Economic Consequences of the U.S. Convict Labor System∗

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Abstract

I study the economic externalities of U.S. convict labor on local labor markets. Using newly collected panel data on U.S. prisons and convict-labor camps from 1886 to 1940, I show that competition from cheap prison-made goods led to higher unemployment, lower labor-force participation, and reduced wages (particularly for women) in counties that housed competing manufacturing industries. At the same time, affected industries had higher patenting rates. I use cross-sectional variation in capacities of prisons built before convict labor system was established for identification. I find that the introduction of convict labor accounts for 1 percentage point slower annual growth in U.S. manufacturing wages. It also induced technical changes and innovations: comparing county at 25th percentile of exposure to convict labor and 75th percentile, the more exposed one would have experience 8.4 more patents in competing industries annually. I also document that technological change in affected industries is capital-biased.

Keywords: Convict Labor, Labor Competition, Patenting, Technology Adoption

JEL Codes: J31, J47, J62, N31, N32, O14, O33


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1 Introduction

“... She had two fine mills, two lumber yards, a dozen mule teams and convict labor to operate the business at low cost.”
Margaret Mitchell, Gone with the Wind (1936)

Convict labor is still wide-spread, not only in developing countries but also among the world’s most developed countries. In 2005 U.S. convict-labor system employed nearly 1.4 million prisoners, among them 0.6 million worked in manufacturing (constituting 4.2% of total U.S. manufacturing employment). Prisoners work for such companies as Wal-Mart, AT&T, Victoria’s Secret, and Whole Foods, and their wages are substantially below the minimum wage, ranging from $0 to $4.90 per hour in state prisons.

Convict labor may impose externalities on local labor markets and firms. Prison-made goods are relatively cheap. Companies that hire free labor find it harder to compete with prisons, especially in industries that rely on low-skilled labor. They face lower demand on their products, pushing down their labor demand. Excess labor moves to industries not competing with prisons and overall wages decreased. Convict labor affects firms, too. Many (predominantly labor-intensive firms) go out of business, unable to compete with prison-made goods, even when they lower wages. Finally, consistent with the evidence in Holmes and Stevens (2014), and Bloom, Draca and Van Reenen (2016), those affected firms that do not close have to innovate and adopt new technology, either to decrease their production costs, or to produce higher-grade goods that do not compete with prison-made goods.

In this paper, I use a historical setting to evaluate the effect of competition with prison-made goods on firms and free workers. It is challenging to identify causal effects of convict labor in the contemporary setting, since the data on prison output are not available, and due to the embedded endogeneity problem. First, U.S. prisons are built in economically depressed counties under the assumption that they will provide jobs (e.g., guards) in the local labor market. Second, contemporary convict-labor legislation is endogenous. For these reasons I rely on the historical setting, to identify the effects of convict labor. I digitize a dataset on U.S. convict-labor camps and prisons. Starting in the 1870s, states enacted laws that allowed convict labor, consistent with the evidence in Holmes and Stevens (2014), and Bloom, Draca and Van Reenen (2016), those affected firms that do not close have to innovate and adopt new technology, either to decrease their production costs, or to produce higher-grade goods that do not compete with prison-made goods.

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but the timing varied from state to state. Its introduction was unanticipated, both by firms and by prison wardens, who were suddenly in charge of employing prisoners within their institutions. Moreover, as all convict-labor decisions were determined at the prison level, subsequent changes in convict-labor legislation were exogenous to the choices of individual prison wardens. In addition, I use the fact that pre-convict-labor-era prisons were built without any anticipation that they would be used to employ prisoners. In comparison with contemporary prisons, old prisons were built in populated areas with higher wages and employment, which hinders my ability to find negative effects on local labor markets. Finally, the historical setting allows me to document effects of convict labor in a developed country during almost 80 years time period.

To elicit the effect of prison-labor competition on the local labor market, I measure the exposure of each county to convict labor as the industry-specific value of convict-made goods in all U.S. prisons weighted by the county’s industry labor share and by the costs of trade between locations of those prisons and a county. This imposes two central assumptions: low labor mobility across counties, and iceberg costs of trade.

I use nation-wide introduction of convict labor in 1870-1886 to estimate the effect of exposure to convict labor on manufacturing wages and employment outcomes, using ordinary-least-squares specification in first-differences. While the first-differences specification allows me to account for time- and county-invariant unobserved heterogeneity, and pretreatment level and trend in dependent variables account for possible mean-reversal and trend-breaks, three endogeneity concerns remain. First, there is an omitted-variable bias due to the endogenous choice of industry and the amount of goods produced by prisons. Second, prisons could be strategically located to earn higher profits for their states. Third, convict labor was used in industries where local labor unions were stronger and the wage growth rate was higher (Hiller (1915)).

To address these concerns, I employ an instrumental variable estimation. I use capacity of prisons that existed before convict-labor laws were enacted to construct an instrument for the prevalence of convict labor. Old prisons were built without any anticipation that they would be used for production of goods; their locations were determined primarily by population size and urban share of population. Thus, conditional on factors important to the location of the old prisons, the interaction of convict-labor legislation and capacities of old prisons is likely uncorrelated with wardens’ activity and possible strategic location of prisons constructed after convict-labor systems were enacted. I find that the introduction of convict labor in 1870-1886 accounts for 1 percentage-point slower annual growth in manufacturing wages, 0.2 percentage-point smaller labor-force participation, and 0.6 percentage-point smaller manufacturing employment share. Comparing two counties, one at the 25th percentile and the other at the 75th percentile of exposure to convict labor, the more exposed county would on average experience a 2 percentage-point larger decline in mean log annual wages in manufacturing, a 0.9-percentage-point larger fall in manufacturing employment share, and a 0.6-percentage-point larger decline in labor-force participation.

5The size of the effects of convict labor shock is comparable to the effects of the “China shock” (Autor, Dorn and Hanson (2013)): it is half the effect of China shock in terms of labor-force participation, 1.5 times larger in terms of manufacturing employment share, and 2.5 times larger in terms of mean log wages in manufacturing.
While prison labor was used in quite a few industries, most prisons were producing clothes and shoes. Apparel and shoemaking industries employed mostly women, and they were the most affected by coerced labor. Female wages decreased 3.8 times more than those of men.

I also show that convict-labor shocks affected technology adoption. Comparing two counties, one at the 25th percentile and the other at the 75th percentile of exposure to convict labor, the more exposed county would be expected to experience a 8.4 more registered patents in industries where prisoners were employed, 8.4 more patents in competing industries annually, 31 percentage-points increase in capital-labor ratio, and 0.48 percentage-point increase in return-to-capital to returns-to-labor ratio annually.

Because forms of convict labor differed in the North and South, I analyze subsamples I show that results are mainly driven by the Northeastern and Midwestern states. For the Southern states, all coefficients remain significant, while the magnitudes of all effects are smaller.

I show that the results are robust to various model specifications and ways I construct the explanatory variable. Results hold if I use exposure to convict labor, weighted only by distance to prison (i.e., disregarding industry shares). I also demonstrate that results are not entirely driven by differences between counties with and without prisons: I find that results hold within the sample of counties with prisons. Then, comparing counties with prisons to counties adjacent to counties with prisons, and to second-order adjacent counties, I find that effects of convict labor decay with distance. Also, I find no effect on manufacturing outcomes when using as a placebo convict-labor output in farming. Further, I find no significant effect of convict labor on the number of patents in industries where prisoners were not employed. Finally, I employ firm-level repeated cross-section data for 1850-1880 from Atack and Bateman (1999) to show that firms in affected industries experienced larger decreases in wages. The firm-level data also suggest a decrease in the number of firms in affected labor-intensive industries.

My results relate to three broad economic literatures. I find that the problem of convict labor is similar to the discussion of low-skilled labor competition related to trade shocks (Topalova (2010), Kovak (2013), and Autor, Dorn and Hanson (2013, 2016)). I find that local labor-market shocks come not only from foreign competition or technological progress but can arise from internal sources. I find a significant effect of convict labor on both the county-industry level and the state-industry level. Also, like Holmes and Stevens (2014), I find that firms that relied on low-skilled, labor-intensive production suffered more than those that did not. Moreover, identification comes not only from timing and industrial composition variation but also from the spatial variation in prison locations.

Besides, my findings relate penitentiary policies to patterns of directed technological progress (Acemoglu (2002, 2007), Acemoglu and Finkelstein (2008), Lewis (2011), and Hanlon (2015)). Here

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6The North and the South differed both in terms of local institutions and industrial composition that resulted in adoption of different systems of convict labor (McKelvey (1936); Wilson (1933)).

7My findings also relates to the literature on the effects of in/out migration on local labor-market outcomes (Card (1990, 2001), Borjas (2003, 2015), Ottaviano and Peri (2012), and Clemens, Lewis and Postel (2017)), and the effects of technology shocks (Acemoglu and Restrepo (2017)) on local labor-market competition.
I show how competition with prison labor led to adoption of both new and existing technologies. I also show that direct technology change can happen not only due to changes in input factor demand (Acemoglu, 2002), but due to local-labor market shocks. Finally, my paper contributes to the discussion if price shocks due to import competition affect firms patenting and R&D decisions (Autor et al., 2016), and provide evidence in support of findings in Bloom, Draca and Van Reenen (2016) and Zhang (2018) that firms increase patenting as a way to survive competition.

This paper also contributes to the public policy literature related to penitentiary policies. New U.S. prisons are generally located in economically depressed regions under the assumption that they will provide jobs (e.g., guards) in the local labor market (Mattera and Khan, 2001). I find, that convict labor that would be used in those prisons may create nation-wide adverse shocks worsen economic outcomes, thus overshadowing any possible local positive effects. By providing evidence of adverse externalities that prison labor creates to free labor, I address discussion of mandatory work programs in contemporary prisons (Polinsky, 2017, and Zatz, 2008). While convict labor may reduce budgetary burden on state and federal governments (Lynch and Sabol, 2000), and help (or not) rehabilitation of prisoners and their future employment opportunities (Bushway et al., 2003; Gomez, Grau et al., 2017; MacKenzie et al., 1995), and Maguire, Flanagan and Thornberry (1988), working conditions of prisoners and their wages should be more comparable to those of free laborers (Haslam, 1994, Western and Beckett, 1999, and Zatz, 2009) to prevent unfair competition.

