per capita in state s in year t taken from the *Census of Manufactures* (1883, 1895, 1933, 1942) will approximate the level of economic activity in each state. Standard errors reported are clustered by state and year.[45] In this model, z_{st} contains a dummy for the region of the country in which state s is located, share of the total black population in the United States residing in state s in year t, year dummies for peaks and troughs of economic activity, and share of patents granted to prolific or "great" inventors in state s in year t.[46]

The findings employing state-level data and a random-effects specification reported in Table 8 generally support those estimated by pooled OLS models for lynchings.[47] The correlation remains significant between lynchings and patent activity in the black samples, but the size of the estimated coefficient is smaller. When controlling for state effects, the magnitude, direction, and significance of the estimated coefficients on riots and Jim Crow laws change. The riot estimates become larger, negative, and more significant. This is intuitive, given that state data allow for more precise measurement of the effects of subnational events. One additional riot in a given state in a given year would diminish the state total by an average of nearly half a patent or by 17 patents in a given year for all states. Being in a relatively more segregated state depresses the expected number of patents, but this relation is not significant. Lynchings and riots are associated with an average decline of −0.4 per state per year or 1,132 patents between 1882 and 1940, which is roughly equivalent to total patents granted in 1853 or 1854 in the United States.

These patterns precede large-scale black migration. To account for the rapid increase in black migration from the South that begins after 1917, the sample is split accordingly and reported in columns 5 (1882–1917) and 6 (1918–1940) of Table 7. The estimated effect of lynchings is larger in the second period, and the estimated effects of riots and segregation laws are smaller and not significantly different from zero in the post-1917 period.

Another question is, does hate-related violence covary with economic activity uniformly? These findings also reveal that the effect differs across economic, technological, and regional categories. Among the most economically important inventions at the time were patents assigned at issue, an approximate indication of early commercial viability and, to a lesser extent, mechanical and electrical patents.[48] As is reported in Table 8, overtly violent acts are negatively and significantly correlated with lower patent activity for assigned patents. For

[45] Tests of the panel data find no evidence of a unit root. Therefore, these data are in levels and not first-differenced. See Maddala and Wu (1999) for unit-root tests in panel data.

[46] The Mid-Atlantic region dummy is the one excluded in estimation. See data appendix for information on construction of the newspaper series. Because systematic data on schooling are not systematically available for the period and states of interest, I use illiteracy rates, which are correlated with schooling variables, in estimation. Illiteracy rates are available for census years only, and the illiteracy rate assigned a specific year is that of the closest census year. A patent is assigned an industry participation rate based on the technological category of the patent, and the value is determined by the closest year available to the grant year. I include a control for prolific inventors in estimation when data on assigned patents are used (Table 8).

[47] This finding is also robust to inclusion of the number of new black-owned banks and new black newspapers in state s and year t in estimation.

[48] Assignment of patent rights to a firm or individual at the time the patent is issued is the best available information on value in the patent data. Nonetheless, it is a crude measure of economic value, because patents could be assigned after the patent is granted and assignment could be a noisy indicator of an innovation's economic value.

Table 7 State regressions dependent variable: patents per state per year

Explanatory variables	(1)	(2)	(3)	(4)	(5)	(6)
Lynchings, per 100,000	−0.058***	−0.055***	−0.031*	−0.028*	−0.035**	−0.069**
	(0.022)	(0.020)	(0.017)	(0.016)	(0.017)	(0.031)
Major riots	−0.429***	−0.461***	−0.333***	−0.364***	−0.419***	0.017
	(0.077)	(0.111)	(0.056)	(0.074)	(0.149)	(0.295)
Segregation laws (1)	−0.100	−0.131	−0.053	−0.081	−0.037	−0.081
	(0.101)	(0.101)	(0.121)	(0.127)	(0.178)	(0.163)
Illiteracy rate	−0.105	−0.407	−1.284***	−1.526***	−2.028***	−4.053*
	(0.400)	(0.416)	(0.478)	(0.515)	(0.696)	(2.160)
Number of firms, per capita			182.054***	179.098***	166.454***	204.407*
			(45.812)	(45.177)	(58.878)	(122.791)
Industry participation rate		0.685		0.623	0.498	0.369
		(0.552)		(0.529)	(0.602)	(1.639)
N	430	428	425	423	276	147
Number of states	49	49	49	49	49	49
R^2	0.105	0.112	0.173	0.179	0.185	0.174
Region	Yes	Yes	Yes	Yes	Yes	Yes
Share African American in state	Yes	Yes	Yes	Yes	Yes	Yes
Peaks and troughs	Yes	Yes	Yes	Yes	Yes	Yes

All models are estimated as random-effects models using patents issued to African American inventors. Standard errors robust to clustering on state and year are in parentheses. Column 5 is estimated for the period 1882–1917. Column 6 is estimated for the years 1918–1940. Dummies for region and controls for average share of African Americans living in the state during the period of interest and for peak and trough years are included in each model. See data appendix for variable descriptions. Coefficients marked with an asterisk (***) are significant at the 1 % level of significance, (**) at the 5 % level, and (*) at the 10 % level

mechanical and electrical patents, the presence of latent violence, as proxied by segregation laws, is negative and depresses mechanical patents by 0.2 per state year, or 579 patents during the period.[49] Again, this finding related to segregation is intuitive, given the ease of mobility required for inventors to be productive.[50]

Further, the results suggest that violence-related factors are particularly important in the South. Similar to the case of mechanical and electrical patents, lynching and riots are negatively but not significantly correlated, but the threat of violence is more negatively and significantly correlated with patent outcomes in the South than in these other groups. This result is not surprising given that the threat of violence that made Jim Crow laws credible likely forged near-convergence between violent acts and latent violent acts, given the persistence and prevalence of hate-related violence in the South during this period.

