Agricultural and Residential Real Estate Returns*

Pedro Gete,† Michael Reher‡ and Athena Tsouderou§

January 2024

Abstract

We show that agricultural real estate prices have grown significantly faster than residential real estate prices over the last 130 years, but their growth exhibits less cross-sectional dispersion than residential real estate price growth. These results hold in multiple datasets and time sub-periods. We rationalize these facts in a framework where fertile soil is scarce and produces a tradable good. Scarcity implies that the aggregate supply of cultivated agricultural land has a lower long-run supply elasticity than housing, which can be built on infertile land and has the potential for density. Tradability implies that agricultural real estate prices grow at similar rates across space. We derive testable implications of the theory and provide empirical support from the cross-section of the agricultural-residential return spread.

Keywords: Agriculture, Cropland, Farmland, Prices, Real Estate, Residential, Returns, Rents, Supply

JEL Classification: R1, R2, R3

*We thank seminar and conference participants at several universities and conferences. Research Reported in this paper was partially funded by MCIN /AEI /10.13039/501100011033 / FEDER, UE Grant No. PID2021-125359NB-I00

†IE University, IE Business School. Email: pedro.gete@ie.edu.

‡University of California San Diego, Rady School of Management. Email: mreher@ucsd.edu

§University of Miami, Herbert Business School. Email: atsouderou@miami.edu.

1 Introduction

Agricultural land is a unique form of real estate for at least two reasons. First, unlike residential or commercial real estate, the land itself can, with appropriate cultivation, produce a tradable good. For example, corn grown in Iowa can be traded in other markets, but one cannot trade housing services produced by a New York City apartment anywhere else.[1] Second, agricultural land requires highly specific soil to produce this good. These soil requirements make agricultural land more scarce than other forms of real estate: one can potentially build housing on fertile soil, but one cannot necessarily cultivate crops on land that is used for housing. The scarcity of fertile soil effectively reduces the long-run supply elasticity of agricultural real estate, which, as with real estate more broadly, can lead to long-run growth in real estate prices (Glaeser and Gyourko 2018). This effect could rise over time as erosion (e.g., Hornbeck 2012) and nutrient depletion (e.g., Smith et al. 2016) related to urban population growth make fertile land even more scarce.

The contribution of this paper is to empirically document the medium-to-long-run behavior of agricultural versus residential real estate price returns in the U.S. and to theoretically analyze a framework explaining this behavior. Our paper thus takes a novel perspective on an active debate about the medium-to-long-run returns to real estate as an asset class (e.g., Shiller 2005; Eichholtz et al. 2021; Jadevicius et al. 2018; Jordà et al. 2019; Chambers, Spaenjers and Steiner 2021). This debate typically concerns the *level* of total return on residential real estate, while our analysis emphasizes the *spread* in price return between agricultural vs. residential real estate and theoretically links this spread to the important issue of long-run food security.

We document two facts. The primary fact is that the price return to agricultural real estate in the U.S. has significantly exceeded that of residential real estate since 1890. Precisely, the real value of agricultural real estate grows approximately 0.7 pps more per year than the real value of residential real estate. Compounding over 130 years, this difference implies that the cumulative return to agricultural real estate exceeds that of residential real estate by around 290 pps. We obtain similar results from various datasets that span different time periods and that measure real estate values in different ways, namely census surveys,

[1] We often use language that connotes cropland when describing our results, but the main idea of our theory could be applied to other forms of agricultural land, such as pastureland, with some reinterpretation of parameters. We generally use the more-general term "agricultural" real estate because this matches what we actually observe in our long-run datasets. According to the USDA's 2022 National Survey, cropland accounts for 60% of all U.S. agricultural real estate value, including both land and buildings. However, it accounts for only 43% of land, in acres. Brain et al. (2023) perform a more comprehensive breakdown and similarly find that cropland accounts for 36% of the combined area of cropland and permanent grassland pasture or range and accounts for 17% of all 2.3 billion acres of U.S. land area. Urban land accounts for 3% of the total, with the remainder consisting of forest (28%) or miscellaneous uses.

appraised values, or transaction values.

The second fact concerns cross-sectional dispersion in the agricultural-residential spread. While the average price return for agricultural real estate exceeds that of residential real estate, the standard deviation of this price return across U.S. states is smaller, especially relative to the higher average return. Precisely, the cross-state standard deviation in residential real estate's price return since 1975 equals 126% of the cross-state average price return (i.e., the coefficient of variation equals 1.26). By contrast, the analogous statistic for agricultural real estate equals only 43% of the average. This finding accords with the idea that residential land produces a non-tradable dividend, housing services, and this non-tradability induces geographic variation in residential real estate values. By contrast, agricultural land produces a tradable dividend and, so, features less such variation.

Our framework explains these two facts by considering a deterministic economy with exogenous population growth and two forms of "capital": residential and agricultural real estate. Producers accommodate demand for housing and food by developing residential real estate and cultivating agricultural real estate, respectively, at a convex cost. However, the latter differs in that it has finite natural supply. This assumption reflects two realistic features of agricultural real estate: first, it requires specific soil to produce output; second, it has limited scope for density. In particular, vertical construction (i.e., taller buildings) allows for density in residential real estate in a way that is not possible in agriculture.

Thus, the supply of cultivated agricultural real estate becomes perfectly inelastic in the very long run. By contrast, the supply of housing retains some elasticity because it can be built on infertile land and because it has greater potential for density. In the presence of exogenous population growth this wedge in very long-run supply elasticities gives rise to significant differences in the very long-run price of the dividends produced by the two types of real estate (i.e., rent and food prices). Forward-looking real estate prices reflect this very long-run difference today in the form of a lower capitalization rate on agricultural real estate and, thus, by present value logic, higher growth in real estate prices.

We do not claim that the previous explanation, alone, can explain the agricultural-residential return spread, but we can evaluate the validity of our mechanism by deriving and testing additional implications of our theory. In particular, we derive three testable implications related to the cross-section of this spread across geographies. Then, we empirically evaluate these implications, finding support for the framework in each case.

