Data Appendix

CONSTRUCTED VARIABLES

Geographical Polygon Features (counties, townships, parcels, VMD)

Geographical boundaries for Ohio counties, townships, parcels, and the Virginia Military District were obtained from the digital map *Original Land Subdivisions of Ohio* (Ohio Department of Natural Resources, 2006). The map represents the digital compilation of the original land subdivisions in Ohio, styled after Sherman's (1922) map. Each unit in the map is represented by a distinct polygon in the spatial dataset. All polygon measures of area, perimeter, and centroid location used in the analysis are calculated from this dataset using geographical information systems (GIS) software.

Perimeter-Area Ratio of Parcel

Using the *Original land subdivisions of Ohio* dataset, we relate the perimeter of a parcel's boundary to the parcel's area with the metric:

$$perimeter\ area\ ratio = \frac{perimeter}{\sqrt{area}}$$

Number of Parcel Sides

To calculate this metric we intentionally modified our source data of parcel boundaries to make meaningful counts of polygon vertices. Polygons in our parcel dataset contain many vertices that are an artifact of the digitization process. To correct for this, the polygon shape file is modified using a simple algorithm based on a method developed by Douglas and Peucker (1973) to remove redundant points, such as over-digitized vertices.[1] The remaining sample represents the unique vertices of the original polygons. Counting them gives the value for the variable *NUMBER OF PARCEL SIDES*.

Parcel Alignment

We define alignment by the angle θ of the longest side of a parcel where θ is measured from a true North-South baseline. The orientation angle θ is measured in decimal degrees and has the range [-90, 90]. When coordinating rectangles in a grid, a value of θ and its right angle counterparts will all represent the same alignment of the parcel. For example, the measurements $\theta = -90$, $\theta = 0$, and $\theta = 90$, are all consistent with an alignment based on true north. To equate values which represent the same alignment we use *ALIGNMENT* $= \min\ [|0-\theta|, (90-|\theta|)]$ which has the range [0, 45]. For more information, contact the authors.

Ruggedness

From the USGS National Elevation Dataset we calculate the slope of the area covered by the digital elevation models, DEM. The slope of a given cell in the DEM is calculated using the change in elevation from its eight neighboring cells. From this the rate of change in elevation is calculated and then used to develop a slope measure with a range of [0, 90], where 0 represents flat land. Terrain ruggedness is then calculated as slope/90 with a possible range of [0,1]. When used in our analysis, the *RUGGEDNESS* variable represents the average ruggedness value for every cell within the boundary of the observation. For more information, contact the authors.

Distance to Geographical Point Vectors (county seats, Cincinnati)

A map of Ohio counties and county seats prepared by the Ohio Department of Development, Policy Research and Strategic Planning (June 2008) was used to determine geographical locations of the county seats and the city of Cincinnati. Locations were digitized into point data by "heads-up" digitizing using GIS software. In our analysis, *Distance to Market*, *Cincinnati* is the straight-line distance measured in miles between the centroid of an observation and the nearest point that represents a county seat and the point representing Cincinnati.

Distance to Geographical Line Vectors (roads, railroads, canals, rivers)

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1 Technical paper, ESRI Inc., "Automation of Map Generalization: The Cutting-Edge Technology", 1996. It can be found in the White Papers section of ArcOnline at this Internet address: http://downloads.esri.com/support/whitepapers/ao_/mapgen.pdf

Source Data - Our source data on roads, railroads and canals come from an 1868 transportation map of Ohio published in the *Atlas of the State of Ohio* from surveys under the direction of H. F. Walling. This map was scanned and geo-referenced to match the *Original land subdivisions of Ohio* shape file. Roads, railroads, and canals were digitized into line vectors by "heads-up" digitizing method. .

Our source data for rivers comes from a statewide hydrography line shape file provided by the Ohio Department of Natural Resources. It was created from Digital Line Graph (DLG) files of each scanned 7.5-minute quad map, using ARC/INFO.

DISTANCE TO ROADS – This is the straight line distance in miles from the center of an observation (parcel) to the nearest vector representing a road. This measurement only relates a parcel's location to a single road and is only used in the analysis of Warren County where the small scale limits the usefulness of the road density measure.

DISTANCE TO RAILROADS - This is a measure of distance to the nearest railroad track from the center of an observation.

DISTANCE TO WATER – This is a measure of distance to the nearest waterway that was used for shipping and transportation from the center of the observation. Waterways include "major rivers" as classified by our hydrography dataset and constructed canals at that time.

