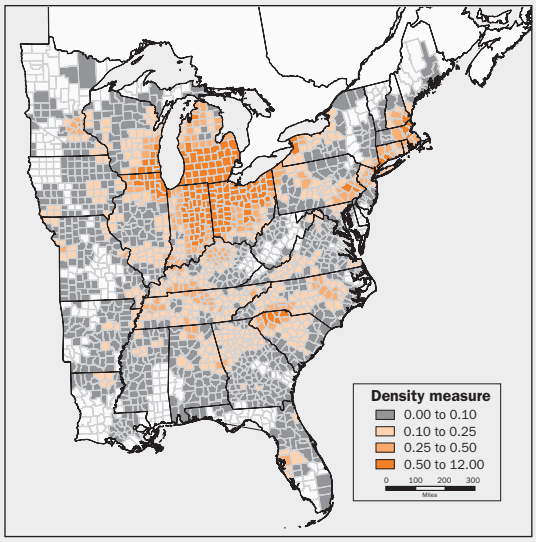
FIGURE 5

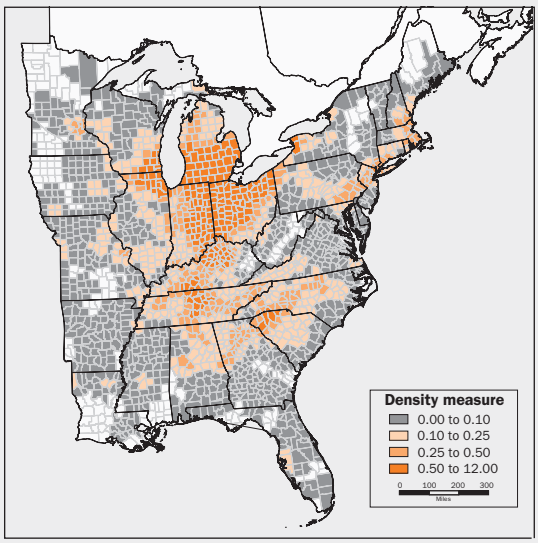
Supplier plant density in 1980



Sources: ELM International, state manufacturing directories, supplier company websites, and Harbour Consulting (2003).

FIGURE 6

Supplier plant density in 2003

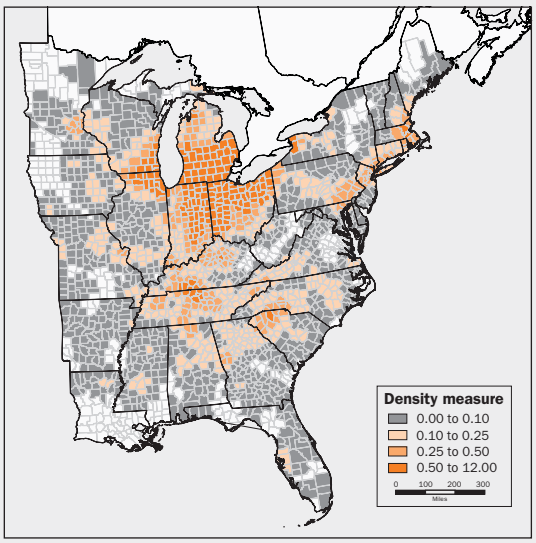


Sources: ELM International, state manufacturing directories, supplier company websites, and Harbour Consulting (2003).