First, in our framework, future housing rents in a given location depend on income growth in that location. However, because crops (i.e., agricultural output) are tradable, future crop prices paid by households in such location depend on aggregate income growth. Consequently, holding current income per capita fixed, a negative shock to income growth rate in

a small location lowers future demand for housing and thus the value of residential real estate. By contrast, the value of agricultural real estate is not affected. As a result, the agricultural-residential return spread decreases with income growth of a specific location. Turning to the data: we find a strong and robust negative relationship between the agricultural-residential return spread and income per capita at the state level. This result builds on the literature's finding that cross-sectional income dispersion explains a large share of house price dispersion since the 1950s (e.g., Glaeser, Gyourko and Saks 2005; Van Nieuwerburgh and Weill 2010; Gyourko, Mayer and Sinai 2013). In particular, it implies that income growth is capitalized into residential real estate prices at a much higher rate than into agricultural real estate prices.

Second, we derive a testable implication based on heterogeneity in the costs of residential development. When such costs are higher, the supply of housing is smaller, which raises the value of residential real estate and, thus, the price return to residential real estate. However, the return to agricultural real estate is unchanged. Thus, barriers to residential density, such as zoning, reduce the agricultural-residential return spread. Empirically, we measure these barriers using the Gyourko, Saiz and Summers (2008) measure of residential land use regulation. We find that states with more-stringent regulation feature a lower agricultural-residential return spread, consistent with the framework's prediction.

Third, we consider a comparative static that raises long-run soil quality. The framework predicts that higher soil-quality correlates with a higher agricultural-residential return spread. Since the relevance of a given crop changes over time due, for example, to climate change, we proxy for "long-run quality" using a measure of the diversity of crops that the soil on a given piece of land can produce from the U.S. Department of Agriculture's Soil Survey. We find that the agricultural-residential return spread is higher in states where the average piece of cropland has few or moderate limitations on its potential use, which we interpret as higher quality. This finding supports the framework's prediction that agricultural real estate values should grow more quickly where the soil is better. Conceptually, the framework generates this prediction because the dividend produced by such soil is especially valuable in the very long run, leading to a lower capitalization rate today and, thus, higher price growth.

Overall, our simple framework matches several empirical patterns regarding geographic variation in the agricultural-residential return spread. These findings lend further support to the framework's main mechanism, land scarcity, as a relevant explanation for the existence of this spread.

Related Literature

We contribute to a set of recent macro-finance papers that have examined the returns to real estate as an asset class over the medium-to-long-run. Some papers document relatively modest total returns (e.g., Eichholtz 1997; Shiller 2005; Eichholtz et al. 2021) Others, like Jordà et al. (2019), find larger total returns comparable to equities. However, the literature typically focuses on residential real estate, not agricultural. Two exceptions are Jadevicius et al. (2018) and Chambers, Spaenjers and Steiner (2021), who study agricultural real estate in the U.K. over 1781-2013 and 1901-1983, respectively. Both papers document price returns to agricultural real estate comparable to those that we document for the U.S. over 1890-2020, but neither delves deeply into the spread in price return relative to residential real estate.[2] By contrast, the agricultural-residential return spread is a central focus of our paper, as well as geographic heterogeneity in this spread.[3]

Second, we contribute to a large literature in urban economics that has studied how variation in the supply elasticity of a particular type of real estate, residential, can explain variation in house price growth across cities, with a summary in Glaeser and Gyourko (2018). In our setting, variation in the very long-run supply elasticity of different types of real estate generates variation in price growth across these types. The key assumption of our model generating this result is that agricultural real estate is less elastically supplied in the very long run due to its specific soil requirements. In the medium run, however, residential real estate may have a lower supply elasticity, consistent with the observation that residential land use regulation has become more restrictive since the 1960s (e.g., Ganong and Shoag 2017). The other key assumption is limited consumption substitutability between food and housing, which generates long-run demand for agricultural land. The combination of long-run demand and inelastic supply raises the price return to agricultural real estate, just as, within residential real estate, the same combination leads some cities to exhibit superstar rent growth (e.g., Gyourko, Mayer and Sinai 2013; Howard and Liebersohn 2021).

Lastly, we build upon the soil science literature, which has documented long-term shifts in soil attributes and productivity due, in part, to cultivation practices. Smith et al. (2016)

[2]Chambers, Spaenjers and Steiner (2021) note a higher price return for agricultural versus residential real estate within the same sample, which we find reassuring in terms of the external validity of our primary fact. However, the main focus of Chambers, Spaenjers and Steiner (2021) is on the level of real estate total returns, especially as they relate to the previously referenced papers, not the spread in price return across different types of real estate, which is our focus both empirically and theoretically.

[3]Our results regarding heterogeneity by soil quality link the value of agricultural real estate to an important environmental issue, food security. Broadly, this result relates to findings from several papers that link the value of residential real estate equity or debt prices to a related environmental issue, climate change, over medium to very-long horizons (e.g., Bernstein, Gustafson and Lewis 2019; Giglio et al. 2021; Gete, Tsouderou and Wachter 2024).

or Wills et al. (2017) provide excellent summaries. Our contribution is to theoretically demonstrate and provide preliminary empirical evidence that the price return to agricultural real estate contains information about fundamental soil productivity.

The paper has the following structure: Section 2 documents the main facts. Section 3 presents the model and derives the key result. Section 4 derives testable implications from the model and brings them to the data using cross-sectional geographical differences in the U.S. Section 5 concludes. The Online Appendix describes the data, contains the theoretical proofs, and provides additional evidence for robustness.

2 Data and Main Facts

This section documents the two main facts that anchor this paper. We begin with a brief overview of our data with details in Appendix A.

2.1 Data

The paper's main facts come from publicly available datasets. Our primary measure of agricultural real estate values comes from the United States Department of Agriculture's (USDA's) Annual Survey, which begins in 1850. We measure agricultural values using average valuation in dollars-per-acre, which includes both land and buildings used for agricultural production, based on the values reported by farm owners to the USDA's Census enumerators. This measure has the advantages of a long time series and public availability. We find similar results based on appraised values of cropland owned by large institutional investors over a shorter time horizon, as described shortly, and we also benchmark our findings with evidence from the literature on U.K. agricultural real estate values.

Our primary measure of long-run residential real estate values comes from the housing price series produced by Shiller (2005), which we cross-reference with the Jordà et al. (2019) series. As Appendix A.2 describes more thoroughly, Shiller (2005) stitches together a variety of datasets to produce a series of owner-occupied real estate values extending back to 1890 that begins to adjust for housing quality in the 1950s. As we describe below, our results are robust to using unadjusted median home values from the U.S. Census. As with agricultural real estate, we supplement our main empirical analysis with data from large institutional investors.