[49] A broader indicator of economic activity may be patenting in the "miscellaneous" category, which includes widely varied patents and consists of 44 % of patents by African Americans during the period. Being in a high-lynching state depresses expected miscellaneous patent counts by 29–55 %. This result is significant at all levels of significance.

[50] The estimated coefficient on riots becomes positive and significant when controlling for firms per capita. Although it is not significant at conventional levels, it does suggest that states where manufacturing firms are more concentrated are also states in which mechanical patents and riots also occur.

Table 8 State regressions—assigned, technological category, region dependent variable: patents per state per year

Explanatory variables	Assigned	Mechanical	Electrical	Southern
	(1)	(2)	(3)	(4)
Lynchings, per 100,000	0.008	−0.023	−0.013	−0.012
	(0.019)	(0.017)	(0.009)	(0.013)
Major riots	−0.526*	0.167	−0.042	−0.123
	(0.290)	(0.121)	(0.120)	(0.108)
Segregation laws (1)	0.105	−0.214***	−0.042	−0.209***
	(0.084)	(0.080)	(0.036)	(0.063)
Illiteracy rate	−0.103	0.081	−0.364**	−0.172
	(0.293)	(0.385)	(0.159)	(0.140)
Industry participation rate	−0.005	−0.840***	−0.078	0.374
	(0.220)	(0.282)	(0.134)	(0.462)
Great inventor	0.788***			
	(0.165)			
N	428	428	428	428
Number of states	49	49	49	49
R^2	0.212	0.083	0.062	0.639
Region	Yes	Yes	Yes	Yes
Share African American in state	Yes	Yes	Yes	Yes
Peaks and troughs	Yes	Yes	Yes	Yes

All models are estimated as random-effects models using patents obtained by African American inventors. Standard errors robust to clustering on state and year are in parentheses. Dummies for region and controls for average share of African Americans living in the state over the period of interest and for peak and trough years are included in each model. See data appendix for variable descriptions. Coefficients marked with an asterisk (***) are significant at the 1 % level of significance, (**) at the 5 % level, and (*) at the 10 % level

3.3 Estimating the effect on productivity

What would productivity have been absent hate-related violence? I use state-level data to execute this counterfactual exercise. By collecting a random sample of patents of white inventors similar to those of African American inventors, I constructed a "placebo" study and compared the productivity of inventors subject to hate-related violence with that of inventors not (or less) subject to hate-related violence. Specifically, I draw a random sample of 714 patents by application year of patents by African American inventors from the USPTO database using Google Patents.[51] The inventors are similar in most respects, such as field of invention.

[51] There are no records of application dates for patents applied for between 1870 and 1873, which diminishes the useable sample size to 714 patents. In fact, two samples are drawn for white inventors. In the first sample, patents of white inventors are matched only by application year to allow variation in other dimensions, such as technology and state or region, which may be exploited in estimation. A second sample, which I do not use in estimation, is drawn by selecting matching patents on state, technology, and application year. The second sample cannot exploit the variation present in the first sample but, as I mentioned, is used to test whether the times between patent application and grant are similar between white and black inventors when controlling for these characteristics, which is what is found.

For this estimation, I organize and pool patent counts by state, and I fit a negative binomial model to the count data.[52] In this model, TP_s is the number of utility patents granted to individuals in state s which is the count variable. I assume that the number of utility patents that can occur follows a Poisson distribution. Moreover, the Poisson parameter is allowed to vary across states and is assumed to follow a gamma distribution. The number of utility patents granted to individuals in state s follows a negative binomial distribution:

$$\Pr(TP_s|L_s) = \frac{\Gamma(TP_s + \alpha^{-1})}{TP_s!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu_s}\right)^{\alpha^{-1}}\left(\frac{\mu^{-1}}{\alpha^{-1}+\mu_s}\right)^{TP_s}, \quad TP_s = 0, 1, 2, \ldots, 49, \tag{3}$$

where $\mu_s = \exp(\mathbf{L}_s\boldsymbol{\lambda})$, Γ is a gamma function, α is degree of dispersion, and L_s is the $(K \times S)$ matrix of conflict-related and other explanatory variables as in earlier state regressions.[53] The model in Eq. (3) is estimated in both samples. Table 9 reports results from the placebo-study regressions.