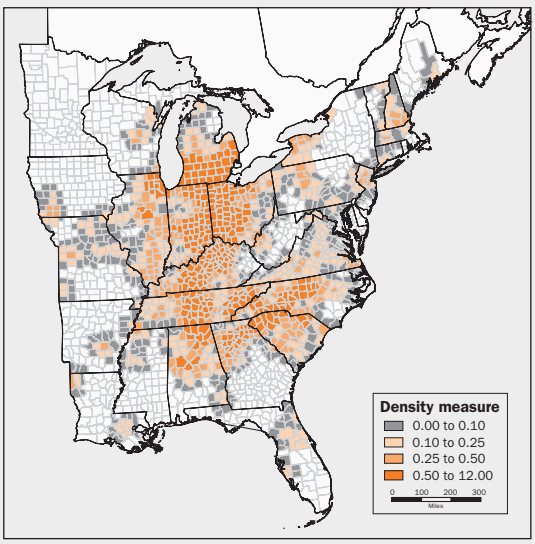
FIGURE 7

Supplier plant density in 2003, by ownership

A. Domestically owned



B. Foreign-owned



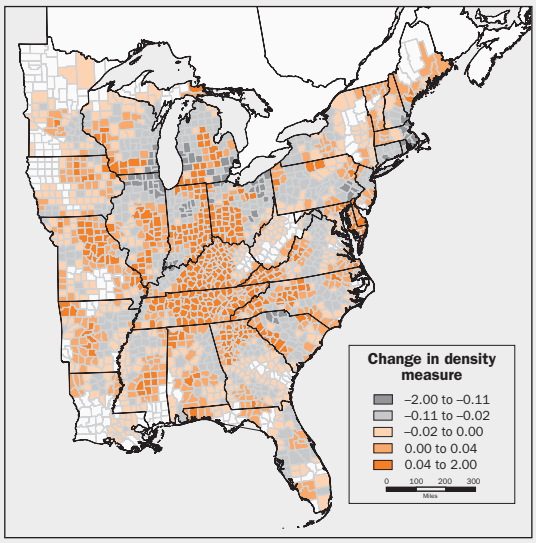
Sources: ELM International, state manufacturing directories, supplier company websites, and Harbour Consulting (2003).

owned supplier plants. Foreign-owned supplier plant density is concentrated in a well-defined north–south region that extends from central Michigan to northern Alabama, and from there northeast into the Carolinas.

To better illustrate the changes in geography, we decided to graph the change in supplier plant density by decade (see figures 8 and 9). The maps now distinguish between counties with growing density (orange) and counties with shrinking density (gray). Even though

FIGURE 8

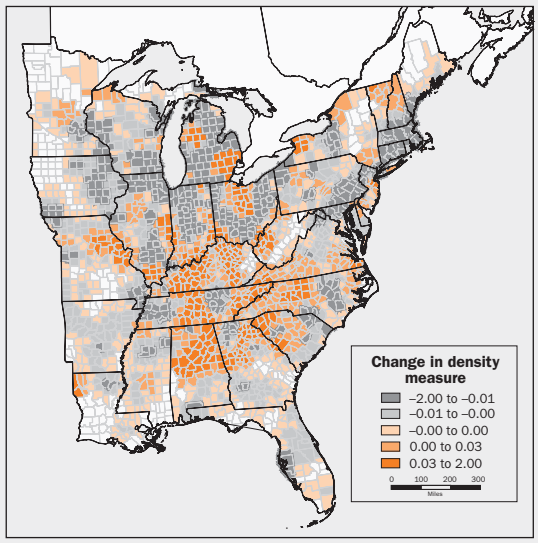
Changes in supplier density during the 1980s



Sources: ELM International, state manufacturing directories, supplier company websites, and Harbour Consulting (2003).

FIGURE 9

Changes in supplier density during the 1990s



Sources: ELM International, state manufacturing directories, supplier company websites, and Harbour Consulting (2003).

the data on supplier locations are conditional on the plant surviving through 2003, a county's density measure can drop over time if the county does not add supplier plants as fast as the entire industry because its density measure is divided by the total number of plants operational in a given decade.

During the 1980s, the greatest increase in supplier plant density occurred in a fairly compact region, bounded to the north by the Detroit area and to the south by northern Alabama. The most significant losses were concentrated in southern Michigan, in the Chicago metropolitan area, and along the East Coast. During the 1990s, however, the observed supplier plant density grew in a different pattern. The strongest increase in supplier plant density occurs in an area between southern Indiana and Ohio and central Alabama, extending east into the Carolinas. Meanwhile, the area of density losses has expanded east and south from where it started. The density of supplier plants also shifted southeast during the 1990s.

Based on these maps, it appears that as assembly plants moved south, so did supplier plants. In the next section, we use regression analysis that takes into account various features affecting plant location decisions, including proximity to a highway, distance to Detroit, and the share of manufacturing employment in the county, among others, to isolate the effect of new assembly line openings on the location of suppliers.

Formal analysis

Here, we present a model of supplier plant location choice.[14] We estimate two logit models of supplier plant location—one for the 1980s and one for the 1990s. The dependent variable is the number of suppliers that opened in a county during the 1980s and 1990s, respectively. The independent variables account for density conditions at the beginning of the decade, changes in assembly line density during the decade, and a number of county-level control variables (for descriptive statistics, see the appendix, table A2).