Many of our framework's empirical predictions concern the cross-section of residential and agricultural real estate values. Documenting these patterns requires us to shorten our time horizon to the medium run, specifically the latter half of the 20th century. This focus

enables us to hold fixed the set of cross-sectional units, since several U.S. territories had not attained statehood until the 1950s. We measure the cross-section of agricultural real estate values using state-level dollars per acre, again from the USDA's Annual Survey. For residential real estate, we primarily use the Federal Housing Finance Authority's (FHFA's) state-level price index, which begins in 1975.

Lastly, unless otherwise stated, we study real outcomes. We deflate nominal outcomes by the full Consumer Price Index (CPI) or historical analogues to CPI from the Federal Reserve Bank of Minneapolis described in Appendix A.

2.2 Fact 1: The Agricultural-Residential Return Spread

Our primary fact is that the price returns to agricultural real estate exceed those from other forms of real estate, particularly residential real estate, in the U.S. over the medium-to-long run. We call this positive difference the "agricultural-residential return spread". We summarize this fact in Panel A of Table 1, based on a variety of datasets. The first row summarizes the agricultural-residential return spread over the medium run using the FHFA data on residential real estate values, which will feature prominently in our cross-sectional tests later in the paper. The corresponding spread over the 1975-2020 period equals 0.46% on an annualized basis, or 35% cumulatively. Note that this time period begins shortly before a severe drop in agricultural real estate values associated with the 1980s Farm Crisis (Appendix Figure A.5), and so the estimate in this first row plausibly understates the long-run agricultural-residential spread. In fact, the second row of Table 1 reports a long-run spread of 0.66% over 1890-2020 based on the Shiller (2005) data, or around 290 pps cumulatively. The Jordà et al. (2019) data provide a similar result of 0.61% over 1890-2020, as shown in the third row.

The results in Figure 1 further emphasize how these differences in annualized returns translate into large differences in cumulative returns over the long run. This figure plots the cumulative real value of U.S. agricultural real estate over 1850-2020 with the cumulative real value of the Shiller (2005) index. Both series are shown at the decadal frequency, which is the frequency at which the Shiller (2005) index is observed in the early part of the sample.[4] Compared to the results in Table 1, the dynamics in Figure 1 imply that the spread in price return between agricultural and residential real estate is not driven by spectacular growth in any particular time period.[5]

[4]Davis and Heathcote (2007) note that the Shiller (2005) quality adjustment may understate house price growth over the 1970s. So in Appendix Figure A.1, we truncate the Shiller (2005) series when it begins to quality-adjust in the 1950s and replace it thereafter with unadjusted median home values from the decennial census. We still observe a positive agricultural-residential return spread over the sample period.

[5]While we are primarily interested in long-run growth rates as opposed to cylicality, we note three

The remainder of this subsection assesses robustness and extensions of this basic fact.

Non-Transactions-Based Data

Calculating residential price returns using median home values from the decennial Census holds fixed the method of data collection. In particular, some of the time periods in the Shiller (2005) index measure residential real estate values using sales prices from transactions, while others rely on values reported to the Census Bureau or other government enumerator. Since our data on agricultural real estate values come from USDA's census enumerators, we hold fixed the method of data collection by calculating residential real estate values using median home values from the decennial Census. The results in the fourth row of Table 1 imply a similar agricultural-residential real estate spread of 0.4 pps over 1950-2020.

Growth Across U.S. States

Our results in the next subsection regarding Fact 2 suggest that the larger growth in agricultural real estate values is not due to any particular region. Suggestive of this point, Figure 2 also uses data on residential real estate values from the decennial census to plot agricultural and residential price returns for four states with the most agricultural output in each of the four U.S. census divisions. The four states are California (West Division, first largest output nationally), Iowa (Midwest Division, second largest output nationally), Florida (South Division, 11th largest output nationally), and Pennsylvania (Northeast Division, 23rd largest output nationally). From 1950 through 2021, Florida saw remarkable growth in the value of agricultural land, which was 2.5 times greater than the growth in residential real estate values. During this period, the value of agricultural land grew at twice the rate of residential real estate in Pennsylvania, and at 1.6 times the rate in Iowa. In California the value of agricultural land and residential real estate grew at the same rate.[6]

interesting dynamics in Figure 1. First, the mid-2000s housing boom does not appear in the residential return series because we are plotting values decade-by-decade. By 2010, real home values in this series had returned to their 2000 level. Second, the remarkable swing in agricultural land values during the 1980s is due to the combination of a credit crunch on farm loans and unusual temperatures (e.g., Bergman, Iyer and Thakor 2020). Third, the decline in agricultural land values in the 1930s coincides with the Dust Bowl that severely reduced crop output in the southwestern Great Plains.

[6] Appendix Figure A.2 contains a similar figure at the annual frequency based solely on data on agricultural real estate values from the USDA. The figure plots these values for California, Iowa, Illinois and Minnesota. These states ranked highest in terms of cropland sales in the USDA's most recent Census of Agriculture (2022).

Total Returns to Institutional Real Estate Investments

We focus primarily on price returns, but, using a sample of data on institutional investments in real estate, we also document a similar agricultural-residential spread in terms of real total return (i.e., price return plus income return). The data come from the portfolio of investors associated with the National Council of Real Estate Fiduciaries, which invests on the behalf of large tax-advantaged institutions, as described in Appendix A. In Figure 3, we plot the cumulative return to the NCREIF sub-portfolios consisting of permanent and row cropland beginning in 1991, when our data begin. We plot the analogous return to the NCREIF residential and office sub-portfolios, respectively.

From 1991 through 2006, the total returns to agricultural real estate (i.e., cropland in this figure) and the other forms of real estate had similar cumulative total return.[7] After 2006, cumulative total returns to office real estate started to slow. After 2008, a large drop in total returns made residential real estate lag behind cropland. Cropland had a positive growth in total returns from 1991 through 2021. Since 2012, the total returns to permanent cropland accelerated faster than row cropland and other forms of real estate. From 2021 to 2024, permanent cropland's cumulative return decreased, while row cropland's cumulative return increased compared to the previous decade.