The literature on coercive institutions, summarized by (among others) Acemoglu and Wolitzky (2011) typically focuses on long-run effects. Here I contribute to the literature by first estimating short-run effects of convict labor. In this sense, my paper mirrors the concept of Markevich and Zhuravskaya (2017) and Nilsson (1994), who looked at the immediate effects of abolishing of slavery/serfdom on contemporaneous outcomes. The effect of coercive institutions is also related to previous studies that highlighted the importance of institutions and differences in the initial factor endowments in explaining the degree of inequality in wealth, human capital, and economic growth (Engerman and Sokoloff, 2002, 2005, and Fujiwara, Laudares and Caicedo, 2017).

The rest of the paper is organized as follows. Section 3 introduces the history of U.S. convict labor and describes the novel data. Section 2 provides records of its competition with free labor and

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8Previous studies (Aghion et al., 2016, Newell, Jaffe and Stavins, 1999, and Popp, 2002) used energy’ price shocks as a driver of energy-saving technological progress. Hanlon (2015) showed how British firms adjusted and evolved when the import of good-quality U.S. cotton stopped during the Civil War. My findings, however, span a longer time period than previous studies, and my identification comes from competition with prison labor rather than input-factor price shocks.

9However, existing evidences are mixed and suggest that prisons have either no effect or adverse (Genter, Hooks and Mosher, 2013; Hooks et al., 2010; McElligott, 2017, and Oppong et al., 2014) or positive effects on the local labor markets (Chirakijja, 2018).

10Sociologists and criminologists thoroughly studied convict labor in the 20th century, but only a few qualitative papers raised the topics of competition between prison-made goods and products created by free laborers (Wilson, 1933, McKelvey, 1934, and Roback, 1984).

11Dell (2010) and Lowes and Montero (2016) examined long-run adverse impacts of the forced labor on contemporary health and institutional outcomes in Peru and Bolivia, and in the Congo, respectively. Others (Acemoglu, Garcia-Jimeno and Robinson, 2012, Buggle and Nafiger, 2015, Nunn, 2008, and Kapelko, Markevich and Zhuravskaya, 2015) have studied the economic consequences of coercive institutions on later institutional development. Nunn and Wantchekon (2011) point out their effect on social capital, and trust in particular.
show motivating facts. Section 4 presents my identification strategy and estimation results. Section 5 assesses the possible impact of the contemporary U.S. convict-labor system and concludes.

2 Historical Background and Novel Data on U.S. Convict Labor

2.1 Emergence of the Convict Labor System

American penitentiary system appeared in the late XVIII century. In addition to rehabilitation through education and manual labor, prison labor was a source of income to offset states’ expenditures for corrections. Prisoners worked in quarries near prisons or were crafting goods for sale in solitary cells (Lewis (1922) pp. 68-70). Nevertheless, prisons operated with massive losses. Historians of the penitentiaries are unanimous about the reasons behind this failure (e.g., McKelvey (1936)). First and foremost was the prisoners’ lack of skill. Most were uneducated and lacked experience in manufacturing jobs. It took years to teach them a skill, and often by the time they learned it, they were already subject to release (Gildemeister (1978) p. 29). Thus quarrying or masonry were the most popular occupations for convicts before the Civil War. The second reason was the small number of prisoners: prison maintenance costs were low, and states did not have strong incentives to employ them.

This situation changed after the Civil War. The prison populations soared. In Ohio, New Jersey, and the Eastern Penitentiary of Pennsylvania, they tripled from 1856 to 1886, compared to population growth of 75.3%. More prisons were needed. In the wake of the Civil War, states had other budgetary problems that made them more eager to find ways for their penitentiaries to fund themselves (Wilson (1933)).

The problem with prisoners’ skills were solved by introduction of factory systems and mechanization. New types of industrialized machinery were replacing many of the manual skills needed to produce particular goods, making low-skilled labor more employable in some industries. And while unionization could protect such industries as coopers, hatters, molders, and shoemakers at the beginning, it couldn’t help against the introduction of prison labor. In particular, mechanization enabled prisons to teach convicts one particular task instead of the whole set of skills necessary to manufacture certain goods and made them perfect strikebreakers.

Then decrease in skill requirements for the prison labor and increase in the number of potential convict laborers pushed states to impose convict labor legislation. Convict labor started to actively spread after creation of the National Prison Association in 1870, and was introduced in almost all states by the end of the presidential term a of Rutherford B. Hayes (1877-1881) who was a big

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12 In 1818 a new type of penitentiary appeared in Auburn, New York, where prisoners were gathered during the day in a workshop and worked together (Gildemeister (1978) p. 16). By 1870, only eight prisons across the U.S. (all in New York) operated with a modest net profit (Department of Labor (1900)).

13 Prison data is from the prisons’ annual reports; population growth is based on changes between 1860 and 1890 from the decennial population census.

14 Moreover, due to slavery and specific “honor” cultural norms (Grosjean (2014)), by the end of the Civil War ex-Confederate states only had three prisons throughout their territory. Although, the one in Atlanta, Georgia was destroyed during the city siege.

sympathizer of convict labor (Wines, 1871)). While in 1870 out of 32,901 prisoners only around 3,500 were employed, by 1886, out of 64,349 prisoners 45,277 were engaged in productive labor (blue and red lines in Figure 1), 15,100 were engaged in prison duties, and only 3,972 were sick or idle. This created a dramatic increase in share or employed prisoners soaring from up to 76% (green bar). I provide detailed information about evolution of convict labor legislation in Section E.

Figure 1: Incarceration and usage of prison labor, 1840-1940

Note: Prisoners employed in prison duties are not counted as engaged in productive labor. Number and share of employed prisoners for 1860 and 1870 are the upper bounds, as there are no data on how many inmates actually worked, only the total prison population of the prisons that employed prisoners.

2.2 Novel Data on U.S. Convict Labor

The primary source of the data for this paper is a set of U.S. Department of Labor reports devoted to convict labor. As competition between convict labor and free labor was a widely discussed topic at the time, the Bureau of Labor decided to inspect all penitentiary facilities to determine the level of competition between goods produced under different convict labor systems and goods produced by free laborers. Approximately every ten years, the Department of Labor was issuing special reports devoted to convict labor, containing meticulously collected information about employed prisoners, and output of U.S. correctional facilities.

I collected and digitized seven reports for the following years: 1886, 1895, 1905, 1914, 1923, 1932, and 1940. Then, I matched all prisons and convict labor camps across years by name and

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16They stopped collecting the data after convict labor was abolished in 1941, and did not resume data collection after it was reestablished in 1979.
location and assigned a FIPS code and GPS coordinates for each one of them. Overall, the dataset contains 464 different locations with correctional facilities or convict labor camp.

The data were collected by Bureau of Labor employees who traveled directly to prisons and filled out the surveys according to the accounting books provided by prisons. Only the data for the 1895 report was obtained not in person but through the mail: prison wardens filled out the survey themselves and sent it to the Bureau of Labor. The data includes all prisons, houses of correction, and convict labor camps, as well as juvenile reformatories and industrial schools. For local county jails they are included only if they employed prisoners.

I assign industry two-digit SIC codes according to the 1987 SIC manual to every item produced in prison: the data does not contain industry codes but does include specific articles of produced goods (e.g., “cane-seating chairs” and “clothing, men, and boys”). Then, I sum up the item values to generate industry-level output values. All values in dollars throughout the paper are normalized to dollar value of 1880.

Convict labor was widespread across all the United States, with the majority of prisoners being employed in the North. Figure 2 demonstrates the distribution of U.S. prisons at its pick in 1932. The size of the red dots represents the total value of goods produced in those prisons: the most producing prisons were concentrating in the Northeast and Midwest. For completeness, Figure A2 shows locations of all prisons and labor camps in my dataset.

Figure 2: Prisons and labor camps in 1932

Source: Computed using the data from Department of Labor (1925).

In addition to geographic diversity, convict labor was also used in almost all industries. However, predominantly it was used in manufacturing, in particular, in production of shoes and clothes. For example, Figure 3 shows the distribution of convict labor by industry (2-digit SIC codes) in 1923. Almost 30% were concentrated in apparel industry, and 15% were employed in production textile
mill goods. By 1923 road construction became a sizable industry. For comparison, I also report industry shares for 1886 in Figure A3.

Figure 3: Convict labor by SIC 2-digit code (1923)

Convict Labor by Industry (SIC2), 1923

Source: Computed using the data from Department of Labor (1925).

These reports also contain information on legal systems of convict labor, sources of capital, detailed costs of prison labor, prisons’ contribution to states revenues, etc. While Southern convict labor was always at the spotlight (e.g., Blackmon (2009)) the bottom part of the iceberg – the convict labor inside prisons was mostly ignored. New data provide us with colorful picture of previously understudies 70 years of U.S. history that shaped contemporaneous economic outcomes and institutions, had long-lasting effects on racial discrimination in policing (Poyker (2018)), and likely shaped contemporaneous convict labor system; opening avenues for new research.

Other Data

For the identification purposes that I describe in Section 4 I construct a dataset of prison capacities (i.e. beds) existing before convict labor was imposed (in 1870). The 1870 census contains the complete directory of prisons. Most of the prison capacity data come from the North American Review (1866) and Wines (1871). For the rest of the prisons, the information is from the state-level official reports related to correctional facilities. If the actual number of inmates is used to measure prison capacities if it exceeds number of beds[^17] I also add GPS coordinates of each prison location.

The rest of the data that appears in this paper was used previously by other researchers; it is described in great detail in Appendix A.