The marginal effect of lynchings is negative for both groups but both negative and significant in the African American regressions. Absent race-related violence, the most significant marginal effect is that derived from economic activity, as theory would predict. In sum, the placebo study suggests that differences between African American and white inventors are largely explained by hate-related violence rather than other factors. Given that estimated effects of black lynchings are biased toward zero because of underreporting, the evidence likely represents a lower bound on the size and significance of the relation between violence and economic activity.[54]

The empirical analysis shows the threat of violence or actual violence likely altered incentives and outcomes for black inventors. The story of Garrett Morgan, the inventor of the modern traffic light (1912) and gas mask (1914), and inductee into the Inventors Hall of Fame,

[52] The random-effects specification using panel data does not work in the placebo experiment. The Tuskegee data report lynchings of whites for each state between 1882 and 1968. Data by state and year are unavailable, and there is insufficient variation in average lynchings per year for estimation. The Ginzburg (1962) and Tolnay and Beck (1995) state data allowed me to minimize this problem in the black series. More important, measurement error was more pronounced for white than for black lynchings. For example, immigrants from Mexico, China, and other countries are recorded as "white" among victims of lynching. Carrigan and Webb (2003) find that mobs lynched nearly 600 Mexicans between 1848 and 1928, which would represent almost half of all white lynchings recorded in the Tuskegee data. The motives for these lynchings would be more heterogeneous than if they were in fact white Americans. Because detailed data were not available on white lynchings outside the South, there was no means of systematically separating whites from nonwhites in the white lynching data. To the extent data are available, they are incomplete with respect to ethnic and temporal coverage, such as the lynchings of people of Mexican origin in the United States from 1848 to 1928 examined in Carrigan and Webb (2003). Variation in lynchings by state-year cannot be exploited in the panel framework. However, these errors are less pronounced when data are aggregated by year or by state, and a negative binomial specification is used for both samples, given overdispersion in the white sample. Because of omitted variables and an overcount of actual white lynchings, the estimated coefficient on lynchings for whites will be biased upward in these (and all) regressions. Finally, measurement error is also problematic in the black sample, as lynchings, especially in northern states, are underreported, and this biases estimated coefficients on lynchings among blacks toward zero in all regressions.

[53] The notation follows Long and Freese (2006). Data on industry participation are not available for whites and are therefore excluded in these regressions

[54] These results are consistent with a second counterfactual exercise presented in Appendix III. In this case, parameter estimates from estimation of Eq. (3) in in the black subsample are used in the white (non-placebo) subsample. As can be seen in Fig. f4, patent output over the period 1882–1940 would have been significantly lower and more volatile for white inventors. This estimation does not fully account for preexisting differences between the two groups. Nonetheless, the results are suggestive that economic activity would be substantially higher and more stable absent hate-related violence.

Table 9 State regressions, African American and white control group inventors dependent variable: patents per state

Explanatory variables	*African American*					*White control group*				
	Patents	Assigned	Mechanical	Electrical	South	Patents	Assigned	Mechanical	Electrical	South
Lynchings per 100,000	−12.81846	−5.577573	−7.465934**	−2.669931**	−8.77348**	−11.63882	−58.15853	−161.1914	−5.390287	−3.699285
	(8.269)	(4.913)	(3.514)	(1.202)	(4.185)	(17.350)	(37.973)	(127.278)	(7.045)	(6.814)
Major riot	132.7069	24.46003	−20.0813	39.40848	86.5511	3.878847	17.40536	141.8573	−2.009391	−4.00433
	(176.072)	(93.858)	(61.069)	(24.662)	(77.554)	(50.164)	(20.712)	(119.103)	(5.108)	(4.086)
Segregation laws(2)	1.215058	0.1551016	0.6864781	0.4199321*	2.045711	2.027396*	0.630609	1.061468*	0.1083483	0.5946363
	(1.290)	(0.578)	(0.531)	(0.245)	(1.283)	(1.084)	(0.426)	(0.597)	(0.093)	(0.454)
Illiteracy rate	−20.47612	−14.24807	−5.506664	−12.38277**	33.091	−49.29367	−12.87619	−173.0689	14.46967	4.410311
	(19.283)	(10.235)	(9.132)	(5.943)	(25.116)	(83.810)	(44.933)	(115.121)	(12.888)	(10.195)
Number of firms, per capita	8965.896*	3072.871*	3778.652*	952.7724**	−1855.699	13274.24***	5464.214***	4893.168*	1158.459***	853.7271
	(4,570.042)	(1,579.991)	(2,148.172)	(466.993)	(1,935.968)	(4,200.694)	(2,011.452)	(2,494.508)	(444.848)	(705.906)
Wald	118.08	91.26	80.57	78.05	83.85	183.42	142.61	89.04	66.42	30.44
N	49	49	49	49	49	49	49	49	49	49
Region	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No

All models are estimated as negative binomial regression models using patents obtained by African American inventors and a random sample of patents obtained by white inventors in the same application years as those of African American inventors. There are 714 patents for each group of inventors. Data are for application years 1882–1940. Coefficients in each column are average marginal effects. Heteroscedasticity-robsut standard errors are in parentheses. Dummies for region are included, with the exception of the models estimated in the southern subsample. Coefficients marked with an asterisk (***) are significant at the 1 % level of significance, (**) at the 5 % level, and (*) at the 10 % level

offers an example of these transactions costs. In 1904, Springfield, Ohio, was one of the first cities north of the Mason–Dixon Line to record a lynching, which was the cause of a major riot (see Table 1). As lynching began to spread across northern states and personal insecurity increased, black groups formed to protect their neighborhoods, families, and property. Morgan joined one of these societies in Cleveland and purchased a gun (Fryer and Levitt 2007). The papers suggest that segregation laws and customs constrained Morgan's market opportunities (Cook 2012). Rather than he himself promoting the masks, advertisements for his gas (and fire-safety) helmets depicted white or racially ambiguous figures wearing the helmets. Further hiding his identity as a black inventor, when demonstrating his helmet across the country, he posed as a Native American chief, the "real" inventor of the mask, and claimed that Garrett Morgan was his assistant. After fire chiefs in southern cities learned his true identity, orders for his mask in the South fell precipitously.[55]

4 Alternative hypotheses and robustness

To check the robustness of the above results, I test whether participation in certain industries (being in the right place at the right time) and literacy explain observed economic outcomes.