Panel B of Table 1 tabulates the difference in average annual total returns between agricultural and residential real estate in the NCREIF portfolio, which varies from 1.1 pps for row cropland to 2.8 pps for permanent cropland. Panel A of Table 1 shows how the price return to agricultural real estate is also higher than residential real estate within the NCREIF portfolio.

Comparison to Literature on U.K. Real Estate

Chambers, Spaenjers and Steiner (2021) collect data on institutional investment in U.K. real estate over 1901-1983 and report that the annualized capital gains on agricultural land exceed those on residential real estate by 1.8 pps to 2.2 pps per year (c.f. Table 7). Similar absolute capital gains on U.K. agricultural land are found by Jadevicius et al. (2018), as noted in the same table. These values exceed our baseline spread of 0.7 pps shown in Table 1, suggesting that our results may be conservative. Interestingly, the spread that we compute using institutional investment shown in the fifth row of Table 1 (1.89%) lies closer to the

[7]Total return includes income, which can come from directly operated cropland or rented cropland. Appendix Figure A.3 documents similar dynamics for both types of cropland separately within the NCREIF portfolio. Appendix Figure A.4 documents similar dynamics for the subsets of cropland in California and Illinois, the two primary states in the NCREIF portfolio. This latter finding supports the result shown in Figure 2.

value of Chambers, Spaenjers and Steiner (2021), who also collect data from institutional investments. Loosely, this suggests that institutional investors under and over-perform in their residential and agricultural sub-portfolios, respectively, compared to investing in the aggregate real estate portfolio.

2.3 Fact 2: Dispersion in Agricultural and Residential Return

Our secondary fact is that the cross-sectional dispersion in agricultural price returns is smaller than the dispersion in residential price returns. As mentioned in Section 2.1, we perform this analysis at the level of the U.S. state and use data on residential real estate from the FHFA and our baseline data on agricultural real estate values from the USDA's Annual Survey.[8]

Figure 4 shows the cross-sectional relationship between a state's 1975-2020 change in log real residential real estate values and the same change in log real agricultural real estate values. The majority of states are above the 45-degree line, in line with the positive aggregate agricultural-residential spread shown in the first row of Table 1. Visually, the figure seems to demonstrate greater variation along the horizontal axis (residential real estate values) than along the vertical axis (agricultural real estate values). A similar result holds qualitatively when measuring residential real estate values using median home prices from the decennial Census (Appendix Figure A.6).

We verify and quantify the visual pattern suggested in Figure 4 by calculating the standard deviation of state-level real estate price returns (i.e., change in log real estate values) over 1975-2020 across U.S. states. The results are shown in Panel A of Table 2. For residential real estate, this cross-state standard deviation in return equals 0.7%, or 126% of average price return. By contrast, the cross-state standard deviation in price return for agricultural real estate equals only 0.61%, or 43% of the corresponding price return. For reference, Panel B computes similar statistics based on aggregate returns for the two types of real estate, finding that the aggregate (i.e., time series) standard deviation of agricultural real estate (5.7%) exceeds that of residential real estate (3.8%). This result implies that cross-sectional dispersion accounts for a much larger share of total variance in price return for agricultural than for residential real estate. Our framework explains this finding by noting that agricultural land typically produces a tradable good, food, whereas residential land produces a non-tradable good, housing services.[9]

[8] We perform most of our cross-sectional analysis using long-differences over the 1975-2020 period because the FHFA data begin in 1975. As noted above, studying this period tends to dampen the level of price returns to agricultural real estate because it comes shortly before the Farm Crisis of the 1980s (Appendix Figure A.5). However, this is not of great concern because we are now interested in cross-sectional differences.

[9] Our framework is deterministic but implies a positive secular trend in the price return to agricultural real estate, as documented in Proposition 1. This secular trend raises the time-series standard deviation of

3 Framework

Households, farmers, and builders inhabit a continuum of identical economies on the unit interval indexed by j. Time evolves continuously, and all agents have the discount rate r.

3.1 Households

Given our interest in production, we model households rather simply. They have preferences $u(h_t, c_t)$ over shelter h_t and food c_t consumed at time t. The utility function u satisfies the Inada condition in both arguments and implies demand curves with finite but non-zero same-price elasticities. We work with the particular functional form

$$u(c_t, h_t) = c_t^{1-\alpha} h_t^{\alpha}. \tag{1}$$

Households live for one period and receive an endowment $y_{j,t} = e^{g_j t}$, in units of an exogenous numeraire. Aggregate income is $Y_t = \int_j e^{g_j t} dj \equiv e^{gt}$, by symmetry. The aggregate population grows at rate η, so that the number of households at time t is $e^{\eta t}$. We assume $r > g + \eta$ to ensure the problem is well-defined.

Shelter produced in j must be consumed in j, but food can be traded across economies. Let $q_{j,t}$ denote the price of shelter in j, which we interpret as quality-adjusted rent. The aggregate price of food is p_t. Given the preferences (1), a household in j chooses

$$c_{j,t}^* = (1-\alpha) y_{j,t} p_t^{-1}, \tag{2}$$

$$h_{j,t}^* = \alpha y_{j,t} q_{j,t}^{-1}. \tag{3}$$

We abstract from household mobility across economies, which is redundant for now as all economies are symmetric.

3.2 Farmers

Each economy j has habitable land described by the interval $[0, \mathcal{L})$. A subset of habitable land, $[0, \overline{L}]$, has fertile soil that can be used to cultivate crops. A given unit of fertile soil produces $e^{\theta_j t}$ units of food. We introduce θ_j to aid in deriving testable implications, but our main theoretical results hold when omitting this parameter by setting $\theta_j = 0$. A measure

agricultural price returns relative to residential price returns, consistent with Panel B of Table 2, and it does not rely on uncertainty. However, we do not press this point because the dynamics in Figure 1 suggest that much of the time series variation in agricultural price returns arises from cyclicality, rather than solely from trend growth in returns.

one of farmers in each economy is endowed with $\overline{L}$ units of agricultural land and chooses to cultivate $L_{j,t} \leq \overline{L}$. A farmer already cultivating $L_{j,t}$ units of land in j earns

$$p_t e^{\theta_j t} L_{j,t} \tag{4}$$

of profit at time t.