[^17]: Data for actual number of prisoners come from Table XIX of Volume I, of the 1870 U.S. population census.
Selection into Having a Prison and Summary Statistics

Prison location is endogenous to local economic conditions, even disregarding the dimension of convict labor. To understand the sorts of selection bias that might plague an evaluation of the effect of convict labor, one must consider how geographic placement of prisons was determined. Historians (Lewis (1922); McKelvey (1936)) and contemporaneous sources (North American Review (1866)) list several criteria that were used to determine prison locations from 1850 to the 1930s: (i) proximity to large urban centers; (ii) proximity to a railroad or a navigable river; (iii) proximity of materials suitable for the construction of a prison. The high cost to transport prisoners and materials clearly influenced the location of prisons. Based on these criteria, it is reasonable to expect counties with prisons to have a higher urban share of population, and higher wages than other parts of the country.\textsuperscript{18}

Table A1 performs a balance test, by comparing counties with and without prisons in 1870 before convict labor was enacted. While the mean population and urban shares are higher for counties with prisons, they are not statistically different from counties without prisons, and two samples do not statistically differ in any covariate. Nevertheless, I choose to control on urban share, population, market access, and counties’ geographic features in all regressions.\textsuperscript{19}

3 Convict Labor in the United States: Motivating Facts

3.1 Factual Records on Competition between Convict Labor and Free Labor

One may think of convict labor as a labor supply shock. However, this would be only partially true. Only convict leasing allowed firms to freely employ prisoners, and the predominantly Southern convict leasing system only employed 20% of prisoners at its prime in 1886 (9,104 inmates), and only 3% in 1914 (1,431 inmates).

The majority of prisoners were employed within the walls of their prisons, and regular firms could not hire convicts directly.\textsuperscript{20} Prisons started to employ prisoners in low-skilled intensive industries and sell final (mostly) low-quality goods on the open market. Prices of prison-made goods were very low: “Our minimum price of bungalow aprons is about one-third higher than the prison-made goods. We can compete with them only because they do not produce enough to supply the market and then only by selling as close as possible to their price on a small margin of profit.” In most cases,

\textsuperscript{18} An example of such thinking by state legislators can be found in Wisconsin, Legislature (1850) (p. 132), where the location of Wisconsin’s first prison is discussed. After some discussion they chose to build it in the north-central woods, to use local timber, and because nearby rail access to the Great Lakes would help minimize the cost to transport convicts. Similar discussion took place in 1857 in Illinois, when the location for the Joliet Penitentiary was chosen. Illinois State Penitentiary (1857), p. 450).

\textsuperscript{19} In Appendix A I discuss robustness of my results to sample trimming based on two-stage procedure, where I first find important covariate through LASSO and then estimate propensity score and drop 15% of counties without prisons (control counties) that are least similar to counties with prisons (treated counties).

\textsuperscript{20} The exception to some extent was the contract system, as it allowed one (or few in rare cases) firms to employ prisoners within prisons premises. However, those firms were often connected to the prison warden either through collusion or they were affiliated to his relatives creating barrier to entry for anyone but few to hire cheap prison labor (Gildemeister (1978); McKelvey (1934)).
such unfair competition meant that firms using free labor had to “let them sell their products before we can [start to sell the same product themselves] begin,” a twine manufacturer from Minnesota noted. Thus, prison can be described as a “firm” producing goods on the open market with access to (limited by prison capacity) labor with a cost lower than cost of free labor and acting like competitive fringe.

Lower prices were possible mainly because prison labor was cheaper than free labor. Prisons either paid too little or nothing at all to the inmates. Using data on weekly incarceration expenses and wages of prisoners (where they earn them) employed in prisons in state $s$ operating in industry $i$ and wages of free workers in those industries and states, in Figure 4, I estimate the ratio of unit labor costs of convict labor to the wages of free laborers for all SIC two-digit codes where prisoners were employed. Among manufacturing SIC codes unit-labor costs vary from 8.5% in stone, clay & glass to 41% in primary metal industries. On average, prison labor was 19% of the costs of free labor.

Losing money, firms had to try to decrease the wages. Competition in final goods markets for certain industries increased and adversely affected labor demand in those industries. Displaced free laborers flew to other industries, pushing down the average wage on the local labor market. Thus the introduction of convict labor was an adverse-labor demand shock to local free workers.

Note: Computed by dividing weekly expenses per prisoner employed in industry $i$ on a weekly salary of free worker in industry $i$.

---

21 In some states prisoners were eligible for earlier release as a result of working records. In other states prisons were obligated to pay lump-sum payments equal to the accumulated wages of the inmates. However, in practice, prisoners were underpaid or received nothing at all (Department of Labor (1887, 1906, 1925)).

22 I also assume that incarceration rates did not have an effect on local labor supply. As convicts left their county of
While convict labor was used in almost all industries (for example, see shares of convict labor output by industry in 1886 and 1923 in Figure A3), Panel A of Figure 5 shows that it was concentrated in several industries. For example, it constituted 11% in furniture, 8.25 of fabricated metal products, and peaked 21.5% in transportation equipment (mostly because of production of carriages and wagons). But even if some it had a small share in some industry (e.g., 2.24% in apparel), it could constitute a significant share of a state’s industry. In Panel B of Figure 5, I show the share of value of clothes produced in corresponding state’s prisons to the value of clothes produced in that state by free labor: e.g., convicts in New Jersey State Prison in the city of Trenton produced clothes equal to 9.9% of total clothes output in New Jersey. In South Carolina prisoners produced 118.5% of the value of clothes produced by free laborers.

3.2 Preliminary Evidence of Effects on Free Labor

Industry matters

Competition with prison-made goods was a big deal at that time and Bureau of Labor was frequently investigating complaints on such malevolent competition. I use one of such cases investigated by the Industrial Commission on Prison Labor (Department of Labor (1900)) to show that the convict labor shock was an industry specific and deterorated with distance.

Coopers in Chicago were producing two types of barrels: “slack” and “tight.” The later required the highest mastery of the craft. It was not until the 1870s that technology and steam-powered
machinery revolutionized the craft in response to major new demands in meat-packing and oil. Meat-packing demands shifted toward lower quality and higher quantity with new processes and rapid market expansion. In 1882, Joliet State Prison started to produce slack low-skill-intensive meat barrels (IL BLS (1886)). Since prisoners could be contracted at less than one third the price of Chicago coopers, the operation (even conditional on lower productivity) became profitable. From 1885 to 1895, average annual wages for coopers dropped by 30%, from $613 to $432. At the same time, the salaries of coopers employed in the production of tight (beer) barrels (not competing with prison labor) decreased only by 8.6% (Panel A of Figure 6).

Figure 6: The Case of Chicago’s Coopers: Wages of Coopers Producing Meat and Beer Barrels

Panel A

Panel B

Note: Annual wages in 1895 dollars. Source: Department of Labor (1900), pp. 38-39.

To demonstrate that the effect of convict labor on wages was industry-specific, in Panels A and B of Figure 7, I plot exposure of each county to convict-made goods in fabricated metal products and lumber and wood products and changes in log wages in corresponding industries. We can see significant negative correlation: counties more affected by convict-made goods in their industries experienced slower wage growth (faster wage decline).

---

24 Of the 65 Chicago shops employing 686 coopers operating in 1880, 16 shops (235 coopers) had closed by 1885, and prices for various types of meat packages fall from 20% to 50%.

25 Here I use changes in wages from 1870 to 1880 as the county-industry data is not available starting from 1890. In Panel A (B) of Figure 4, I plot placebo exposure to prison-made goods in metal (wood product) industry and changes in wages in wood product (metal) industry and I find no significant correlation. Thus my measure of exposure to convict labor indeed captures industry-specific shocks to local-labor markets. For completeness, I present similar example with two other important for convict labor industries (leather goods and primary metals in Figure 5).
Distance-to-prison matters

Due to transportation costs the adverse effect on wages of coopers was smaller farther away from the prisons that produced those barrels. The Illinois prison depressed wages as far as Milwaukee to the north and Kansas City to the west. In Panel B of Figure 6, I plot wages of coopers in cities where prison-produced barrels were found by the investigators of the Industrial Commission on Prison Labor and distance from those cities to the Joliet State Prison. This is consistent with Fogel (1964), Rhode and Strumpf (2003), and Donaldson and Hornbeck (2016) who argue that transportation costs were large at that time.

Defining convict-labor shock

To conclude convict labor shock was not a pure industry shock similar to the setting of Autor, Dorn and Hanson (2013), neither it was entirely local. In Figure 8 I plot changes in log manufacturing wages between 1870 and 1900 on the vertical axis, and the Bartik measure on the horizontal axis. The solid red line represents the measure of the convict labor shock as the total value of prison-made goods in each industry weighted by county’s industry composition (pure Bartik measure). The slope is indeed negative. However, as we saw in the previous figure, both distance and industry matter. Thus I measure exposure of each county to prison-made goods by weighting the value of goods produced in each U.S. prison by cost of trade with counties where those prisons are located. The dashed red line shows the slope for the Bartik measure where I weight by distance to prisons instead of industry compositions. The slope of the line is steeper than for the measure with

\[^{26}\text{I assume, that the change was from zero-level in 1870 to the level of 1886, when the first data is available.}\]
industry weights. Thus the convict labor shock was local, and counties located closer to prisons were more affected than those located farther away. Finally, I construct Bartik measure by weighting both by industry and trade costs between a given county and all counties with prisons and plot the linear fit with the black solid line. Its slope is also negative, lying in between of other two measures, suggesting that both industry and distance (trade costs) were important for the convict labor shock.

Figure 8: Convict Labor and Changes in Manufacturing Wages

Note: Each cross is a county plotted against exposure to prison-made goods in 1886 weighted by industry labor share and trade costs. Black line: Bartik measure weighted by industry labor share and trade costs. Red line: Bartik measure weighted by industry labor share only. Red dashed line: Bartik measure weighted by trade costs only.

4 The Effect of Convict Labor on Wages and Firms: 
Introduction of Convict Labor in 1870-1886

4.1 Convict Labor and Local-Labor Outcomes

4.1.1 Empirical Specification

In this Section, I exploit the effect of introduction of convict labor in 1870-1886 on local-labor markets. I use a first differences specification:

$$\Delta y_{c,1880/1900} = \alpha + \gamma \Delta CL_{c,1870/1886} + \Pi \Delta X_{c,1870/1880} + \eta y_{c,1870} + \varepsilon_c,$$

(1)
where main dependent variable $\Delta y_{c,1880/1900}$ is the change in log manufacturing wages in county $c$ between 1880 and 1900. $y_{c,1870}$ is the pre-treatment level of the dependent variable: I use 1870 level, as level of 1880 is already influenced by the convict labor in 1880 and mechanically correlates with convict labor in 1886.