4.1 Alternative hypothesis—"Right Place, Right Time"

At the time of the Second Industrial Revolution, invention-intensive firms such as AT&T and General Electric were increasingly internalizing their research activities.[56] Simultaneously, Margo (1990) finds that employment became more racially segregated between 1900 and 1950, particularly among skilled blue-collar workers and in manufacturing. Although his results are focused on the South, the evidence suggests that outside the South the labor market, through union rules, state legislation, federal legislation, or custom, was becoming more racially divided.

From this change in industrial organization, there are at least two outcomes of interest to this study. First, the move by firms to incorporate patentees into newly established research departments may have lifted the veil on anonymity, thus raising uncertainty and diminishing the incentive to patent for African Americans, who had worked through intermediaries in the past.[57] Second, even if we assume that black and white inventors had roughly equal access to scientific and invention-related resources, including apprenticeships, before this change, the gap between insider-inventors' and outsider-inventors' access to resources should have diverged significantly, particularly if externalities from industrial research groups are captured by the firm.

To test the employment hypothesis, I control for the share of employment in patent-intensive industries using (Margo (1990)) industry-participation variable. I matched this

[55] The case of Dr. Percy Julian, the developer of cortisone and the first African American to head a major industrial research laboratory (Glidden Industries), is more direct. Julian began his patenting career at the end of the 1930s. During his tenure at Glidden, his home in a predominantly white neighborhood in Oak Park, Illinois, was firebombed twice. Such violence was likely extraordinary in industrial research circles.

[56] See Mowery and Rosenberg (1998) for a comprehensive discussion of the development of R&D activities within firms during the twentieth century.

[57] Anecdotal and historical evidence suggest that several inventors were extended jobs as inventors in industrial laboratories as a result of phone interviews, such as Lloyd Hall, but were not allowed to take the positions once their race was known.

variable to the technological category of the patent in estimation. Industry participation is significantly different from zero in the regressions using mechanical patents. In general, the effect of black representation by industry on innovation is ambiguous.

4.2 Alternative hypotheses—literacy

Did the increasing requirement of specialized skills for patent activity at the end of the nineteenth and start of the twentieth centuries affect patent outcomes? If so, differences in literacy, education, and training might explain the "patent gap." I estimate that 79 % of blacks were illiterate in 1870. High illiteracy rates are related to low levels of schooling in the post-Civil War era, as is consistent with the findings of Card and Krueger (1992), who show a high but declining racial gap in school quality from 1915 and those of Collins and Margo (2003), who find significant but narrowing racial differences in literacy, school attendance, spending per pupil, and other education variables. If patenting activity were increasingly a function of tertiary education in the sciences, blacks would have been at a disadvantage, because it was not until the 1920s that blacks began earning PhDs in the sciences in earnest. Consistent with the historical literature on patenting, I find that illiteracy is negatively correlated with patent activity in more specialized fields—in the electrical regressions—and is increasingly negatively correlated with patenting over time (Table 8). Nonetheless, the effect of illiteracy is ambiguous across the category regressions. In sum, the evidence supports neither industry participation nor education as a significant determinant of patenting activity across models and subsamples.

Recent studies use micro evidence from experiments to find a relationship between violence and economic outcomes of interest and propose alternative mechanisms. Using experimental and administrative data from Afghanistan, Callen et al. (2012) found a relationship between violent trauma and risk preferences, a finding that could also apply to the United States at the turn of the twentieth century. Others have found similar relationships internationally (Becchetti et al. 2011; Voors et al. 2012; Bauer et al. 2011; Gilligan et al. 2011; Bertrand and Mullainathan 2004; Callen et al. 2012; Blattman 2009; Rohner et al. 2013). The direction of causality in these studies is also from violence to economic activity.

Another plausible mechanism arises from displacement. Inventive activity, which may require periods of concentrated, uninterrupted work and thought, would likely have been disrupted and fallen as a result of displacement. Likewise, social networks would be disrupted. Cook (2011), for example, finds that inventors, like researchers and other economic agents, were displaced by riots and segregation laws, which would lead to ruptured social networks. Likewise, using county-level census and other geographic data, Tolnay et al. (1996), Loewen (2005), and Jaspin (2007) identify displacement due to lynching and other violent acts. Recent work by Shafir and Mullainathan (2012) also points to an alternative mechanism— scarcity. Using data from a randomized experiment involving sugar-cane harvesters in India, Shafir and Mullainathan (2012) find that in periods of relative scarcity, or pre-harvest periods, harvesters perform worse on IQ and attention tests and have shorter time horizons than in post-harvest periods. Similarly, Wang et al. (2010) find that those making more difficult decisions involving more conflicting tradeoffs—personal security or livelihood in this instance—make decisions with worse outcomes than those making easier decisions, e.g., those without extraordinary threats to personal security. Both of these situations could apply to black innovators at the turn of the century.