Farmers can till $I^C_{j,t}$ units of new agricultural land at a cost

$$\frac{1}{2}(I^C_{j,t})^2 \tag{5}$$

in units of numeraire. We focus on the simplifying case in which agricultural land does not "depreciate,"

$$\dot{L}_{j,t} = I^C_{j,t}, \tag{6}$$

which may be interpreted as either the costless re-planting of row crops (e.g., corn) or the planting of a truly permanent crop (e.g., tree nuts).[10]

Farmers maximize

$$V^C(L_{j,t}) = \max_{\{I^C_{j,\tau}\}} \int_t^\infty e^{-r(\tau - t)} \left[p_\tau e^{\theta_j \tau} L_{j,\tau} - \frac{1}{2}(I^C_{j,\tau})^2 \right] d\tau, \tag{7}$$

subject to

$$L_{j,\tau} \leq \overline{L} \tag{8}$$

for all τ and the law of motion in equation (6), $\dot{L}_{j,\tau} = I^C_{j,\tau}$. From the demand curve (2), the price of food p_τ will depend on aggregate crop production and, thus, aggregate cultivated agricultural land. However, individual farmers take p_τ as given. In particular, when constraint (8) does not bind, cultivated land evolves according to L^*_t,where L^*_t is the solution to

$$r\dot{L}_{j,t} = \ddot{L}_{j,t} + e^{\theta_j t} \underbrace{\frac{(1-\alpha)e^{(g+\eta)t}}{e^{\theta t} L_t}}_{p_t}, \tag{9}$$

where $e^{\theta t} \equiv \int_j e^{\theta_j t} dj$ and, by symmetry, $L_{j,t} = L_t \equiv \int_j L_{j,t} dj$ for all j. Appendix Lemma 1 derives equation (9).

[10] A single dot above a variable denotes a first derivative with respect to time: $\dot{X}_t = \frac{dX_t}{dt}$. A double dot denotes a second derivative: $\ddot{X}_t = \frac{d^2 X_t}{dt^2}$.

Equation (2) also implies that aggregate crop demand, C_τ, scales with aggregate income, Y_τ,which grows at rate g. Since aggregate demand equals aggregate supply in equilibrium, we have $C_\tau = \int_j \theta_j L_{j,\tau} dj = \theta L_\tau$, where $\theta \equiv \int_j \theta_j dj$ and $L_{j,\tau} = L_\tau$ for all j, by symmetry. This implies that cultivated land also grows until it reaches the resource constraint $\overline{L}$. Let $T < \infty$ denote the time when the economy reaches this constraint, which we assume exists. In particular, T solves

$$\overline{L} = L_T^*. \tag{10}$$

For $t \geq T$, farmers' value function equals

$$\overline{V}_t^C = \int_t^\infty e^{-r(\tau - t)} \frac{(1-\alpha)e^{(g+\eta)\tau}}{L_\tau} d\tau = \left[\frac{1-\alpha}{r-\eta-g}\right] \overline{L}^{-1} e^{(g+\eta)t}, \tag{11}$$

which is well-defined given $r > g+\eta$ and also implies that $V^C(L_{j,t})$ satisfies the transversality condition: $\lim_{t\to\infty} e^{-rt}\overline{V}_t^C = 0$.

3.3 Builders

Shelter is produced by homes. Unlike agricultural land, homes can be developed on any kind of soil in the interval $[0, \mathcal{L})$. A given plot of land in economy j has $k_{j,t}$ homes on it. These homes produce $h_{j,t} = \xi_j k_{j,t}$ units of shelter, where ξ_j governs residential amenities. Since we do not focus on variation in residential amenities in our empirical analysis, we simply set $\xi_j = 1$. The total amount of shelter produced in j is then

$$H_{j,t} = K_{j,t}, \tag{12}$$

where $K_{j,t}$ denotes the housing stock. The owners of the housing stock in j earn profit

$$q_{j,t} K_{j,t}. \tag{13}$$

As with agricultural land, the housing stock does not depreciate.

A builder who builds $I_{j,t}^H$ homes on a given plot of land retains a claim to the profit produced by those homes, described by equation (13). The cost of developing these homes is

$$\frac{\psi_j}{2}(I_{j,t}^H)^2, \tag{14}$$

in units of numeraire. The quadratic cost function in equation (14) is standard, but it also conveys a particular economic message regarding the costs of density. Essentially, significant

expansions of the housing stock in a short amount of time ($I^H_{j,t}$ large) require building vertically, which is costly (e.g., RSMeans 2021). The parameter ψ_j governs these costs and has natural empirical analogues in measures of land use regulation (e.g., Gyourko, Saiz and Summers 2008) or topography (e.g., Saiz 2010). As with θ_j, we introduce ψ_j to derive testable implications, but our main theoretical result does not require this parameter.

Builders maximize a similar objective as farmers, but without the land constraint (8). Specifically, they solve

$$V^H(K_{j,t}) = \max_{\{I^H_{j,\tau}\}} \int_t^\infty e^{-r(\tau-t)} \left[q_{j,\tau} K_{j,\tau} - \frac{\psi_j}{2} (I^H_{j,\tau})^2 \right] d\tau, \tag{15}$$

subject to the law of motion

$$\dot{K}_{j,t} = I^H_{j,t}. \tag{16}$$

As with individual farmers, developers also do not internalize that their decisions affect rents $q_{j,\tau}$ through the demand curve (3), and so the solution takes a similar form as equation (9) but depends on local growth in income (g_j) and population (η_j), not aggregate growth.[11]

3.4 Relative Growth in Real Estate Values

Suppose a fringe of investors is willing to pay fair value for a unit of cultivated agricultural land in j at time t. This value equals

$$P_{j,t} = \int_t^\infty e^{-r(\tau-t)} e^{\theta_j \tau} p_\tau d\tau, \tag{17}$$

which evolves according to

$$\dot{P}_{j,t} = r P_{j,t} - e^{\theta_j t} p_t, \tag{18}$$

[11] Explicitly, $K^*_{j,t}$ solves $r\psi_j \dot{K}_{j,t} = \psi_j \ddot{K}_{j,t} + \frac{\alpha e^{(g_j+\eta_j)t}}{K_{j,t}}$, shown in appendix Lemma 1.

which maps empirically to dollars-per-acre studied in our empirical analysis.[12] The analogous value for residential real estate is

$$Q_{j,t} = \int_t^\infty e^{-r(\tau-t)} q_{j,\tau} d\tau, \tag{19}$$

which maps empirically to quality-adjusted home values and evolves according to

$$\dot{Q}_{j,t} = rQ_{j,t} - q_{j,t}. \tag{20}$$

Define the price returns to agricultural and residential real estate as

$$r^C_{j,t} = \frac{d\log(P_{j,t})}{dt}, \tag{21}$$

$$r^H_{j,t} = \frac{d\log(Q_{j,t})}{dt}. \tag{22}$$

The following proposition provides a theoretical explanation for why, as in Figure 1, the long-run price return to agricultural real estate exceeds that of residential real estate.