Supplier plant location choices are likely influenced by location choices of their customers. We include three variables each to account for changes in the assembly line density during a given decade: assembly line openings and closings in a specific county, as well as those within 100 miles and 450 miles of the actual assembly line location. To control for the initial industry conditions, we include the density of assembly lines measured at a 450-mile radius and the density of supplier plants measured at a 50-mile radius.

A number of variables control for county characteristics. Distance to Detroit measures the straight-line distance between the centroid of the county and the centroid of Wayne County—the home of Detroit, Michigan. We also control for the presence of an interstate highway in the county and the U.S. Census region or division in which the county is located.[15] In addition, we include a number of demographic controls, such

TABLE 1

Supplier plant locations during the 1980s and 1990s

	1980s	1990s
Assembly line opened in county	1.802**	3.001***
	(0.829)	(1.180)
Assembly line opened within 100 miles	0.952***	0.264
	(0.189)	(0.218)
Assembly line opened within 450 miles	0.276	0.221
	(0.339)	(0.330)
Assembly line closed in county	–1.250	1.326
	(0.935)	(1.671)
Assembly line closed within 100 miles	0.118	0.263
	(0.254)	(0.328)
Assembly line closed within 450 miles	–0.140	–0.255
	(0.430)	(0.586)
Assembly line density within 450 miles in 1980	–0.032**	—
	(0.016)	
Supplier plant density within 50 miles in 1980	1.237***	—
	(0.249)	
Assembly line density within 450 miles in 1990	—	–0.032*
		(0.019)
Supplier plant density within 50 miles in 1990	—	1.660***
		(0.304)
Distance to Detroit (miles)	–0.003***	–0.005***
	(0.001)	(0.001)
Interstate highway	0.508***	0.866***
	(0.154)	(0.195)
Northeast	–0.438	–0.026
	(0.304)	(0.585)
West South Central	0.238	0.147
	(0.322)	(0.434)
South Atlantic	0.210	0.163
	(0.295)	(0.376)
East South Central	0.927***	1.534***
	(0.286)	(0.358)
Population density	–0.329**	–0.113
	(0.143)	(0.107)
Percentage of whites	0.981	0.374
	(0.764)	(0.928)
Share of high school graduates	2.815**	3.833***
	(0.978)	(1.386)
Share of manufacturing employment	2.570***	4.360***
	(0.826)	(1.177)
Violent crime rate	0.879**	0.316
	(0.434)	(0.395)
Property crime rate	0.160***	0.237***
	(0.050)	(0.074)
Constant	–4.774***	–5.826***
	(1.280)	(1.745)
Observations	1,956	2,048
Pseudo R-squared	0.233	0.312

*Significant at the 10 percent level.
**Significant at the 5 percent level.
***Significant at the 1 percent level.

Notes: Standard errors are in parentheses. There are 92 fewer counties in the 1990s data due to missing values for the two crime variables. For details on the U.S. Census regions and divisions, see www.census.gov/geo/www/us_regdiv.pdf.

Sources: ELM International; assembly and supplier company websites; Maptitude; U.S. Census Bureau; and U.S. Department of Justice, Federal Bureau of Investigation.

as a county's population density, the percentage of white residents, the share of high school graduates, the share of manufacturing employment, and the rates for violent and property crimes.

On balance, the results for both the 1980s and 1990s are rather similar (see table 1). Supplier plants tend to locate near other supplier plants within a rather small radius. In addition, there is a within-county effect of an assembly line opening during the decade. A new assembly line attracts suppliers to locate within the same county. This effect is statistically significant for both decades. During the 1980s, the effect of an assembly line opening extends further out, as the likelihood of new suppliers opening within 100 miles of the new assembly line also increases in a statistically significant way. Assembly line closings have no statistical effect on supplier plant openings.[16]

Similar to what we found in earlier work (for example, Klier and McMillen, 2005), the presence of an interstate highway significantly increases the likelihood of a supplier plant opening in a county. Furthermore, counties closer to Detroit are more likely to attract new supplier plants. This result reflects the reorientation of the auto region from one that extends east–west to one that stretches north–south. The regional dummy variables support evidence from the maps, as new suppliers are more likely to choose the East South Central (U.S. Census) region. Finally, the likelihood of attracting new auto supplier plants increases with the share of high school graduates in a county's work force and the share of a county's employment in manufacturing. A somewhat surprising result is our finding that the probability of opening a supplier plant is higher in counties with high crime rates. This result holds even though we have controlled for the population density in the counties. A possible explanation is that high crime rates reduce land values in a county and that auto plants substitute toward private security provision. Another possibility is that crime rates are correlated with urban locations in a way that is not captured by the population density variable.