4.3 Reverse causality

Can we entirely rule out causality that runs in the other direction? It should be acknowledged that earlier studies have found support for the direction of causality going from economic growth to violence, such as Miguel et al. (2004). Yet, the evidence from recent experiments is consistent with a direction of causality going from violence to economic outcomes. In the analysis in this paper, four empirical reasons suggest that violence causes changes in economic activity. First, the best evidence on the economic factors related to lynching is the empirical relation between cotton prices and lynching, an association that breaks down after 1905 and is valid for only a fraction of the period of interest. Specifically, several studies have looked at the causal relation between labor-market competition between blacks and whites and lynchings; Raper (1933), Hovland and Sears (1940), and Tolnay and Beck (1995) find an inverse relation between cotton prices, and therefore competition for jobs in agriculture, and black lynchings. This relation breaks down in the early twentieth century. Darity and Price (2003) examine the relation between racial stigma, or status as a former slave, and lynching activity. Their findings suggest that racial stigma is a relatively less important determinant of lynching activity than labor-market competition. Evidence on the determinants of lynchings after 1905 is inconclusive in this study as well.[58] Further, these causal factors are unrelated to traditional determinants of patenting activity.

Second, the violent or violence-related acts are not confined to economically depressed regions. To recall, 60 % of riots between 1900 and 1940 did not occur in the South—that is, they occurred in areas that were relatively less economically depressed than the South.

Third, in a systematic review of recorded motives for riots and lynchings, neither type of violent act had a direct economic motive. Contemporaneous newspaper reports (e.g., Ginzburg 1962/1988), case studies (e.g., Cecelski and Tyson 1998 on the Wilmington riots and Crowe (1968, 1969) on the Atlanta riot), and official government investigations, such as the *Final Report of the Oklahoma Commission to Study the Tulsa Race Riot of 1921* (2001), rarely cite economic motives for riots. Of the 27 major riots between 1870 and 1940, only two—in New Orleans in 1895 and in East St. Louis in 1917—were documented in the literature as having an economic motive. In the HAL lynching data set that includes offenses ostensibly leading to lynching, of 2,806 victims of all races listed, only 98 were lynched for offenses related to possible commercial factors, including two strikebreakers, two men suspected of being foreign workers, one brothel owner, one moonshine producer, and one horse thief (HAL 2004).[59]

Finally, I execute a Granger causality test on the riot variable, which is the best-measured violence variable. In the black sample I find that major riots Granger-cause patent activity,

[58] Other hypotheses related to the causes of lynching have been advanced and tested. Blalock (1967) argues that lynching of blacks was a response to rising political competition between blacks and whites. Inference is difficult, Tolnay et al. (1989) find, because parameter estimates in these models are sensitive to outliers and model misspecification, among other problems. Recently, research has focused on preservation of social norms as an explanation for lynching, e.g., Carden (2006, 2009), Feimster (2009), Markovitz (2004), and Wood (2011). Still other evidence suggests that the origins of lynching are economic. "Whitecapping," or the organized efforts of nightriders using violence to drive blacks from their land, was a common practice in the Deep South. See Holmes (1980), Whayne (1996), and Winbush (2003) for an elaboration of the practice of "whitecapping" and the "whitecapping" hypothesis.

[59] This sum includes 84 thefts and robberies, which may or may not have had an economic motive. These data were also reviewed, along with the data and literature on riots, for political motives. Only 0.4 % of lynchings and five of 27 riots during this period could be traced to an explicit and documented political motive, such as voting. Because lynchings were extralegal killings, it is difficult to know the underlying relation between offenses recorded and actual offenses.

whereas I cannot reject the null hypothesis that patent activity has no useful predictive content with respect to riots at the 10 % level of significance. Simultaneously, in the white sample I cannot reject the null hypotheses that patent activity has no useful predictive content with respect to major riots and that major riots have no useful predictive content with respect to patent activity. Results from the Granger causality test support our intuition that violent acts can predict patent outcomes and not vice versa.

To be sure, the correlation between the variables proxying for violence and the error term will not be zero. For example, the magnitude and full extent of informal segregation and deep psychological factors, such as degree of racial mistrust, are difficult to measure and cannot be included in estimation. Data on minor riots, which may be correlated with major riots and lynchings (and Jim Crow laws), are neither systematically reported nor available and also cannot be included in the regressions. However, the data, historical literature, and empirical tests suggest that the direction of causation from violence to economic activity is the one more consistent with the evidence available.

Finally, the quantitative measure of legal segregation—number of new segregation laws passed in a given year—will not fully capture the depth and scope of informal segregation, such as the extent of discriminatory informal customs and practices, the quality of legal enforcement, and laws overturned after 4 years. It is reasonable to assume that informal Jim Crow customs and practices for which there was significant political consensus became embedded in law; however, many such practices did not rise to this level of agreement but remained embedded in society. For example, Margo (1990) finds that southern apprenticeship and employment opportunities were considerably restricted by discrimination, though not necessarily by formal laws on the books, prior to 1950. As I mentioned above, customary segregation in the North and South led Garrett Morgan to dress as a Native American or hire a white person to demonstrate his gas mask to white audiences. The segregation variable can measure some, but not all, informal segregation.