Proposition 1 *There exists* $0 < \tilde{L}_t < \mathcal{L}$ *such that, for* $\overline{L} \leq \tilde{L}_t$*, the relative return to agricultural real estate exceeds the relative return to residential real estate in all economies:*

$$r^C_{j,t} > r^H_{j,t}. \tag{23}$$

Moreover, for any $\overline{L}$*:*

$$\frac{\partial}{\partial \overline{L}} \left[r^C_{j,t} - r^H_{j,t} \right] > 0. \tag{24}$$

Proposition 1 provides a theoretical explanation for the difference in price return documented in Table 1. This theoretical result arises because the aggregate supply of cultivated agricultural land becomes perfectly inelastic in the very long run. By contrast, the supply of housing retains some elasticity because it is not bound by a constraint analogous to (8), which we interpret as reflecting how housing can be built on infertile land and has the potential for density. In the presence of exogenous population growth η, this wedge in very long-run supply elasticities gives rise to significant differences in the spot price of the dividends produced by the two types of real estate in the very long run. Since the land prices in equations (17) and (19) are forward-looking, these very long-run differences imply a lower capitalization rate (i.e., higher land price) for agricultural real estate. To maintain the same

[12] Equation (17) may appear similar to the marginal value of a unit of cultivated agricultural land from a farmer's perspective, but it differs because it does not account for the shadow cost of cultivation in tightening the land constraint in the future, as we show in Appendix Lemma 1.

required rate of total return, r, this lower capitalization rate must come with a higher price return. This can be seen explicitly by dividing equation (18) by P_t.[13]

The parameter $\overline{L}$ governs the degree of this very long-run supply inelasticity. When $\overline{L}$ is small, fertile soil is extremely scarce, and so the supply of cultivated agricultural land becomes perfectly inelastic more quickly. This intuition explains why, as in equation (24), restricting $\overline{L}$ raises the relative price return of cropland compared to residential real estate. The fact that the price of agricultural real estate tends towards infinity as the amount of fertile soil approaches zero further explains why there must exist some $\overline{L}$ below which agricultural real estate appreciates at a higher rate than residential real estate, per equation (23).

4 Testable Implications and Evidence

In this section, first we derive testable implications of the previous model, summarizing them in Proposition 2. Then we evaluate whether the data support these predictions.

4.1 Testable Implications

We can derive testable implications of the model by perturbing some measurable parameter μ_j by $d\mu_j$,which, because each economy j is atomistic, does not change the aggregate value of the parameter, μ. The following proposition collects a set of predictions that we can take to the data.

Proposition 2 *The following derivatives hold,*

$$\frac{\partial}{\partial g_j}\left[r^C_{j,t} - r^H_{j,t}\right]\Big|_{y_{j,t}} < 0, \tag{25}$$

$$\frac{\partial}{\partial \psi_j}\left[r^C_{j,t} - r^H_{j,t}\right] < 0, \tag{26}$$

$$\frac{\partial}{\partial \theta_j}\left[r^C_{j,t} - r^H_{j,t}\right] > 0. \tag{27}$$

Equation (25) arises because future housing rents in economy j depend on income growth in economy j. However, because crops are tradable, future crop prices paid by households in

[13]A limitation of our framework is the inability to explain the difference in total return noted in Panel B of Table 1. The total return, that is, the sum of price growth and the capitalization rate, equals r for both types of real estate in our framework. In a stochastic setting with risk-averse producers, a wedge between total returns may arise if producers require a risk premium due to, for example, unique shocks to agricultural output. Such a setting may still feature higher price return on agricultural real estate due to very long-run land scarcity, provided the capitalization rate on agricultural real estate does not rise too much due to the introduction of dividend risk.

economy j depend on aggregate income growth. Consequently, holding current income-per-capita $y_{j,t}$ fixed, a negative shock to income growth rate in economy j lowers future demand for housing and thus the vaue of residential real estate. By contrast, the value of agricultural land in j does not change. As a result, the spread $r^C_{j,t} - r^H_{j,t}$ increases.

Equations (26) and (27) arise because shocks specific to the production of crops or housing services do not affect the price of residential or agricultural real estate, respectively. For example, equation (26) reflects how higher costs of residential development reduce the supply of housing, which raises the value of residential real estate and, thus, by equation (20), the price return to residential real estate. However, the return to agricultural real estate is unchanged, so that an increase in ψ_j corresponds to a decrease in the spread $r^C_{j,t} - r^H_{j,t}$. On the other hand, raising the productivity of agricultural land, θ_j, raises the growth in the value of agricultural real estate while not affecting the value of residential real estate. Consequently, an increase in θ_j corresponds to an increase in the spread $r^C_{j,t} - r^H_{j,t}$, as shown in equation (27).

4.2 Evidence

Empirical Proxies for Model Parameters

We evaluate the predictions in Proposition 2 by first constructing empirical proxies for the parameters g, ψ, and θ. We proxy for g using the 10-year rolling growth rate in log income per capita, obtained from the Bureau of Economic Analysis's Personal Income by State dataset. The fact that this proxy varies over time enables us to include a state fixed in our empirical analysis, which enables an empirical comparison that more closely resembles the theoretical comparison made in Proposition 2.

Our proxies for ψ and θ do not vary over time. In particular, we proxy for ψ using the Wharton Residential Land Use Regulation Index developed by Gyourko, Saiz and Summers (2008). This index derives from textual analysis of municipal land use codes. We aggregate the metro-level index values from Gyourko, Saiz and Summers (2008) to the state level using their proposed weights and standardize the resulting index to have a mean of zero and a variance of one.