Main explanatory variable $\Delta CL_{c,1870/1886}$ is a change of exposure to convict labor from 1870 to 1886: as convict labor was virtually non-existing at 1870, the change ($\Delta CL_{c,1870/1886}$) is actually a level of exposure to convict labor in 1886 ($CL_{c,1886}$). I define two measures of exposure to convict labor to which I later refer to as “continuous” ($CL_{c,t}^{\text{continuous}}$) and “discrete” ($CL_{c,t}^{\text{discrete}}$). In the former, I allow all counties to be treated by convict labor; to measure effects on the local labor markets, I weigh the effects of each county with prison by the trade costs between it and a given county and by counties industrial composition:

$$CL_{c,1886}^{\text{continuous}} = \sum_{i \in I} \left( \lambda_{i,c} \times \sum_{k \in K} \frac{\ln(\text{Value of goods produced}_i,k,1886)}{\text{Trade costs}_{c,k}^{\sigma}} \right),$$  \hspace{1cm} (2)

where $K$ is the set of all counties with convict labor in 1886, $\text{Trade costs}_{c,k}$ is a cost of trade in 1870 between county $k$ (where prison-made goods are produced) and county’s $c$ centroid (in km), and $\lambda_{i,c}$ is a labor share of industry $i$ in county $c$ in 1870.\footnote{I assume linear decay of convict-labor treatment with cost of trade ($\sigma = 1$). Section 1 demonstration that results also hold if I use specification with only industry weights or only with trade-cost weights.}

In the discrete measure, only counties that had prisons are considered as treated:

$$CL_{c,1886}^{\text{discrete}} = \sum_{i \in I} \left( \lambda_{i,c} \times \ln(\text{Value of goods produces}_{i,c,1886}) \right),$$  \hspace{1cm} (3)

where $\text{Value of goods produces}_{i,c,1886}$ is the value of prison-made goods produced in county $c$ at year $t = 1886$, and $\lambda_{i,c}$ is the same. Thus this measure assign the value of zero to all non-treated counties (counties without convict labor). I use these two measures as the baseline measures.

$\Delta X_{c,1870/1880}$ is a matrix of changes in control variables that I describe later in the text.\footnote{To prevent post-treatment contamination, I use changes from time before convict labor was measured.}

\footnote{My choice of the years for the long-differences is dictated by the nature of historical data. First convict labor data exists for 1886, and was collected because the competition with prison-made goods already affected free labor. Thus I use 1880-1900 instead of 1870-1900 as a time period for dependent variable to insure that explanatory variable is not affected by reverse causality.}

\footnote{As a robustness check I report results with 1870 value shares, and with 1880 (labor and value) industry weighting (based on \cite{Atack1999} state-representative sample of manufacturing firms) in Appendix C.3.}

\footnote{I explore sensitivity of the results to other values of $\sigma$ in the Table A.5. Results are also robust to using distance (in km) between county $c$ and prison $p$ instead of the trade costs (see Table A.4).}

\footnote{Following \cite{Wooldridge2015}, I add the constant as a difference of the intercepts between decades; however, results are robust to specification without the constant. In Table A.13 I show that results hold if I allow each state to be on a different intercept.}

\begin{thebibliography}{99}

\end{thebibliography}
4.1.2 Standard Errors

As convict labor was subject to state-level legislation I cluster standard errors by state. The number of clusters (41 states) is slightly below the “rule of 42” (Angrist and Pischke (2008)) and I report wild bootstrapping (Cameron, Gelbach and Miller (2008)) p-values in Table A7.

The continuous measure of exposure to convict labor (equation 2) raise additional discussion of clustering standard errors. First, as counties, e.g., in NJ can be affected by prisons in NY (not subject to NJ’s convict-labor legislation) I also use robust standard errors without clustering by states. Second, I use spatial HAC errors to correct for spatial autocorrelation in panel data (Conley (1999, 2010)). Both resulting standard errors are always smaller or similar to those clustered by state, and I choose to report clustered-by-state standard errors as the most conservative (see Appendix C.4).

4.1.3 Identification

My main identifying assumption is that there are no other variables that are correlated with exposure to convict labor and have effects on manufacturing outcomes. This first-differences model cannot account for unobserved factors that vary by county and over time and are correlated with the prevalence of convict labor. For example, if a prison site was chosen in a place with cheap land with a decreasing wage trend, I will overestimate the effect of convict labor. Conversely, if prisons started to produce more goods in a location where wages tended to increase, I will underestimate the effect of convict labor. As discussed in the previous Section, convict labor mostly thrived in locations where wages were high, and wardens chose to produce those goods whose price was increasing, and/or if that industry’s unions were becoming stronger. This also would cause downward bias. Similarly, as prisons were more likely to be located in urban counties with higher population growth, wages tended to rise, and consequently I underestimate the effect of convict labor. To address these facts I control for changes in total population, and urban share, and average farm value. I also add controls for the changes in shares of African-American population to control for possible institutional omitted variables, correlated with convict labor and wages, and I add changes foreign-born population as proxies for the changes in crime rate.

An important source of the omitted variable can come from counties’ economies (e.g., county with large manufacturing sector relative to convict labor should be less affected by it), thus I add changes in values of manufacturing output.\footnote{I prefer to flexible control for the log of manufacturing on the right-hand side of the equation instead of using a share of log of prison-made goods out of the log of total manufacturing outcome in the discrete measure. However, weighting by costs-of-trade in my continuous measure may distort this relationship and in Table A8 I show that my results are robust to usage of the measure of exposure to convict labor similar to the one in Autor, Dorn and Hanson (2013): $\sum_{i\in I} \left( \frac{L_{e,i,t}}{L_{i,t}} \times \sum_{k\in K} \frac{\ln(\text{Value of goods produced}_{i,k,t})}{\text{Trade Cost}_{i,k}} \right) / L_{e,t}$, where convict labor shock is scaled by...}
There are two possible sources of measurement error bias. First, wardens often did not write down in their books all the output that the prisoners produced, or through collusion with the contractor artificially decreased the value of goods produced (Gildemeister 1978; McKelvey 1934, 1936). The second possible source is the cost of convict labor: in many cases prisoners were employing all their prisoners, while on paper some of them were idle, ill/handicapped, or working not full day. In addition, no one controlled the working hours of prisoners; thus, potentially, inmates could make more goods than were reported. Thus in addition to classical measurement error I may have upward bias due to under-reporting. However, it will cause only scaling upward bias and will not affect the significance of point-estimates. Moreover, assuming, that every warden reports only a quarter of the true value of prison-made goods the evaluation of the overall effect of convict labor (e.g., comparison of counties in 25th and 75th percentile of exposure to convict labor) won’t be affected.

Another endogeneity concern is related to the choice of industry by prisons. Hiller (1915); Gildemeister (1978) point out that wardens chose to employ prisoners in industries where unions were maintaining high wages, or, in some cases, because convict labor catalyzed unionization of local affected industries. This would cause a downward bias of my OLS estimates.

Overall, OLS estimates will be biased because of endogeneity in the amount of prison-made goods, and endogeneity in selection into building a prison when convict labor is already allowed. Thus concerns about omitted variable bias suggest that I will more likely underestimate the effect of convict labor on wages.

To deal with the embedded endogeneity problem, I use IV estimation. I use plausibly exogenous cross-sectional variation of the state prisons that existed in 1870 before convict labor was allowed (hereafter, old prisons). Old prisons were built without consideration of manufacturing goods for profit, and their locations can be considered exogenous, conditional on population and urban share. I assume that preexisting prisons are uncorrelated with the error term, are good predictors of the usage of convict labor, and do not directly affect wages in manufacturing.

The first stage of the 2SLS specification can be written as:

\[ CL_{c,1886} = \alpha + \gamma \text{Old Prisons}_{c,1870} + \Pi \Delta X_{c,1870/1880} + \eta y_{c,1870} + \epsilon_c. \]  

\( (4) \)

The second stage can be written as:

\[ \text{county’s } c \text{’s labor force } (L_{c,t}), \text{and share of county } c \text{ in U.S. employment in industry } i \left( \frac{L_{c,i,t}}{L_{i,t}} \right) \text{ at year } t = 1870. I \text{ do not use this measure as a baseline because I do not have county-industry level data starting from 1890 and I want my main explanatory variable in this Section to be similar to one in the panel specification in Section E.} \]
\[
\Delta y_{c,1880/1900} = \alpha + \gamma \hat{C}L_{c,1886} + \Pi \Delta X_{c,1870/1880} + \eta y_{c,1870} + \varepsilon_c,
\]

(5)

where the variable \( \text{Old Prisons}_{c,1870} \) measures exposure of each county by the \textit{old} prisons around it:

\[
\text{Old Prisons}_{c,1870} = \sum_{k \in K} \left( \frac{\ln(\text{Old prison capacity}_k)}{\text{Trade Cost}_{c,k}} \right),
\]

Old prison capacity equal to actual time-invariant \textit{old} prisons capacities in county \( k \).

To visualize the fact that counties that had more prison capacities before convict labor was imposed also had higher values of prison-made goods in 1886. I Panel A of Figure 9 shows that there are several old prisons that were closed by 1886, and quite a few new prisons opened; however, there is strong positive correlation between old prisons’ capacities and total value of prison-made goods in counties that did not close old prisons (“counties-compliers”). In Panel B, I present the first-stage residual plot: the relationship between the endogenous explanatory variable \( (CL_{c,1886}) \) and the instrument \( (\text{Old Prisons}_{c,1870}) \) are strong and linear. Reduced form results are presented in Table A6.

Figure 9: The First Stage: Correlation Between Total Value of Prison-Made Goods and the Capacities of Old Prisons, and the Residual Plot

Panel A contains only counties with prisons. Panel B contains added-variable plot from the regression specification in Column II of Table 1. Results of the first stage are available in the Table A6.

4.1.4 Results

Result for the continuous specification are presented in Panel A of Table 1. Columns I and II show OLS and 2SLS of regression of convict labor on changes in log manufacturing wages in 1880-1900. I only add controls for changes in log manufacturing output (to control for vulnerability

\(^{37}\)Here I also assume that \( \sigma = 1 \); however, results hold if I use \( \sigma = 0.5 \) and 2. I use prison capacities at 1870 instead of using prison capacities in a year just before the state has accepted convict labor legislation (e.g., 1881 for Indiana) in case prison could expand their capacities in expectation of new convict labor legislation (if they see nearby states adopted them early). Nevertheless, results hold if I use the latest prison capacities before the enactment of the convict labor legislation.
of the local manufacturing sector), and population and urban share (as main determinants of the location of old prisons). Both estimates are significant, and the IV estimate is, approximately, 45% larger than the OLS one, while the first-stage F-statistics of excluded instrument is around 83.7.