Conclusion

In taking a more long-term view of the changing footprint of the U.S. auto sector, this article demonstrates the changing nature in the geography of the auto industry.

Assembly and supplier plants co-locate primarily due to production requirements of best-practice, just-in-time manufacturing systems. Within the past 25 years, there has been a clear break from the pre-1980 location pattern in this industry. During the 1950s, at the height of the branch assembly plant system, assembly plants located not only near one another in the Midwest but also near large population centers along both coasts. As that pattern lost its rationale, central locations became crucial once again, and the auto corridor was established.

The tendency for new assembly plants, as well as new supplier plants, has been to locate farther south. In the case of assembly plants, the southward movement occurred in two distinct waves. The movement in the 1980s represents a reconfiguration of the industry region from one with an east–west orientation to one with a north–south orientation. During the 1990s, the newly located assembly plants strongly pushed the edge of that auto region to the deep South. As supplier plants appear to be willing to locate wherever a new assembly plant locates, it is not surprising to find a similar pattern for the changing density of supplier plant locations. Today's auto region clearly extends south from Detroit. Within this region, Detroit is continuing to shed its dominant role, while an increasing share of the industry is locating toward the southern end of the auto corridor.

Our formal analysis using two decade-specific logit models suggests that the underlying drivers of supplier plant location have not changed all that much since 1980: Supplier plants locate close to one another. They also locate close to newly opened assembly lines and interstate highways. The model results suggest the possibility of stronger local effects of assembly line openings on supplier plant location choices during the 1990s than during the 1980s. This tendency could be related to the increasing role of logistics and supplier functions having to be performed in proximity to the assembly location.

NOTES

[1]*Chicago Tribune* reporter Stephen Franklin (2006) refers to it as perhaps the greatest downsizing in Detroit's history.

[2]See Cooney and Yacobucci (2005).

[3]Branch plants date back to Henry Ford, who decided to implement them around 1911. Up to that point, vehicle assembly plants had primarily been located in the manufacturing belt, extending east from Chicago to New York.

[4]During the 1950s, at the height of the branch assembly plant system, the best-selling vehicles had much larger production runs, each supporting multiple assembly plants (Rubenstein, 1992).

[5]In that context, it is important to note that the most recent capacity reduction by the Big Three resulted in their production operations becoming more concentrated in the states of Michigan, Indiana, and Ohio (see http://midwest.chicagofedblogs.org/archives/2006/03/auto_parts_issu.html).

[6]Data on the location and operation of assembly lines were obtained from ELM International as well as assembly company websites.

[7]The data include information on "captive" supplier plants, which are parts operations, such as engine and stamping facilities, that assemblers own and operate themselves.

[8]Plants for which no matching records were found were contacted by telephone.

[9]We thank James Rubenstein for sharing his plant-level data for the 150 largest supplier companies. The 150 largest supplier companies are listed annually in the industry weekly *Automotive News*.

[10]Figures 5 and 6 suggest that survivor bias is not an issue.

[11]The scale of the density measure varies across the individual maps. In each of the maps, the scale was configured to have an equal number of counties in each of its categories.

[12]Table A1 in the appendix provides details on assembly lines for each letter-coded area.

[13]In the appendix, table A1 includes information about changes in the location of assembly lines since 2003. Hyundai built a new assembly plant in Alabama. Toyota is finishing one in San Antonio, Texas, which will start production later this year. Kia just announced the construction of an assembly plant in Georgia. On the other hand, the cutbacks of production capacity by the Big Three continue. For example, since 2003, four of their assembly lines on the East Coast were closed or are slated to be closed. This is also the case for the Big Three's oldest domestic southern assembly cluster: The remaining assembly lines in the Atlanta area are scheduled to close by 2008.