<u>Line Vector Density</u> (road, railroad, stream)

The density of line features such as roads, railroads and streams, are calculated by measuring the length of the line feature over a given area. Using our road and railroad data from the 1868 Walling Atlas of the State of Ohio, we calculate

$$Road\ Density = \frac{Length\ of\ Roads\ within\ Township}{\sqrt{Land\ Area\ of\ Township}} \quad Railroad\ Density = \frac{Length\ of\ Tracks\ within\ Township}{\sqrt{Land\ Area\ of\ Township}}$$

where land area is found by subtracting the area of water bodies within a township (USGS National Hydrography Dataset) from the total area within township boundaries. Our stream data comes from the Ohio Department of Natural Resources hydrography line dataset. Only streams classified having year-round flow were are used to calculate

$$Stream\ Density = (Length\ of\ Streams)/(\sqrt{Area})$$

<u>Soil Quality Variables</u>

Percent Arable Land was measured as the percent of land in a county falling into Land Capability Classes I-IV in the Natural Resource Conservation Service (NRCS) Ohio soil surveys. We obtained soil quality micro-data for Warren County from the NRCS Soil Survey Geographic (SSURGO) Database. Percentage of prime farmland was calculated for each parcel.

<u>Farm Acreage and Improvement</u>

In the U.S. Census of Agriculture, land is considered improved if it has been cleared and utilized for grazing or crop production (or was fallow at the time of the enumeration) and is unimproved otherwise. We calculate total farm acreage and improved/total farm acreage.

<u>Farm Value</u>

The U.S. Census of Agriculture collects specific valuation information from farmers including: present cash value of farmland, cash value of livestock, and value of farming implements and machinery reported in dollars. Using this data we calculate total farm value per acre as the sum of these divided by total farm acres.

<u>Data Sampling</u>

<u>*VMD and Adjacent Counties*</u>. The 39 counties included in the analysis are listed with (% in VMD) Adams (100), Allen (0), Auglaize (0), Brown (100), Butler (0), Champaign (.32), Clark (.18), Clermont (100), Clinton (100), Crawford (0), Delaware (.14), Fairfield (0), Fayette (100), Franklin (.40), Greene (.67), Hamilton (.09), Hancock (0), Hardin (.41), Highland (100), Hocking (0), Jackson (0), Knox (0), Lawrence (0), Licking (0), Logan (.58), Madison (100), Marion (.15), Miami (0), Montgomery (0), Morrow (0), Pickaway (.57), Pike (.64), Ross (.70), Scioto (.48), Shelby (0), Union (100), Vinton (0), Warren (.42), and Wyandot (0).

<u>*Township Level Analysis*</u>.

Ohio data from the 1850 and 1860 Censuses of Agriculture and Population, were entered into excel from microfilm copies of the original schedules. The population schedules were obtained from Ancestry.com and Geneology.com and the agriculture schedules from the National Archives. Both census years were sampled to secure a sample of sufficient size for analysis. We were not able to match census entries with the original parcel maps, which apparently is a common problem. Counties partially or completely in the VMD, as well as counties adjacent to the district, were sampled. For 1850, these included Adams, Allen, Auglaize, Brown, Butler, Delaware, Fairfield, Franklin, Fayette, Greene, Hamilton, Hancock, Hardin, Highland, Hocking, Knox, Lawrence, Licking, Logan, Madison, Marion, Miami, Montgomery, Ross, Scioto, Shelby, Union, Vinton, Warren, and Wyandot. For 1860 the same counties were sampled, except for Miami, Shelby, Union, Vinton, Warren, and Wyandot, which were unavailable because these original surveys were destroyed prior to microfilming. In the analysis individual observations are averaged by township. Because of the lost county data for 1860, we have 768 township observations, rather than potentially 874 (437 townships in the VMD and adjacent counties x 2). The 1850 census was sampled at approximately a 10 percent rate, but a 5 percent rate was used for the more comprehensive 1860 census. Data from the Census of Agriculture were matched to the farmer's population census records for the corresponding years. The matches were made using a searchable electronic database available by description at Ancestry.com. For both census periods, we were able to match an average of over 60 percent of the farms.

Warren County Analysis.