In Columns III and IV, I add controls, for the changes in shares of Black and foreign-born population (that may correlate with job opportunities and crime rates), average farm value (to control for the opportunity cost of working in agricultural sector). I also control for the county’s geographic coordinates (to control for the clusterization of certain industries in certain locations), and its area (to address the fact that more western counties have larger area). I also add a pre-treatment level of the dependent variable (log Wage in Manufacturing, \( \Delta \text{log Wage in Manufacturing}_{c,1870} \)) to address potential mean-reversion. Results remain significant, also coefficients slightly decrease in magnitude.

Table 1: Convict Labor and Labor Market Outcomes: Introduction of Convict Labor (1870-1886)

<table>
<thead>
<tr>
<th>Panel A</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
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<td>OLS</td>
<td>2SLS</td>
<td>OLS</td>
<td>2SLS</td>
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<td>OLS</td>
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Exposure to convict labor is normalized. All columns contain a constant and the following control variables (in changes, 1870-1880): log manufacturing output, log total population, and urban share. Additional controls include changes in share of Black, share of foreign-born, log value of farms, log county’s area, latitude, and longitude. Robust clustered by state standard errors are in parentheses. *** \( p < 0.01 \), ** \( p < 0.05 \), * \( p < 0.1 \)

The main identification assumption here is the absence of counterfactual trends that correlate with exposure to convict labor and labor-market outcomes. While it is not testable, I address the concern of the pre-trend in dependent variables in Columns V and VI, where I add pre-treatment
changes of the dependent variable included as control. Such very restrictive specification allows me to directly control for the pre-trend in the dependent variable. Inclusion of the pre-trends does not affect the significance of the coefficients of interest while slightly decreasing in magnitude point-estimates for wages and employment share in manufacturing. The difference between the county-level convict labor change in counties at the 25th and 75th percentiles is a 2 standard deviation.

Evaluated using the Column VI estimate, a county at the 25th percentile experienced an 6.8 percentage-point larger wage decline (or smaller wage increase) than a county at the 75th percentile in 20 years, or 0.34 percentage-point annually.

Finally, in Columns VII and VIII, I add controls for the changes in market access, and pre-treatment level of market access. Changes and the level of market access can be correlated with the growth rates of manufacturing wages and incarceration: areas experiencing higher increase in market access may have higher wage growth rates, and at the same time higher incarceration and crime rates (thus demanding more convict labor to finance growing penitentiary system). This would cause me underestimate the effect of convict labor. However, market access is accounted for in the explanatory variable and the instrument as it uses trade costs between county and location of all prisons, thus risking to make the first-stage less strong. Nevertheless, inclusion of these controls indeed decreases F-statistics falls to 17.2 it does not change significance or magnitude of the effect of convict labor.

The discrete specification yield similar results (Panel B of Table I). This specification also alleviates the concern that distances to prisons (and thus trade costs) correlate with manufacturing outcomes. While all OLS and 2SLS estimates remain significant all magnitudes experience slight decrease (comparing to corresponding columns in Panel A). The most plausible explanation for this effect is that the effect of competition with prison-made goods exceeded the boundary of a county, and thus in the discrete specification, I count partially treated counties (close to counties with prisons) as control counties. Thus the differences in wages between them is smaller, and I underestimate the effect of convict labor.

38Panel specification in the Section allows me to directly control for county-specific trends.
39It is equivalent to the specification in stacked difference. However, I cannot use the later as the levels of exposure to convict labor between 1850 and 1870 are approximately equal to zero.
40Approximately 16% of all counties are not treated, because they do not have industries in which prisons were producing goods.
41Alternatively, increase in market access can increase competition and have adverse effect on wage growth rate (Hornbeck and Rotemberg (2015), Xu (2013)), and increase in crime rates (as the opportunity cost of crime decreases). This would make me overestimate the effect of convict labor.
42Despite the fact that this specification is very restrictive, the first stage is strong enough. The Anderson-Rubin test’s p-value is 0.07. Partial R-squared is equal to 0.09, in comparison to 0.19 in Column VI. Both are high enough to show that instrument has explanatory power in the variable of interest but not high enough to be afraid that it is similar enough to it to suffer from the same endogeneity concerns.
43It is worth noticing, that in discrete specification, inclusion of the market access controls does not weaken the first stage, as the explanatory variable does not include trade costs.
Evidence from the Panel Data

To be sure that counties located closer to prison were more severely affected than those that are farther away, I use an event-study design. I run a regression of the log value of goods produced in 1886, on log wages in manufacturing, controlling only for decade, and state fixed effects and log manufacturing output. Resulting coefficients are presented in Figure 10. I present the result for the counties that had prisons with the blue line. The OLS coefficient becomes negative and significant as soon as convict labor laws was enacted, and the effect persisted afterwards.

Then I repeat the same regression, but I treat counties adjacent to counties with prison. Resulting coefficients are smaller in magnitude that those for counties with prison. Thus, the effect was smaller in nearby counties. Finally, I show that estimates become even smaller, when I use adjacent counties to counties that are adjacent to counties with prisons.

At the same time, treated counties did not experience any demographic/urban shock that could explain. In Table 11 I show absence of significant effect (and no difference between adjacent counties) of convict labor on population, urbanization and share of Black.

Figure 10: Convict Labor and Log Manufacturing Wages: Event Study

Each square is the coefficient of the event-study regression of the log wages in manufacturing on time-invariant log value of convict labor output in 1886 in a county, interacted with decade dummies. Relative time (in decades) is plotted on the horizontal axis, such as 1880 is counted as 0 – first decade when convict labor is imposed. Wages data for 1910 is not available. I omit dummy, but results are unaffected if I use other as the baseline. I use state, and decade fixed effects, and log manufacturing output in a county as controls. The dark blue line corresponds for regression where I treat counties that had convict labor in it as treated. The green line treats counties that are adjacent to counties that had prisons. The gray line assumes that counties that are adjacent to counties that adjacent to prisons as treated. Results hold if I double-count adjacent counties that are adjacent to more than one county with prison. 95% confidence intervals are depicted.

Figure 10 suggests, that the elasticity of the effect of convict labor on log manufacturing wages in 1880 in counties with prisons is equal to 0.02. I find similar results by using firm-level data.
spanning from 1850 to 1880 from Attack and Bateman (1999) I find elasticity of the effect of convict labor on wages of firms in the same county and industry equal to 0.014 (see Column IV of Table 12).

I explore county-decade panel nature of the data county-decade further in Section E. First benefit of this approach is that I can use not only exogenous introduction of convict labor, but also changes in intensity of competition with prison-made goods, and opening/closure of new prisons. Second, it also allows me to use federal legislation of 1936 restricting convict labor to estimate exogenous shock of decrease in competition with prison-made goods. Third, panel dataset allows me to account for time- and county-invariant unobserved heterogeneity and county-specific time trends. Forth, in comparison with specification in first-differences, here I use levels, and can estimate elasticity of effect of convict labor on wages.

However, this specification also requires additional identification assumptions when I employ an instrumental variable estimation. I use state-level variation in the timing of passage of convict-labor laws interacted with the capacity of prisons that existed before convict-labor laws were enacted to construct an instrument for the prevalence of convict labor. Prison production was determined by a prison’s warden, and the state-level legislature can be considered exogenous. Old prisons were built without any anticipation that they would be used for production of goods; their locations were determined primarily by population size and urban share of population. Thus, conditional on factors important to the location of the old prisons, the interaction of convict-labor legislation and capacities of old prisons is likely uncorrelated with wardens’ activity and possible strategic location of prisons constructed after convict-labor systems were enacted.

Results of these specification supporting my hypothesis: a county at the 25th percentile experienced an 1.26 percent larger manufacturing annual wage decrease (or 2 percent larger decline in mean log annual wages in manufacturing) than a county at the 75th percentile.

Other Local–Labor Market Outcomes

Similarly in Panel A of Table 2 report result for continuous and discrete specifications for changes in manufacturing employment share in 1880-1900. Evaluated using the Column II estimate, a county at the 25th percentile experienced an 5.6 percentage-point larger fall in manufacturing employment share than a county at the 75th percentile. Panel B show effect of convict labor on changes in labor-force participation. Using estimate from Column II, a county at the 25th percentile experienced an 2.4 percentage-point larger fall in labor-force participation than a county at the 75th percentile.

I do not find evidence that convict labor caused unemployment and decreased the labor-force participation rate in the panel specification (Table A25). One plausible explanation is that convict labor may have affected labor-force participation only at the time it was introduced and abolished (section 4.1.6).

44Based on IV estimate with continuous measure of convict labor from Column II of Table 10.
Exposure to convict labor is normalized. All columns contain a constant and the following control variables (in changes, 1870-1880): log manufacturing output, log total population, urban share, share of Black, share of foreign-born, log value of farms, market access, changes in log manufacturing wages in 1860-1870, level of log manufacturing wages (1870), level of log market access (1870), log county’s area, latitude, and longitude. Robust clustered by state standard errors are in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

### 4.1.5 Measuring the Effect of Convict Labor

To gauge the economic magnitude of these effects I compare the estimated reduction in wages and employment with the observed changes during 1880 to 1900. Here I make and assumption, that exposure to prison-made goods affected absolute level, and not just a relative level of manufacturing employment, wages, and labor-force participation across U.S. counties. Given the magnitude of the convict labor output (for each manufacturing worker with average annual wage of $242 (in dollars of 1880) there were at least $18 per worker of prison-made goods in 1886) it seems plausible that competition with prison-made goods had an absolute impact on U.S. manufacturing.

My IV specification in Panel A of Table [1] uses normalized explanatory variable, however for the purpose of evaluating the effect of the introduction of convict labor I use estimates from non-normalized explanatory variable. During the 1870-1886 the log of value of prison-made goods grew by 421.8. Applying this value to the non-normalized estimate for the continuous specification in Column VI of Table [1] (−0.00024), I calculate, that 20 years of exposure to convict labor decreased growth in manufacturing wages by 10.0 percentage-points, or 0.5 percentage-points per year. Wages in manufacturing were growing at that time 35.6% on average, thus in absence of convict labor, annual manufacturing wage growth would be 28% higher.