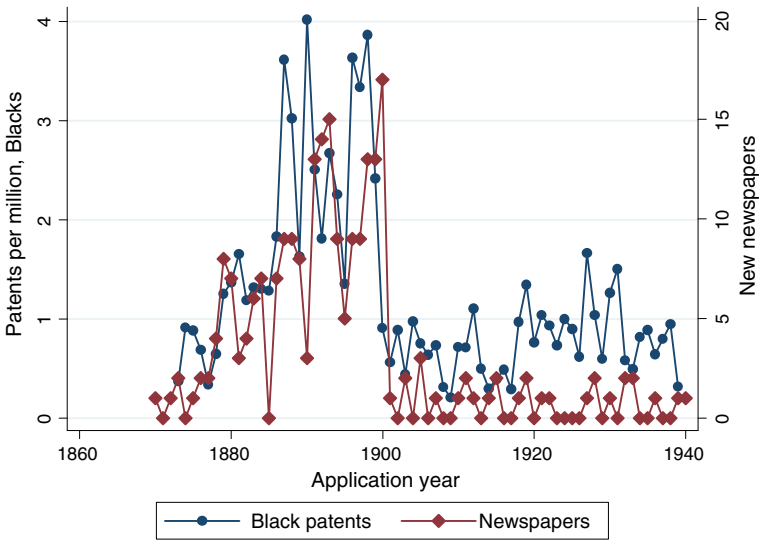

Fig. 3 African American newspapers and patents, 1870–1940. *Source* Author's calculations; see data appendix

4.4 A final observation

Are these results unique to patents? Some readers may suggest that the data and inventors are unique and the results difficult to generalize. However, the data are not special. The data I constructed on the establishment of black newspapers, for example, are quite similar to the patent data.[60] Newspapers have some of the same features of patents, including reliance on the protection of property rights. However, they differ in the sense that newspaper publication is an obviously public act, whereas patenting is not. Newspapers owned by or sympathetic to African Americans may attract attention from mobs and individuals, as would any retail firm or independent communications outlet. As Fig. 3 shows, these data follow largely the same pattern as the patent data. The series increases significantly up to 1899 and falls to a permanently lower rate of increase after 1900. This implies that the findings from the current study may be more generally applicable to productive activity.

5 Conclusion and future research

This research contributes to the literature on the economic effects of conflict and political instability. By using an historical experiment, I examine the effects of hate-related violence on innovation, and, by extension, real economic activity and living standards. This paper introduces and analyzes a new data set on patents obtained by African Americans between 1870 and 1940. The evidence from time-series and cross-section estimation suggests that hate-related violence, the reporting of which began nationally during this period, was by itself important. More important was the sense among African American inventors and other economic agents that hate-related violence would likely not be adjudicated and that the rule of law, typically through federal government intervention, would likely not prevail.

The increase in scope and intensity of hate-related violence in the late nineteenth and early twentieth centuries depressed patent activity among African Americans by 1 % per year, or the equivalent of a year's worth of African American patent activity. The gap between white and black patents per million was maximized in years of heightened violence, such as 1889 (536.7) and 1909 (547.1), and minimized in years of diminished violence, such as 1937 (341.5) and 1940 (357.1). In general, by 1936, the effect of conflict indicators on patenting by blacks falls as conflict itself wanes. This violence would have implied a decline of roughly 40 % in patenting and greater volatility in output among most U.S. inventors during that period. The most valuable patents—assigned, electrical, and mechanical—were sensitive to acts of hate-related violence and to laws promoting racial segregation. I tested alternative theories against my main hypothesis that hate-related violence reduced patent activity, but I find mixed or no support for these theories. Using patents as an example, the results suggest that changes in personal security and the rule of law can shift the scale, quality, and direction of technological progress and economic activity. This evidence is consistent with existing research on conflict and economic outcomes, particularly recent research from randomized experiments.

The import of this data set goes beyond patenting outcomes. A comparison to newspapers founded by African Americans implies that my results may reflect more general effects on economic activity. These findings would be particularly relevant for countries that are experiencing violence and ethnic conflict and are characterized by weak protection of property rights, but aspiring to catch up to rich countries in economic growth and development.

[60] See Data Appendix for a description of the construction of the newspaper series.

It is important to recognize the limitations of my argument and the data. Given data constraints, the decline in patenting activity with increased violence can be attributed to several factors. These include the direct effect of diminished personal security owing to riots, lynchings, and segregation laws as well as the indirect effect of mistrust of institutions that results from these acts. In addition, the direct effect of declines in property values owing to the lack of the rule of law (diminishing resources to finance innovation) can also influence patenting activity. The direct effect of informal (or formal but not legislated) segregation could also have an effect, particularly segregation that placed physical constraints on movement. This could serve to limit protection of intellectual property because of limited access to patent agents, attorneys, and information. More detailed data on individual characteristics of all inventors, such as property ownership, and on informal or more localized segregation would be required to disentangle these effects.

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Appendix I: Data

Data sources

Data on patents obtained by African Americans between 1870 and 1940 come from the author's data set, which extends the Baker (1913/1969, 1917, 1921) data set. Total patent data are from the U.S. Patent and Trademark Office database. Patents held by white inventors are derived by subtracting patents obtained by black inventors from the total. Data on lynchings by race of victim per year per state in southern states are from Beck and Tolnay (1995). Data on lynchings in other states are from the Tuskegee Institute data set and are averages for the period 1882 to 1930; annual data are not available by state. Data for blacks and whites after 1930 are from the Tuskegee data set. I find that the Tuskegee data underestimate lynchings among blacks and whites in nonsouthern states. Data from Ginzburg (1988) were added for blacks in nonsouthern states. Data on major riots and segregation laws are from the U.S. House of Representatives Select Committee (1979), Library of Congress (2004), Higgs (2007), "The History of Jim Crow" (www.jimcrowhistory.org), and the *Final Report of the Oklahoma Commission to Study the Tulsa Race Riot of 1921* (2001). Aggregate and state illiteracy data are extracted from Integrated Public Use Microdata Series (2004), approximately 50,000 individuals over 10 years old, and from the University of Virginia Library (2004), full sample, individuals over 10 years old. Data on aggregate illiteracy rates in 1890 are taken from Collins and Margo (2003). These data are derived from the population of 10- to 69-year-olds using the full count. Population data are extracted from Gibson and Jung (2002). Regions