Lastly, we proxy for θ using data on soil capability, from the USDA's Soil Survey Geographic Database (SSURGO). This database contains information on limitations on the types of crops that can be grown on a given piece of land based on the land's soil as of 2023. The data are collected in the field from soil samples and other measurements, and then aggregated to a given micro-geography. Cole et al. (2017) effectively audit the SSURGO data by comparing it to data independently obtained from the field, finding that the SSURGO

data have a high level of accuracy and can be used to predict other non-sampled variables like the soil's infiltration rate. As described in Appendix A, we aggregate the raw data from the micro-geography level to the state level, and then we restrict to the subset of land in a state with little or no erosion. Within this subset of land with minimally-eroded soil, which we call "potential cropland," we compute the share with few or moderate limitations. This share serves as our proxy for θ.

Results

Figure 5 evaluates prediction (25): $\frac{\partial}{\partial g_j}\left[r^C_{j,t} - r^H_{j,t}\right]\Big|_{y_{j,t}} < 0$. Using data over 1975-2020, we produce a scatterplot of the 10-year rolling growth rate in log agricultural real estate value minus the same growth rate of residential real estate value against the 10-year rolling growth rate in log income per capita (i.e., g) described above.[14] The figure shows a significant negative relationship between the agricultural-residential spread and income per capita, consistent with inequality (25). In particular, the slope of the best-fit line is -1.53, which is statistically significant. Appendix Figure A.7 contains an analogous scatterplot in terms of aggregate income by state, not income per capita, and finds the same result as in Figure 5.

Figure 6 evaluates prediction (26): $\frac{\partial}{\partial \psi_j}\left[r^C_{j,t} - r^H_{j,t}\right] < 0$. This figure is a scatterplot of the change in state-level log agricultural real estate value over 1975-2020 minus the same change in log residential real estate value against the proxy for ψ, which, again, is measured by the degree on residential land use regulation. The result implies a significant negative relationship between the agricultural-residential return spread and this proxy for ψ. For example, the slope of the best-fit line is -0.20, which is statistically significant.

Figure 7 evaluates prediction (27) in a similar fashion as the previous two figures. Explicitly, the figure contains the same variable on its vertical axis as in Figure 6, but the variable on the horizontal axis is now the proxy for θ, namely the share of soil on potential cropland that has few or moderate limitations on crop use. The slope of the best-fit line is 0.45, with a standard error of 0.23. That is, there is a positive relationship between the agricultural-residential value gap and soil, consistent with the prediction $\frac{\partial}{\partial \theta_j}\left[r^C_{j,t} - r^H_{j,t}\right] > 0$.

[14] Each observation corresponds to a state-year pair, and the plot is binned so that each point is an average of around 20 state-year pairs. The observations are residualized against a state fixed effect so that the comparison holds fixed time-invariant characteristics at the state level. The state fixed effects absorb the two other conditioning variables studied in this subsection, namely the proxies for ψ and θ just described. Symmetrically, Figure 6 contains a proxy for ψ on its horizontal axis, and so it residualizes against the change in log income per capita over 1975-2020 (i.e., g) and the proxy for θ. Likewise, Figure 7 contains a proxy for θ on its horizontal axis, and so it residualizes against the same change in log income per capita over 1975-2020, as well as the proxy for ψ. The latter two figures cannot include a state fixed effect because the proxies for ψ and θ do not vary over time.

5 Conclusions

In this article, we investigate the price return on agricultural real estate and compare it to the return on other types of real estate, especially residential real estate. It is striking how there is a significant excess price return on agricultural real estate in the U.S., especially since 1950 and since the late 1990s. Moreover, agricultural real estate exhibits less cross-sectional dispersion than residential real estate.

We propose a framework that can explain such differences in the level and cross-sectional variance of the agricultural-residential return spread. The framework has two key ingredients. First, agricultural land produces a tradable good (food) while residential land produces a non-tradable good (housing services). Second, residential real estate is relatively more elastic because it can be built on infertile land and because it has the potential for vertical density. We do not claim that the previous explanations are the unique explanations, but we show support for them using cross-sectional data from U.S. states.

Future research will dig further on the excess price return on agricultural real estate empirically. For example, we plan to build repeat-sale indices for the two types of real estate based on transaction-level data. We also plan to incorporate medium-run dynamics into the framework so that we can better understand time-varying incentives to convert from agricultural to residential land and vice versa. More broadly, we will think about incorporating and empirically testing alternative drivers that so far we have not considered. For example, it may be that agriculture land is more illiquid than residential land. Another idea to consider is that unproductive agricultural real estate is converted into either residential real estate while productive agricultural real estate continues to expand. This reallocation may further contribute to the agricultural-residential return spread.

References

American Farmland Trust: 2020, Farms under threat: The state of the states.

Bergman, N. K., Iyer, R. and Thakor, R. T.: 2020, The effect of cash injections: Evidence from the 1980s farm debt crisis, *The Review of Financial Studies* **33**(11), 5092–5130.

Bernstein, A., Gustafson, M. T. and Lewis, R.: 2019, Disaster on the horizon: The price effect of sea level rise, *Journal of Financial Economics* **134**(2), 253–272.

Brain, R., Perkins, D., Ghebremichael, L., White, M., Goodwin, G. and Aerts, M.: 2023, The shrinking land challenge, *ACS Agricultural Science & Technology* **3**(2), 152–157.

Chambers, D., Spaenjers, C. and Steiner, E.: 2021, The rate of return on real estate: Long-run micro-level evidence, *The Review of Financial Studies* **34**(8), 3572–3607.

Cole, S., Mikhailova, E., Post, C., Privette, C., Schlautman, M. A. and Cope, M.: 2017, Comparing ssurgo data with geospatial field measurements to estimate soil texture and infiltration rate classes in glaciated soils, *Communications in Soil Science and Plant Analysis* **48**(11), 1309–1318.

Davis, M. A. and Heathcote, J.: 2007, The price and quantity of residential land in the united states, *Journal of Monetary Economics* **54**(8), 2595–2620.

Davis, M. A., Ortalo-Magne, F. and Rupert, P.: 2007, What's really happening in housing markets?, *Federal Reserve Bank of Cleveland Economic Commentary* .

Eichholtz, P.: 1997, A long run house price index: The herengracht index, 1628–1973, *Real Estate Economics* **25**(2), 175–192.