[14]We model supplier plant location choices as there are far more observations for this part of the industry. From 1980 to 2003, only 20 new assembly lines were built (see the appendix, table A1).

[15]We include regional dummies so that we can examine whether there is evidence of agglomeration once we control for regional effects.

[16]Note that the data on supplier plants do not record plant closings.

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APPENDIX

TABLE A1

Assembly line openings and closings details

Details for figure 1 (1980)

A – 19 lines in southeast Michigan: 10 GM, 5 Chrysler, 4 Ford
B – 1 line in Minneapolis, Minnesota: Twin Cities Assembly Plant (Ford)
C – 6 lines in southern Wisconsin and Chicago, Illinois: 3 Chrysler, 2 GM, 1 Ford
D – 4 lines in Kansas City, Missouri: 2 Ford, 1 GM, 1 Chrysler
E – 4 lines in St. Louis, Missouri: 2 Chrysler, 1 GM, 1 Ford
F – 2 lines in Louisville, Kentucky: 2 Ford
G – 2 lines in southwest Ohio: 2 GM
H – 3 lines in Atlanta, Georgia: 2 GM, 1 Ford
I – 4 lines in northern Ohio: 2 Ford, 1 GM, 1 Chrysler
J – 1 line in Westmoreland, Pennsylvania: Westmoreland Assembly Plant (Volkswagen)
K – 1 line in Norfolk, Virginia: Norfolk Assembly Plant (Ford)
L – 3 lines in Maryland and Delaware: 2 GM, 1 Chrysler
M – 4 lines in New York City, New York: 2 GM, 2 Ford
N – 1 line in Boston, Massachusetts: Framingham Assembly Plant (GM)

Details for figure 2 (1990)

O – 3 lines opened in southeast Michigan: 2 GM, 1 AutoAlliance International
P – 1 line opened in Normal, Illinois: Mitsubishi Motor Manufacturing
Q – 1 line opened in Lafayette, Indiana: Subaru-Isuzu Automotive
R – 1 line opened in Fort Wayne, Indiana: Fort Wayne Assembly Plant (GM)
S – 2 lines opened in central Ohio: 2 Honda
T – 1 line opened in St. Louis, Missouri: Wentzville Assembly Plant (GM)
U – 1 line opened in Georgetown, Kentucky: Toyota Motor Manufacturing 1
V – 2 lines opened in central Tennessee: 1 GM (Saturn), 1 Nissan
W – 1 line opened in Shreveport, Louisiana: Shreveport Assembly Plant (GM)
X – 4 lines closed in southeast Michigan: 2 GM, 2 Chrysler
Y – 2 lines closed in Kenosha, Wisconsin: 2 Chrysler
Z – 1 line closed in Kansas City, Missouri: Kansas City Leeds Assembly Plant (GM)
AA – 1 line closed in St. Louis, Missouri: St. Louis 1 Assembly Plant (GM)
BB – 1 line closed in Norwood, Ohio: Norwood Assembly Plant (GM)
CC – 1 line closed in Westmoreland, Pennsylvania: Westmoreland Assembly Plant (Volkswagen)
DD – 1 line closed in New York City, New York: Mahwah, NJ Assembly Plant (Ford)
EE – 1 line closed in Boston, Massachusetts: Framingham Assembly Plant (GM)

Details for figure 3 (2003)

FF – 1 line opened in southeast Michigan: Lansing Assembly Grand River (GM)
GG – 1 line opened in Princeton, Indiana: Toyota Motor Manufacturing
HH – 1 line opened in Georgetown, Kentucky: Toyota Motor Manufacturing 2
II – 1 line opened in Canton, Mississippi: Nissan North America
JJ – 1 line opened in Tuscaloosa, Alabama: Mercedes-Benz U.S. International
KK – 1 line opened in Lincoln, Alabama: Honda Motor Manufacturing
LL – 1 line opened in Greer, South Carolina: BMW Assembly Plant
MM – 3 lines closed in southeast Michigan: 3 GM
NN – 1 line closed in Atlanta, Georgia: Lakewood-Atlanta Chevy Assembly Plant (GM)
OO – 1 line closed in New York City, New York: Tarrytown Assembly Plant (GM)

Since 2003 (not shown in figure 3)