do not conform exactly to census divisions: Delaware and Maryland are considered Mid-Atlantic states in this paper and are considered South Atlantic states by the U.S. Census Bureau. Data on black-owned banks are from Ammons (1996). Industry and occupation data are from Margo (1990). The industry-participation variable is available only for 1910 and 1940 and is only for the South. Patents obtained up to and including 1900 are assigned industry-segregation values for 1900, and patents obtained after 1900 are assigned values for 1910. Technological categories are taken from NBER-Hall et al. (2001). Economic peak and trough data are from the NBER Business Cycle Dating Committee (2007). As many years of abnormal economic activity are controlled for in estimation as possible. Data on unemployment rates are taken from Lebergott (1964) and are available from 1890 to 1940. Data on industrial production are taken from the Miron and Romer (1990) aggregate index of industrial production, which has 13 components. Data on African American newspapers founded in a given year were collected from the University of Georgia (2007), Harvard University (2007), and the Library of Congress (2007). Firm data for each state are collected from U.S. Census Bureau's *Census of Manufactures* (1883; 1895; 1933; 1942).

Variable definitions

Variable	Definition
Lynchings	Lynchings per million in a given year
Riots	Major riot in a given year
Segregation laws	Laws promoting segregation between races passed in a given year and not overturned within 3 years
Newspaper	Newspaper established for or by African Americans in a given year
Illiteracy rate	Person can neither read nor write; over 14 male population, by race
Bank	African American banks founded in state by a given year
Great inventor	Prolific inventor as defined in Cook (2011)
Population, south	Proportion of U.S. population living in the South, by race
Industry participation rate	Proportion of employment in given industry, southern blacks only, 1900
Industrial production	Miron–Romer index of industrial production
Unemployment	Annual national rate

Appendix II: Identifying African American Inventors in Patent Data

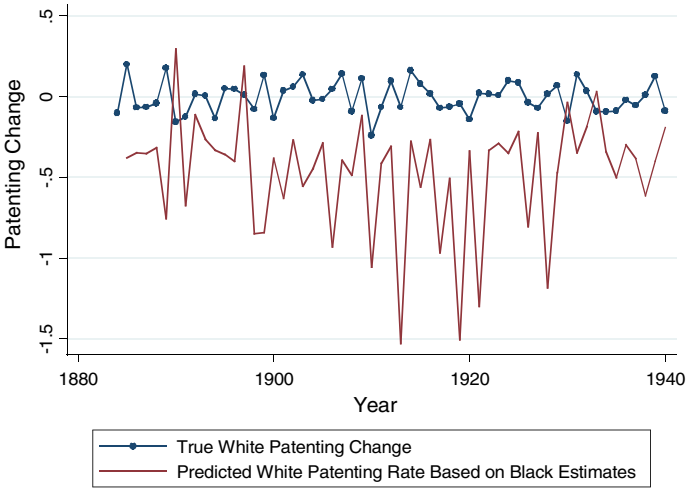
As I mentioned, it is very difficult to identify the race of a patentee because patent records did not record it, with only one exception since 1790. The first systematic attempt to identify African American patentees was an effort by the Patent Office, which undertook surveys in 1900 and 1913. The objective of the surveys was to locate African American patentees whose achievements would be featured in the 1900 Paris World's Fair and to commemorate