Similarly I calculate what would be the labor-force participation and manufacturing employment share without exposure to convict labor. Over 1880-1900s labor-force participation grew by 2.1 percentage-point, however, using coefficient from Columns IV (−0.018), I find that exposure to

---

45To make growth in value of prison-made goods comparable to my measure, I compute it as $\sum_{i} \sum_{k} \left( \ln \left( \text{value of goods produced}_{i,k} \right) \right) / (\text{mean trade costs} \times \# \text{industries})$. For comparison, the mean value of the explanatory variable is 450.8.

46While my results are robust to various specifications, I use the continuous one from Column VI of Table [1] as the baseline, as it contains the most conservative estimate of the effect of convict labor on manufacturing wages, and the strongest first-stage result.
convict labor caused differential decrease in labor-force participation by 0.2 percentage-point. Manufacturing employment share grew by 3.0 percentage-points, and using coefficient from Columns VI (-0.049) I calculate, that exposure to convict labor decreased growth in manufacturing employment share by 0.6 percentage-point. Thus without convict labor labor-force participation and manufacturing employment share would be 20.3% and 16.9% larger correspondingly.

4.1.6 Heterogeneous Effects of Convict Labor on Female-Labor-Market Outcomes

Convict Labor in Female-Labor-Intensive Industries

Firms affected by competition with prison labor were trying to decrease wages to keep up with the prison-made goods, and the well-being of low-skilled laborers deteriorated. The group that experienced the most intense competition was unskilled women. The number of female-labor-intensive industries was limited, and prisons were heavily involved in all of them (e.g., see Figure A3). The following quote (Department of Labor (1925), pp. 112-113) describes how the demand for low-skilled laborers was affected by this competition:

"We have been forced to go into higher line. One of the worst elements in the situation is the difficulty in training girls. When we had a large output of lower grade goods we put new hands on them. They could turn out the dresses rapidly, make better money and have enough showing in quality to hold their interest until they were expert enough to do the fancier garments. Now we cannot afford to produce enough of this class of merchandise for training purposes. Instead, men are being trained to do it in prisons. They can never use this training after their discharge as this kind of work is wholly monopolized by women. A new girl put on the higher grade stuff in the factory can not make more than one garment a day and then it is not well done and she is under severe nervous strain. The girls become discouraged and quit and we have it all over again. We have girls crying around here all the time because they can not handle the only work we have for them. ... We have closed one plant with 40 machines, employing 50 girls, where we produced only the cheap goods. It was closed two years ago and we do not expect to operate it again. Prison labor has shot this industry to pieces."

The garment and shoemaking industries were hammered the hardest by prison-made goods. The share of the value of prison-made products in these industries was around 45% percent in 1886 and reached 75% by 1940. Two reasons distinguish why those industries were overcome by convict labor: the relative simplicity of the production process and the relative weakness of women’s labor rights. Male laborers and their unions fought fiercely against employment of convicts in their industries (Gildemeister (1978)), but women could not fight back against prison labor in the same way. Thus

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47Another way to indicate significance of the introduction of convict labor is to compare its effects to those of China shock (Autor, Dorn and Hanson (2013)). Comparing two counties one at 25th percentile and the other at 75th percentile of exposure to convict labor, the more exposed county suffered 43% of the size of China shock in terms of labor-force participation, 1.5 times larger shock in terms of manufacturing employment share, and 2.5 times larger in terms of mean log wages in manufacturing.
over time prisons shifted their production toward less-protected female-labor-intensive industries. And later, as the state-use system came into vogue (again, due to anti-convict-labor campaigns), prisons could sell their goods only to state or federal agencies (e.g., the Army), which had a large demand for clothes.

Labor demand decreased in apparel and shoemaking industries decreased, but if men could move to another industry, there was often fewer alternatives for women.\(^{48}\) I expect that wages will decrease more for women than for men, because there were few industries were women could find a job, and in most of them they competed with prison-made goods. If we see a drop in labor-force participation after the introduction of convict labor, it should also be larger for women than for men.

**Effect of Convict Labor on Female Labor Market Outcomes**

I estimate ideologically the same specification as in Table 1; however, as data by gender is available only for 1890 and 1900 (from Haines (2004)), I use changes in log manufacturing wages from 1890 to 1900.\(^{49}\) Thus even if the convict labor shock is exogenous it is hard to argue absence of pre-trends or mean-reversal of dependent variable due to data limitations. Thus, I provide OLS results with strong suggestive correlation; however, as IV coefficients in the previous Section were larger than OLS (while statistically not different from each other), OLS should yield more conservative estimates.

As data on female wages is also available from the 1940 and 1950 population censuses I use another plausible exogenous shock of convict labor. Enactment of federal anti-convict labor legislation decreased the volume of prison-made goods and allows me to estimate the effect of the demise of convict labor on rebouncing of female and male wages. In 1936, two federal laws (the Ashurst-Summers and Walsh-Healey Public Contracts Acts, 1936) were enact to prohibit any interstate trade with prison-made goods and have any contracts with private contractors. While convict labor was abolished only in 1941 by President Roosevelt’s Circular 3591, most of the prisons produced significantly less goods for sale. Thus I use the fall in convict labor output between 1932 and 1940 (\(\Delta CL_{c,1932/1940}\)) due to the anti-convict labor legislature in 1936 on the changes in wages and labor-force participation between 1940 and 1950, as they should bounce back after distortion is removed.

Results for the continuous and discrete specifications are presented in Table 3. Each column

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\(^{48}\)In many cases the situation was exacerbated on account of minimum wage laws pertaining for women (Department of Labor (1925), p. 110): “Under our [Illinois] minimum wage laws we must pay a beginner $9 per week. She earns about $4 the first week. Instead of the $1 we figure for labor cost, her work cost us $1.50. It takes four weeks before she earns what she is paid and she never makes up the difference because she goes onto piece rates and is paid for what she does. The prison has no labor laws and under their contracts, the amount the contractor pays is reduced in proportion if the output does not measure up to the contract terms.” State-level minimum wage laws related to women, children and Black started to appeared in the earlier 20th century long before first federal-level minimum wage laws (Thies (1990)). Their effects on labor-force participation, and women-men and Black-White wage gaps is an important topic, that can be studied in the future.

\(^{49}\)Dependent variables for manufacturing employment and labor-force participation are constructed the same way as in Table 1. As they constructed using IPUMS, data for 1890 is not available there.
contain results of two separate regressions: one with outcome for females, and (shaded in gray) – for males. The table also contains p-values of the test if the differences between point-estimates for men and women are statistically significant.

Table 3: Heterogeneous Effects of Convict Labor on Female and Male Labor Market Outcomes

<table>
<thead>
<tr>
<th>Panel A</th>
<th>Introduction of Convict Labor (1870-1886)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Outcome:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convict Labor (Continuous)</td>
<td>Δ log Wage in Manufacturing</td>
<td>Δ Labor-Force Participation</td>
</tr>
<tr>
<td>Female</td>
<td>-0.119*** (0.028)</td>
<td>-0.005* (0.002)</td>
</tr>
<tr>
<td>Male</td>
<td>-0.031*** (0.007)</td>
<td>-0.009** (0.004)</td>
</tr>
<tr>
<td>Convict Labor (Discrete)</td>
<td>Female</td>
<td>-0.028*** (0.010)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>-0.011*** (0.002)</td>
</tr>
<tr>
<td>γ_Male-γ_Female=0, p-value</td>
<td>0.00</td>
<td>0.06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B</th>
<th>AS and WH Public Contracts Acts (1936)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Outcome:</td>
<td>Δ log Wage in Manufacturing</td>
<td>Δ Labor-Force Participation</td>
</tr>
<tr>
<td>Convict Labor (Continuous)</td>
<td>Female</td>
<td>0.088*** (0.021)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>0.044** (0.019)</td>
</tr>
<tr>
<td>Convict Labor (Discrete)</td>
<td>Female</td>
<td>0.010* (0.006)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>0.010* (0.005)</td>
</tr>
<tr>
<td>γ_Male-γ_Female=0, p-value</td>
<td>0.5292</td>
<td>0.4082</td>
</tr>
</tbody>
</table>

Both values of exposure to convict labor are normalized. Each row contains results from two different regressions: one for female outcomes, and one for outcomes of males. Coefficients in Panel B are multiplied by -1 to show the reduction in convict labor output. All columns contain OLS in first differences. All columns contain a constant. The following variables are used as controls (in changes): ln of total population, urban share, share of Black, share of women, share of foreign-born, ln of manufacturing output, ln of value of farm products, and log of market access (the change and the base level of 1870). Robust clustered by state standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

In Panel A, I study the shock of the introduction of convict labor. As expected, the relationship between wage changes and introduction of convict labor is negative. This implies that counties facing the largest increase in competition with prison-made goods experienced slower wage growth than counties facing smaller increase in exposure to convict labor. The estimate for women in Column I of -0.119 implies that a county facing a one standard deviation larger increase in exposure to convict labor experienced a 11.9 percentage-point larger female-manufacturing-wage decline (or smaller wage increase) relative to other counties. The difference between the county-level convict labor change in counties at the 25th and 75th percentiles was a 0.66 standard deviation. Evaluated using the Column I estimate, a county at the 25th percentile experienced an 7.4 percentage-point

27
larger wage decline (or smaller wage increase) than a county at the 75th percentile. The estimate for the manufacturing wages of men in Column I is 3.8 times smaller in magnitude than the one for women, and the difference is statistically significant at the 99% level. I found similar results for the discrete measure in Column II.

In Panel B, I show the growth of wages and labor-force shares after the enactment of anti-convict labor legislation in 1936. Estimates for the wage effect are comparable in magnitude; however, the effect of the anti-convict labor legislation is quite large. The difference between the county-level convict labor change in counties at the 25th and 75th percentiles was 0.70 standard deviations. Thus a county at the 75th percentile experienced a 0.70 standard deviation larger female (male) wage increase (or smaller wage decrease) than a county at the 25th percentile. I also find that a positive effect for the discrete measure in Column II. However, male-female estimates in both columns do not differ statistically from each other.