Openings:
2005 – Montgomery, Alabama: Hyundai Assembly Plant
2006 – Lansing, Michigan: Lansing Delta Township Assembly (GM)
2006 – San Antonio, Texas: Toyota Motor Manufacturing of Texas
2008 – West Point, Georgia: Kia Assembly Plant

Closings:
2004 – Edison, New Jersey: Edison Assembly Plant (Ford)
2004 – Lorain, Ohio: Lorain Assembly Plant (Ford)
2005 – Baltimore, Maryland: Baltimore Assembly Plant (GM)
2005 – Linden, New Jersey: Linden Assembly Plant (GM)
2005 – Lansing, Michigan: Lansing "M" Plant (GM)
2006 – Oklahoma City, Oklahoma: Oklahoma City Assembly Plant (GM)
2006 – Lansing, Michigan: Lansing Craft Centre (GM)
2006 – Spring Hill, Tennessee: Spring Hill Manufacturing Complex 1
2006 – Hazelwood, Missouri: St. Louis Assembly Plant (Ford)
2008 – Doraville, Georgia: Doraville Assembly (GM)
2008 – Hapeville, Georgia: Atlanta Assembly Plant (Ford)
2008 – Wixom, Michigan: Wixom Assembly Plant (Ford)
2008 – St. Paul, Minnesota: Twin Cities Assembly Plant (Ford)
2008 – Norfolk, Virginia: Norfolk Assembly Plant (Ford)

Sources: ELM International, *Ward's Automotive Yearbook*, and assembly company websites.

TABLE A2

Descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum
1990				
Supplier plant opened in county	0.172	0.378	0	1
Assembly line opened in county	0.006	0.078	0	1
Assembly line opened within 100 miles	0.162	0.369	0	1
Assembly line opened within 450 miles	0.814	0.389	0	1
Assembly line closed in county	0.006	0.101	0	3
Assembly line closed within 100 miles	0.117	0.321	0	1
Assembly line closed within 450 miles	0.099	0.299	0	1
Assembly line density within 450 miles in 1980	13.836	12.412	0	47.767
Supplier plant density within 50 miles in 1980	0.215	0.540	0	9.690
Distance to Detroit (miles)	491.541	210.129	13	1,169
Interstate highway	0.486	0.500	0	1
Northeast	0.106	0.308	0	1
West South Central	0.210	0.407	0	1
South Atlantic	0.287	0.452	0	1
East South Central	0.175	0.380	0	1
Population density	0.294	1.906	0.002	62.420
Percentage of whites	0.875	0.162	0.106	1
Share of high school graduates	0.568	0.117	0.253	0.885
Share of manufacturing employment	0.260	0.107	0.024	0.615
Violent crime rate	0.246	0.252	0	2.442
Property crime rate	3.108	2.017	0	18.711
2003				
Supplier plant opened in county	0.114	0.318	0	1
Assembly line opened in county	0.003	0.058	0	1
Assembly line opened within 100 miles	0.159	0.366	0	1
Assembly line opened within 450 miles	0.724	0.447	0	1
Assembly line closed in county	0.002	0.049	0	1
Assembly line closed within 100 miles	0.077	0.267	0	1
Assembly line opened within 450 miles	0.130	0.336	0	1
Assembly line density within 450 miles in 1990	14.328	13.287	0	52.109
Supplier plant density within 50 miles in 1990	0.216	0.500	0	8.995
Distance to Detroit (miles)	497.098	209.061	13	1,169
Interstate highway	0.471	0.499	0	1
Northeast	0.106	0.308	0	1
West South Central	0.215	0.411	0	1
South Atlantic	0.288	0.453	0	1
East South Central	0.178	0.382	0	1
Population density	0.296	1.735	0.003	53.126
Percentage of whites	0.867	0.167	0.107	0.999
Share of high school graduates	0.677	0.103	0.355	0.914
Share of manufacturing employment	0.228	0.096	0.022	0.537
Violent crime rate	0.291	0.351	0	3.449
Property crime rate	2.547	1.916	0	12.124

Note: For details on the U.S. Census regions and divisions, see www.census.gov/geo/www/us_regdiv.pdf.
Sources: ELM International; assembly and supplier company websites; Maptitude; U.S. Census Bureau; and U.S. Department of Justice, Federal Bureau of Investigation.