1867 Parcel maps of farms in Warren County, Ohio (split by the VMD) were obtained from http://www.rootsweb.ancestry.com/~ohwarren/maps/1867map.htm. "Map of Warren Co Ohio from actual Surveys by G. P. Sanford, J. Silliman Higgins & R. H. Harrison, Civil Engineers; A. Warner Publisher; Philadelphia, 1867." Names from the 1867 plat map were matched to names from the 1870 population census via Ancestry.com. These names were then matched to farmer names on the 1870 agricultural census schedule on microfilm (National Archives, Non Population Census Records: Ohio, 1870, T1159, Role 42.

County Level Analysis

Annual conveyance and mortgage data are from *Second Annual Report of the Commissioner of Statistics, to the General Assembly of Ohio*: *For the Fiscal Year 1858*. Columbus, Ohio: Richard Nevins, State Printer. 1859 and the *Third Annual Report of the Commissioner of Statistics, to the General Assembly of Ohio: For the Fiscal Year 1859* Columbus, Ohio: Richard Nevins, State Printer. 1860. The mean value for the two years is used in the regressions. 1860 was not available to us. Population and county size are from 1860 Census, Geospatial & Statistical Data Center http://fisher.lib.virginia.edu/collections/stats/histcensus/php/county.php.

OHIO COURT ANALYSIS

We searched compendiums of Ohio court cases in the 19th century and then turned to Westlaw and Lexis/Nexis for case reports: *Page's Ohio Digest: A Digest of All Reported Decisions of the Courts of Ohio from the Earliest Period to Date*, John L. Mason Editor in Chief, Volume One, Part One, Abandonment to Assault and Battery; Part Two, Assignments to Charities, Volume Four, Deeds to Equity, Volume Eight, Subrogation to Youthful Employee, Cincinnati: The W.H. Anderson Company, 1914; *A Digest of All Reported Decisions of the Courts of Ohio from the Earliest Period to Date*, Lifetime Edition, edited by William Herbert Page, Volume 10, Parties to Receipts, Volume Twelve, Part One, Taxation to Venditioni Exponas, Cincinnati: W.H. Anderson Company, 1936. *Ohio Jurisprudence: A Complete Statement of the Law and Practice of the State of Ohio with Forms*, Editor in Chief: Willis A. Estrich, Consulting Editor William M. McKinney, Managing Editor, George S. Gulick, Volume 1, 1928, Historical Introduction to Adverse Possession; Volume 5, Bail to Boundaries, 1929, Volume 15, 1931, Easements to Encumbrance, Volume 32, 1934; Pledges to Public Schools, Volume 39, 1935, Taxpayers' Actions to Trial, Rochester, New York: The Lawyers Co-operative Publishing Company. The Lexis/Nexis search used terms: boundary, quiet title, trespass, and ejectment.

Survey Validity Issues:

These cases involve a dispute where two different surveys claim the same land. *E.g., McArthur v. Phoebus*, 2 Ohio 415 (1826). In these, the general question is which survey was valid and which was invalid. This should be differentiated from cases where two parties claim the same land because the survey, or several competing surveys, does not clearly delineate a line between the properties. These cases generally hinge on whether the survey was correctly recorded or implemented. In general, these cases are more common in VMD areas, but do exist in RS areas of Ohio, but the issues are far easier to resolve in the latter, generally hinging on resolving a clear surveying error, rather than conflicting land claims. *See Hamil v. Carr*, 21 O.S. 258 (Ohio 1871).

Boundary Issues:

This is a broader area of conflict, and includes cases where there is a dispute about where a boundary line actually stands. The majority of relevant cases fall in this area and typically occur because the survey, or multiple surveys, do not make it legally clear where the boundary line stands. These cases also frequently occur when a deed does not make clear part of a plat it is granting.

Both these disputes occur in VMD and non-VMD areas, although the former are generally far more complex, hinge on far less clear legal principles, and occur with greater frequency than in RS (non-VMD) areas.

Validity of Deeds/Patents

These cases occur frequently and all hinge on whether a deed or patent was valid. While these are actually two fairly different legal issues, they generally depend on the same type of questions, namely was the deed/patent correctly recorded under the relevant statute and does the deed/patent correctly describe the land it grants. If not, the deed/patent is generally invalid. For the most part, these cases do not involve any boundary disputes, except in the cases where the validity of a patent is used as a collateral attack on cases of overlapping surveys. It is worth noting, however, that patent validity seems to be an issue mostly in VMD cases, largely due to the complexity of the issues involved. The case, Ohio (Pt 1) 206 *Porter v Robb* from Clermont County illustrates some of the boundary problems found in the VMD, especially where there was a chain of entries and surveys. See also *Huston v McArthur*, 7 O (Pt 2) 54.