Columns III–IV of Panel A show adverse effect on labor-force participation of both men and women. One standard deviation in convict labor output decreased labor-force participation by 0.5 percentage-point for women, and 0.9 percentage-point for men, and the difference of the effect between genders is statistically significant. These effects are small: a county at the 5th percentile experienced a 0.3 (0.6) percentage-point larger female (male) labor-force participation decline (or smaller labor-force participation increase) than a county at the 75th percentile. Male-female differences between the continuous and discrete measures are statistically significant, however it suggest that labor-force participation for decreased more than women. This may partially explain the fact that wages of males experienced slower growth than wages of women: labor supply of men adjusted and pushed wages upward.

In comparison with the introduction of convict labor, the labor-force participation results for the period of its abolishment in Column III of Panel B are much larger. Evaluated using the Column I estimate, a county at the 75th percentile experienced an 1.3 (1.5) percentage-point larger female (male) labor-force participation growth in (or smaller labor-force participation decrease) than a county at the 25th percentile and the difference of the effect between genders is statistically insignificant. However, estimates are only significant for the continuous measure. As transportation costs decreased substantively by 1930-1940s, the discrete measure is less informative, as convict labor shock became rather nation-wide, than local competition.

In Columns V and VI of Panel A, I check if introduction of convict labor also affected employment share in manufacturing. One standard deviation in convict labor output decreased labor-force participation by 0.7 percentage-point for women, and 1.3 percentage-point for men. Evaluated using the Column V estimate, a county at the 25th percentile experienced an 0.7 percentage-point larger fall in women’s (men’s) manufacturing employment share than a county at the 75th percentile. However, I find no evidence of increase in manufacturing employment share after convict labor was abolished in Panel B.

Thus, competition with prison-made goods indeed had a larger effect on female wages, at least during the introduction of convict labor. This table also suggests that public forms of convict labor
were also deleterious to low-skilled workers. Because the legislation not only decimated private systems but also prohibited interstate trade of prison-made goods, prisons operated under the public-account system also decreased their output. Moreover, as convicts remained employed in the clothing industry under the state-use system, women’s wages did not fully adjust; thus in Panel B I don’t find a statistically significant difference in wage estimates.

Finally, Table A15 checks whether the effect of convict labor was driven only by Northern states. Each row contains estimates from a separate regression with continuous and discrete measures of convict labor. I present results for the changes in wages in Columns I-VI. The resulting coefficient is robust to the exclusion of Southern or Western states in Columns I-IV. However, in Panel A when we exclude Northern states, the estimate becomes insignificant for women but not for men. The coefficient for the continuous specification in Column VI, is negative and significant: while its magnitude is smaller than of the estimate on the full sample, it suggests that there was also a wage effect although less pronounced in the South (most of the clothes and shoes there were produced in South Carolina). In Panel B, however, the exclusion of Northern states led to the opposite situation. We see a significant increase in women’s wages following the decrease of convict labor in Column V and zero effect in Column VI. This result is in line with the fact that clothes and shoes became dominant industries for prisons. Columns VII-XII suggest that labor-force participation was indeed hindered by convict labor, but it was mostly a Northern thing.

4.2 Convict Labor and Technology Adoption

4.2.1 Factual Records

As competition with prison-made goods was tough, and despite the decrease in wages, firms could not employ free laborers for (near) zero wage. Some firms had to close, partially or entirely; some survived.

However, the prisons were producing low-quality goods and high-end markets were less affected. Thus firms could “innovate away” from the competition with prison-made goods. The first option was to switch to production of high-quality goods (“we are trying to meet the situation by producing a better garment that will command a higher price,” and “we have found it impossible to compete in price with prison-made stoves. Our only method is to produce a higher grade arti-

50Output of prison-made goods increased in the clothing industry under the state-use system from 1932 to 1940. This increase was most likely driven by the increase in military contracts, as WWII had already started.

51In addition, some manufacturers were arguing that states did not tax prisons, and often bought new equipment for the prison using taxpayers money, thus making competition to be unfair not only in terms of the cost of labor. For example, all binder twine machinery in IN, KS, MI, MN, MO, ND, OK, SD, and WI was bought by the governments of their states. Prisons were exempt from paying federal, state, county, and municipal taxes (Sharkey and Patterson (1933)). Moreover, “a prison plant pays freight, and it may pay insurance, but its books show no payment for interest, depreciation, or carrying charges. These costs exist, nevertheless, and become a burden to the taxpayers.”

52Quality was not only low in the clothing industry but also in industries that required standardized quality. For example, one of the largest free-labor manufacturers of twine in Minnesota noted: “The most popular twine is “Standard” twine which is supposed to run, and is labeled to run, 500 feet to the pound. The free-labor twine is made under laws that require it to fulfill its guarantee, but State owned and operated plant is not amenable to its own State and can not be made to live up to honest mercantile standards, and, in fact, in a great many cases does not.”
or buy higher-quality materials that require less labor input ("when poorer material or less trimming is used, more work is done"). The second option was to improve their technology to make it less labor-intensive and allow them to create the same type of good cheaper or with better quality ("we have to be constantly producing new styles and each new style makes additional expense").

Here, I show that counties more affected by the competition with prison-made goods have higher patenting in affected industries. They also have higher capital-labor ratio and higher return-from-capital to return-to-labor ratios. However, increase in capital-labor ration is not only driven by the technology adoption but by the changes in industrial composition (through death of labor-intensive firms). Finally, I demonstrate that firms in affected industries and locations improved their technological frontier (Caselli and Coleman (2006)).

4.2.2 Patenting

I start by replicating the baseline specification 1 from Section 4.1.1 and evaluate the effect of introduction of convict labor on patenting. The dependent variable is the difference between the number of registered patents in a decade of 1890–1900 and 1870–1880.

Table 4: Convict Labor and Patenting: Introduction of Convict Labor

<table>
<thead>
<tr>
<th>Outcome (1880-1900)</th>
<th>Δ Patents in Competing Industries</th>
<th>Δ Patents in Noncompeting Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Exposure to Convict Labor (continuous, 1886)</td>
<td>OLS 37.81**</td>
<td>80.28**</td>
</tr>
<tr>
<td></td>
<td>2SLS</td>
<td>(15.24)</td>
</tr>
<tr>
<td>Exposure to Convict Labor (discrete, 1886)</td>
<td>OLS 32.39***</td>
<td>82.70**</td>
</tr>
<tr>
<td></td>
<td>2SLS</td>
<td>(11.92)</td>
</tr>
<tr>
<td>First-stage instrument's coefficient</td>
<td>0.049***</td>
<td>0.047***</td>
</tr>
<tr>
<td>(0.004)</td>
<td>(0.008)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.950</td>
<td>0.95</td>
</tr>
<tr>
<td>F-stat excl. inst.</td>
<td>160.8</td>
<td>33.0</td>
</tr>
<tr>
<td>Observations</td>
<td>1,603</td>
<td>1,603</td>
</tr>
</tbody>
</table>

Exposure to convict labor is normalized. All columns contain a constant. The following variables are used as controls (in changes): ln of total population, urban share, share of Black, share of women, share of foreign-born, ln of manufacturing output, ln of value of farm products, log of number of slaves in 1860 (level), and log of market access (the change and the base level of 1870). All columns have corresponding lagged outcome variable (level) as a control. Robust clustered by state standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Results are presented in Table 4. Columns I–IV estimate the effect of convict labor on patenting in affected industries. Columns I and II contain OLS and IV coefficients for continuous measure of convict labor: both are positive and significant. Using coefficient from Column II and comparing county at 25th percentile of exposure to convict labor and 75th percentile, the more exposed one would have experience 8.4 more patents in competing industries annually. I show results for the

---

53 In addition to the set of controls from the Table I, I also control for the changes in capital and number of manufacturing firms, and with changes in farm output, as some patents are related to agricultural implements.

54 The dependent variable measures differences between the number of patents registered from 1890 to 1900, and from 1870 to 1880. I use differences between the number of accumulated in 10 years patents because some counties have very few patents registered annually. Due to this reason I also use the number of patents instead of log; however, my results hold if I use change in logs of patents.
discrete measure of convict labor in Columns III and IV, but they yield very similar results. In Columns V–VIII I show results for falsification test, where I estimate the effect of convict labor on patents in industries that did not employ prisoners: all resulting coefficients are negative and insignificant, supporting the hypothesis that patenting was a reaction on competition with prison-made goods.

4.2.3 Technology Adoption and Changes in Industrial Composition

County-Level Data

I also show supporting evidence for my findings related to changes in industry composition in Table 5. In Columns I-IV, I find that exposure to convict labor increased average capital-labor ratio. Comparing county at 25th percentile of exposure to convict labor and 75th percentile and using estimate from Column II, the more exposed county would have experience an increase in capital-labor ratio equal to 31.0% of its standard deviation (in 1870). These results are in line with historical records, quoted above, suggesting that convict labor mostly affected firms that were producing low-quality goods, which could be replaced by low-skilled laborers with the help of necessary machinery, while firms producing higher grade goods were less likely to suffer (like the Amish shops in Holmes and Stevens 2014).

Table 5: Convict Labor and Technology Adoption: Introduction of Convict Labor

<table>
<thead>
<tr>
<th>Outcome (1880-1900)</th>
<th>Δ Capital-Labor Ratio</th>
<th>Δ (r/w)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Exposure to Convict Labor (continuous, 1886)</td>
<td>28.89**</td>
<td>100.52*</td>
</tr>
<tr>
<td></td>
<td>(13.412)</td>
<td>(52.898)</td>
</tr>
<tr>
<td>Exposure to Convict Labor (discrete, 1886)</td>
<td>31.43**</td>
<td>38.07*</td>
</tr>
<tr>
<td></td>
<td>(12.09)</td>
<td>(20.00)</td>
</tr>
<tr>
<td>First-stage instrument's coefficient</td>
<td>0.078***</td>
<td>0.207***</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.041</td>
<td>0.03</td>
</tr>
<tr>
<td>F-stat excl. inst.</td>
<td>66.5</td>
<td>47.0</td>
</tr>
<tr>
<td>Observations</td>
<td>1,603</td>
<td>1,603</td>
</tr>
</tbody>
</table>

Exposure to convict labor is normalized. All columns contain a constant. The following variables are used as controls (in changes): ln of total population, urban share, share of Black, share of women, share of foreign-born, ln of manufacturing output, ln of value of farm products, log of number of slaves in 1860 (level), and log of market access (the change and the base level of 1870). All columns have corresponding lagged outcome variable (level) as a control. Robust clustered by state standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

The increase in capital-labor ratio also indicates possible directed technological change, as return to capital become larger relative to return to labor. In vein of Acemoğlu (2002), and Acemoğlu and Autor (2011) (who studied return to skills/college premium), in Columns V–VIII, I show that counties more exposed to competition with prison-made goods had higher return to capital than returns to labor because they could not compete with prisons in terms of labor costs. Using the IV coefficient and comparing county at 25th percentile of exposure to convict labor and 75th percentile,
the more exposed one would have experience a 0.48 percentage-point increase in return-to-capital to returns-to-labor ratio annually.