scientific achievements by African Americans in the 50 years following the end of the Civil War. Directed by one of the lead examiners, Henry E. Baker, surveys were sent to 9,000 of the approximately 12,000 patent attorneys and agents. Responses to the survey were collected and analyzed by Baker and published in several formats (Baker 1913/1969, 1917, 1921). A subset of the original responses were donated to Carter G. Woodson, a noted historian, and, in turn, donated by him to the Library of Congress. The Baker data extend from 1834 to 1917. The investigation in this paper required that the data be extended to 1940. A first strategy to extend the data set was to include patents obtained in 1913 and beyond by inventors already in the data set. These data were collected using the European Patent Office (EPO) search engine, which is searchable by name from 1920. Google Patent Search, which can also conduct historical searches, became available after 2004, when these data were originally collected. Google Patent Search misses some historical patents, and the EPO search is more reliable. One strategy for identifying additional black inventors would be to match patentees from USPTO data to Census data. This method should work for inventors who lived and patented in the same place. However, this procedure fails, because African Americans during this period did not patent where most African Americans live, as Table 2 shows. Before 1940, most African American inventors obtained patents in northern states rather than in southern states. Unlike today, specific addresses were not reported by the Patent Office, just the city or town in which the inventor resided or from which he or she applied for a patent. It is difficult to find a unique first- and last-name match using census data, because of the proximity of first and last names of African American inventors to those of other inventors, especially inventors of British origin. Eight patentees were identified as African American using this method. Only with significant additional biographical data does this method work, and these data are available for few inventors in the data set. And if additional biographical data were introduced, the selection problem would be of greater concern, because biographical information is available for only the most famous and prolific inventors. Another strategy would be to match common names given to African Americans to patent data. A three-pronged strategy in the spirit of Fryer and Levitt (2004) and Bertrand and Mullainathan (2004) was executed but was unsuccessful in identifying black patentees. This mechanism is described below. A second-best method would be to match known black inventors to names in the patent data. This method was significantly more successful in producing matches. The second method and its limitations are described in the text. An index of black names for the period 1870 to 1940 was constructed from census data in two ways. The first strategy answered the question: conditional on being black, which names are most likely to be observed? Random samples of black (“Negro”), “mulatto”, and “colored” heads of households from the 1870, 1900, and 1920 censuses were drawn for the District of Columbia, Georgia, Michigan, and New York. From these samples, frequencies were calculated for first and last names separately. There were 14 first names and 11 last names that appeared more frequently than the median frequency and were included in the index. The second strategy answered the question: conditional on observing a certain name, what is the likelihood that the person is black? First and last names of blacks (“Negroes”) and whites were extracted from the 5% IPUMS sample of the 1870 census. Unlike the above samples, names were not restricted to heads of households. From these samples, frequencies were calculated for first and last names separately and by race for names occurring at least 80 times. Among blacks, there were 27 first names and 20 last names that appeared more frequently than the median frequency for whites or were a larger share of the total names than the black share of the total population and were included in the index. A third approach was an extension of the second approach and answered the question: conditional on having a name widely adopted by African Americans following the end of slavery, what is the probability that the person is black? This strategy was intended to take

advantage of a well-known practice among African Americans of adopting the first and last names of presidents, e.g., George Washington, or famous people in the black community, e.g., Booker T. Washington, as first and middle names. The entire 1900 census was used and also was not restricted to heads of households. These approaches yielded largely similar results from which I constructed an index of "black names." Results were nearly identical with respect to surnames. Yet the composite index was unable to predict matches in the 1880 census sample of the 690 individuals identifying their occupation as "inventor." I was able to predict a small number of black inventors but, with the exception of George Washington Carver and George Washington Murray, not ones that could be matched to a patent. The index significantly underpredicted matches to black inventors and overpredicted matches to white inventors in New England, particularly those born in England, as was the case with the first census-based approach. Additional location and biographical data would have been required to obtain unique first- and last-name matches. In general, these methods are more suitable for the current rather than historical period. This highlights a problem associated with occupation identification and reporting among inventors. Many identify themselves as machinists or artisans or engineers rather than inventors, irrespective of race. Thomas Edison, among other "great inventors" who are alive and active as inventors, does not appear in the 1880 sample. The final strategy to extend the Baker data set was to construct a broad-based data set of African American inventors, i.e., potential patentees, and to match the resulting data to patent data. Among the historical and contemporary sources used to create a pool of potential patentees were searches of historical newspapers, including obituaries, e.g., from the Ohio Historical Society Newspaper online database and newspaperarchive.com; correspondence from Carter G. Woodson, Henry E. Baker, and patent survey participants (Library of Congress); the Garrett Morgan Papers; historical and contemporary directories of African American medical doctors, scientists, and engineers, e.g., academic journals, including the Journal of Economic History and the Journal of Negro History; historical and contemporary biographies of African American inventors and general biographies, e.g., Great Negroes Past and Present; and programs of exhibitors in the African American sections or exhibitions of historical fairs, including the "Exhibit of American Negroes" at the 1900 Paris World's Fair, the 1904 "Great Negro Fair" in Raleigh, North Carolina, and the 1933 Chicago World's Fair "Negro Day." Newspaper and obituary searches and programs of exhibitions allowed the identification of lesser known inventors. A complete list of sources appears in a companion paper. Not all inventors and others in the pool of potential patentees were matched to patent records and were dropped from the data set. Others were dropped if there was not a unique first- and last-name match, e.g., James Young in the patent data. Ultimately, while second best, this process provides a more systematic and less ad hoc means of recovering black patentees to extend the data set. This summary is adapted from Cook (2011).

Appendix III: Estimating the Effect on Productivity Using Black Parameters

Let us consider a second counterfactual exercise. How much lower would inventive activity in the U.S. have been if all inventors operated under violence-related conditions? We can address this question by taking parameter estimates from estimation of equation 3 in the black subsample and using them in the white subsample. As can be seen in Figure 4, patent output over the period 1882 to 1940 would have been nearly 1% per year, or 40% over the period, lower and would have displayed significantly more volatility for white inventors, who constitute the overwhelming majority of inventors at that time. Like Abadie and Gardeazabal (2003), I find that volatility seems to increase in the presence of greater violence. Of course,



Note: Figure 4 is estimated from Equation (1).

Fig. 4 Predicted White Patent Activity Using African American Estimates

the comparison using black parameters with the white sample should be interpreted with caution, because it not only reflects the evolution of violence but also pre-violence differences in determinants related to patent or economic activity. There is an imperfect mapping between technological progress and patent activity, and there are other factors that would change in the white subsample, e.g., illiteracy rates. Nonetheless, the results are suggestive that the rate of technical change in the U.S. may have been substantially lower in the absence of the rule of law affecting both races. Further, concomitant improvements in living standards may have increased much more slowly.

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