Benchmarking these results I find, that introduction of convict labor resulted in 6% higher growth rates in patents in industries that competed with convict labor, and 9.8% higher increase in capital-labor ratio.

Evidence From the Firm-Level Data

My findings suggest that convict labor boosted technology adoption by forcing firms to invent or adopt new technologies that could make them more competitive. In Table 8 I try to unveil the mechanism behind the increase in capital-labor ratio by using firm-level data. I aggregate firm-level data on industry-state-decade level in order to be see the effect of convict labor on industries and consider the following specification:

$$y_{i,s,t} = \alpha_s + \beta_t + \xi_i + \gamma CL_{i,s,t} + \Pi X_{i,s,t} + t\delta_s + \varepsilon_{i,s,t}.$$ (6)

Unit observation is the firm industry $i$ in state $s$ at decade $t$, and $y_{i,s,t}$ is a dependent variable. As I know the industry in which firm is operating, I can use discrete measure of convict labor in industry $i$ in state $s$ at decade $t$ as treatment. I double-cluster standard errors on state and industry level (Cameron, Gelbach and Miller (2006)).

In Column I-III, I present OLS results of regression of exposure to convict labor on share of firms of industry $i$ in state $s$ on the total number of firms in state $s$. Column I reports specification with industry, state and decade fixed effects. One percent increase in convict labor output decreases number of firms in that industry by 0.7%. In Columns II and III I add industry-year fixed effects, and state-specific trends, respectively. The magnitude of the coefficients increase and remain significant. It suggests, that firms in affected industries run out of business. Columns IV-VI contain similar specification. The dependent variable is the average capital per firm in industry $i$ in state $s$. I find, that 1% increase in convict labor output is associated with (at least) $720 increase in average capital. At the same time, I also observe increase in capital-labor ratio (Columns VII-IX). These findings suggest, that capital labor increased not only because firms in affected industries shifted to better machinery to compete with prison labor, but also because more labor-intensive firms died out thus changing industrial compositions in their states and counties.

Thus, I find that convict labor increased aggregate county-level capital-labor ratio. Firms started to buy better machinery to produce higher-grade goods: “we have put in every modern machinery and process that we know of to produce our goods at a minimum cost” (Department of Labor (1925), pp. 111-113). Possible explanation behind counter-intuitive result (from a 2-factor model perspective) that convict labor mostly affected firms that were producing low-quality goods, which could be replaced by low-skilled laborers with the help of necessary machinery, while firms producing higher grade goods were less likely to suffer (e.g., the Amish shops in Holmes and Stevens (2014)).

\textsuperscript{55}Clustering by industry or state yield similar or smaller standard errors, and I do not report them.
High-labor intensive firms in affected industries did not survive. Moreover, because surviving firms had to switch their production line to better quality goods, that compete less with prison products, I expect them to be more capital-intensive, or substitute their low-skilled laborers with capital.\footnote{The latter also indicates possible directed technological change, as return to capital become larger relative to return to labor. In vein of \cite{Acemoglu2002}, and \cite{AcemogluAutor2011} return to skills/college premium, in Panel A of Figure \cite{figure8} I show that counties more exposed to competition with prison-made goods had higher return to capital. Finally, following \cite{Hanlon2015} I show, that those counties also had larger number of registered patents in industries in which convicts used to be employed in 1886. Thus convict labor boosted technology adoption by forcing firms to invent or adopt new technologies that could make them more competitive.}

4.2.4 Shifting Technological Frontier

Another way to address the increase in patenting and shift to more capital-intensive technologies is to use methodology developed in \cite{CaselliColeman2006}. They assume that there is a trade-off between technologies favoring productivity of capital and productivity of labor, and that the same output can be achieved by choosing various combinations of both values. The output is maximized if chosen productivity of labor and capital are on the technological frontier — the “budget constraint” for firms’ productivity choice set.

Using authors’ methodology, I document that firms located in counties affected by competition (in the same industry) with prison-made goods invested in technologies associated with the increase in productivity of capital, and disinvested in the technologies that improve productivity of labor. At the same time firms located far from the competition with prison-made goods (or firms in non-affected industries) did not experience much changes. I provide an example in Figure \cite{figure11}. On the left side I depict the technological frontier for metallurgic firms in 1870 located in areas that were subject to high competition with prison-made goods in 1886. On the horizontal axis I depict log of productivity of labor, and log of capital productivity is plotted on the vertical axis. Clearly, after convict labor was enacted, affected firms shift to more capital-intensive technologies. Moreover, the technological frontier of affected firms moved slightly upward. On the right side I show firms in metallurgy industry that were not affected by the competition. Their capital and labor productivity did not change much from 1870 to 1880, and, if so, the technological frontier moved inward.\footnote{More detailed description of Caselli and Coleman’s (2006) model and its implementation in my setting is presented in Appendix \cite{AppendixD}. I provide results for other industries in Figures \cite{figureA9} and \cite{figureA10}.}

Overall, the technology-adoptation hypothesis is confirmed: counties more exposed to competition from prison-made goods either adopt existing technologies or contribute to new technologies, resulting in substitution of labor with capital.
Figure 11: Technological Frontier in Metallurgy: Affected vs. Not Affected Firms

Panel A: Affected by Convict Labor
Panel B: Not Affected by Convict Labor
5 Discussion of the Contemporary U.S. Convict Labor System and Concluding Remarks

Convict labor has always been controversial topic riven with acrimony. New England settlers wanted to remedy the supposed moral failures of criminals by forcing them to perform hard labor, and today its proponents argue that in-prison labor creates skills needed the after-release employment and saves the state money. However, while the debate about whether convict labor is the best way to rehabilitate inmates is ongoing, externalities of convict labor have never been thoroughly studied.

In this paper, I show that coercive institutions that appeared in the United States after the Civil War affected the economic welfare of free laborers. I document that convict labor decreased wages in manufacturing, especially for women. At the same time, it hastened technology adoption and capital investments that allowed firms competing with prisons to thrive.

Troubling the private use of convict labor was allowed again in 1979. Convict labor benefits specific interest groups and institutions in the federal and state prison systems, as well as private prison companies. Federal Prison Industries, a U.S. government corporation operating under the federal Bureau of Prisons (BOP) (with prison population of approximately 192,000) pays inmates roughly $0.90 an hour to produce a wide range of everyday products, from mattresses and spectacles, to road signs and body armor for other government agencies, earning $500 million in sales in fiscal 2016. Meanwhile, state prison systems and private prisons often contract out prison labor to private manufacturing (e.g., inmates in North Carolina made lingerie for Victoria’s Secret in the 1990s, and until 2016, prisoners in Colorado made goat cheese and raised tilapia for Whole Food’s).

The current expansion of private prisons is heavily debated in the public space. The morning after Donald Trump was elected President, the share price of controversial private prison operator CoreCivic (Corrections Corporation of America) jumped 34%, while GEO Group stocks rose by 18% (Quartz (2016)). Even the BOP had been planning to stop renewing contracts with private prisons, the new Trump administration has decided to extend contracts with several private prison companies.

The effect of contemporary convict labor on the U.S. economy is potentially large. We data is released on the amount and industrial composition of convict labor, but according to the U.S. Census of prisons and jails, approximately 1.4 million prisoners were employed in 2500 U.S. prisons in 2000. They still receive lower-than-minimum wage and have externalities on free labor.

However, the effect of contemporary convict labor is different from the historical one because transportation costs have decreased over time and competition with prison-made goods may spread.

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50 The trend also exists in other countries: for example, in Russia, the government started convict leasing in 2017 and began allowing state-owned companies to house and employ prisoners for almost zero wages (The Moscow Times (2016)).
60 See U.S. Department of Justice (2016) and CNN (2017)
61 See Figure 19 for a map of contemporary prisons. Some of those prisoners are assigned to halfway houses and are allowed to work outside the prison premises.
farther from the prison\textsuperscript{63} Thus, the overall effect of convict labor on contemporary manufacturing wages could be smaller around the prison but larger overall. Moreover, the number of convicts has soared from approximately 160 thousand in 1932 to more than 2.3 million today.

While I observe neither the industry where prisoners are employed nor the value of goods produced, I attempt to elicit the magnitude of the effect of competition with prison-made goods on wages in manufacturing by using a back-of-the-envelope calculation\textsuperscript{64} Take Colorado State Penitentiary, located in the Fremont county. As of 2010, its capacity was 756 beds but it was expanded by adding additional 300 beds. This 39% increase in prisoners led to $0.39 \times 0.24 \times 100 = 9.36\%$ decrease in local wages in manufacturing per 10 years, or 0.9% annually. Even if my estimate is an upper bound of the effect and the actual effect is smaller, the contemporary policy of placing prisons in economically depressed regions may be fallacious. Thus the government should at least consider imposing welfare redistribution to local low-skilled workers to alleviate the effect of competition with convict labor.

My analysis highlights the fact that many aspects of economic life and many groups of people can be affected directly and indirectly by competition from prison-made goods. Thus when we evaluate the overall effect of the penitentiary system, we should carefully weight the long-run impact and the negative externalities created by convict labor.

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\textsuperscript{63}In addition labor mobility has increased over time, shrinking the wage effect in the proximity of the prison. However, [Autor, Dorn and Hanson (2013)] argue that U.S. low-skilled labor mobility remains low.

\textsuperscript{64}To do it, I cannot use the estimate from Column IV of Table 10 with point-estimate $\gamma = -0.24$ ($se = 0.088$). I choose the discrete specification, as it yields an estimate more conservative in magnitude, and because it is easier to interpret the results. Suppose that the relationship between convict labor and wages remains the same.
References


Gildemeister, Glen A. 1978. “Prison labor and convict competition with free workers in industrializing America, 1840-1890.”