Eichholtz, P., Korevaar, M., Lindenthal, T. and Tallec, R.: 2021, The Total Return and Risk to Residential Real Estate, *The Review of Financial Studies* **34**(8), 3608–3646.

Ganong, P. and Shoag, D.: 2017, Why has regional income convergence in the u.s. declined?, *Journal of Urban Economics* **102**, 76–90.

Gete, P., Tsouderou, A. and Wachter, S. M.: 2024, Climate risk in mortgage markets: Evidence from hurricanes harvey and irma, *Real Estate Economics* **52**, 660–686.

Giglio, S., Maggiori, M., Rao, K., Stroebel, J. and Weber, A.: 2021, Climate change and long-run discount rates: Evidence from real estate, *The Review of Financial Studies* **34**(8), 3527–3571.

Glaeser, E. and Gyourko, J.: 2018, The economic implications of housing supply, *Journal of Economic Perspectives* **32**(1), 3–30.

Glaeser, E. L., Gyourko, J. and Saks, R. E.: 2005, Why have housing prices gone up?, *American Economic Association Papers and Proceedings* **95**(2), 331–335.

Grebler, L., Blank, D. M. and Winnick, L.: 1956, *Capital Formation in Residential Real Estate: Trends and Prospects*, Princeton University Press.

Gyourko, J., Mayer, C. and Sinai, T.: 2013, Superstar cities, *American Economic Journal: Economic Policy* **5**(4), 167–199.

Gyourko, J., Saiz, A. and Summers, A.: 2008, A new measure of the local regulatory environment for housing markets: The wharton residential land use regulatory index, *Urban Studies* **45**(3), 693–729.

Hornbeck, R.: 2012, The enduring impact of the american dust bowl: Short and long-run adjustments to environmental catastrophe, *American Economic Review* **102**(4), 1477â1507.

Howard, G. and Liebersohn, J.: 2021, Why is the rent so darn high? the role of growing demand to live in housing-supply-inelastic cities, *Journal of Urban Economics* **124**, 103369.

Jadevicius, A., Huston, S., Baum, A. and Butler, A.: 2018, Two centuries of farmland prices in england, *Journal of Property Research* **35**, 72–94.

Jordà, Ò., Knoll, K., Kuvshinov, D., Schularick, M. and Taylor, A. M.: 2019, The rate of return on everything, 1870–2015, *The Quarterly Journal of Economics* **134**(3), 1225–1298.

Plazzi, A., Torous, W. and Valkanov, R.: 2010, Expected returns and expected growth in rents of commercial real estate, *The Review of Financial Studies* **23**(9), 3469–3519.

RSMeans: 2021, *Building Construction Costs with RSMeans Data 2022*, 79th edn, Gordian.

Saiz, A.: 2010, The geographic determinants of housing supply, *The Quarterly Journal of Economics* **125**(3), 1253–1296.

Sherrick, B.: 2020, The relationship between inflation and farmland returns, *Technical report*, TIAA Center for Farmland Research.

Shiller, R. J.: 2005, *Irrational Exuberance*, 2 edn, Princeton University Press; Broadway Books.

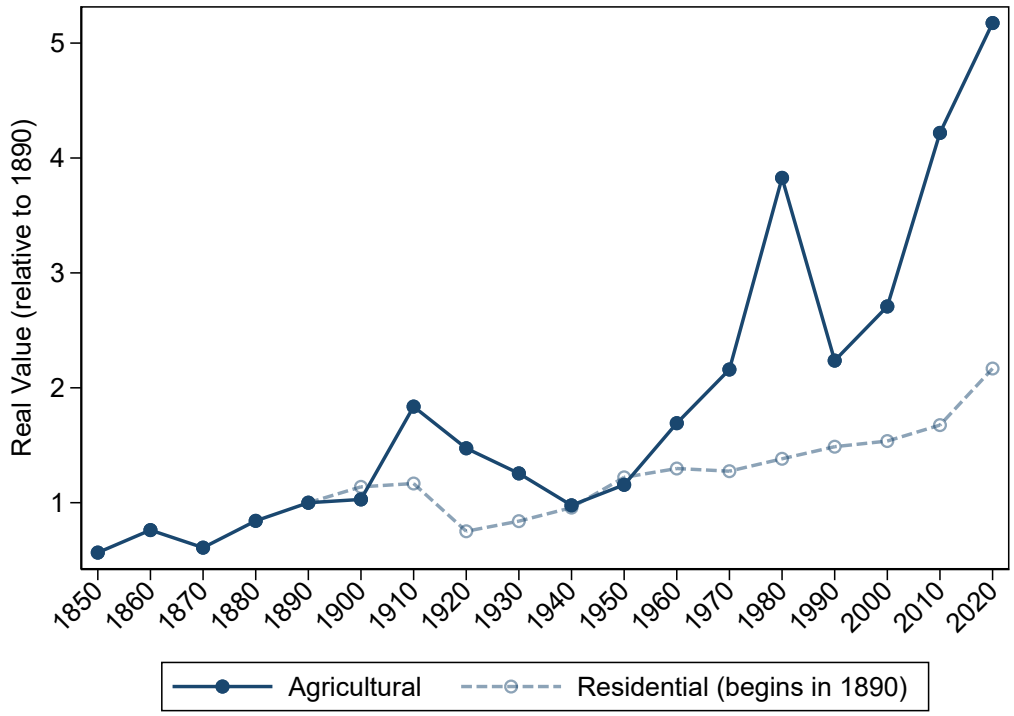
Smith, P., House, J. I., Bustamante, M., Sobocká, J., Harper, R., Pan, G., West, P. C., Clark, J. M., Adhya, T., Rumpel, C., Paustian, K., Kuikman, P., Cotrufo, M. F., Elliott, J. A., McDowell, R., Griffiths, R. I., Asakawa, S., Bondeau, A., Jain, A. K., Meersmans, J. and Pugh, T. A. M.: 2016, Global change pressures on soils from land use and management, *Global Change Biology* **22**(3), 1008–1028.

Van Nieuwerburgh, S. and Weill, P.-O.: 2010, Why has house price dispersion gone up?, *Review of Economic Studies* **77**(4), 1567–1606.

Wills, S. A., Williams, C. O., Duniway, M. C., Veenstra, J., Seybold, C. and Presley, D.: 2017, *Human Land-Use and Soil Change*, Springer International Publishing, Cham, pp. 351–371.

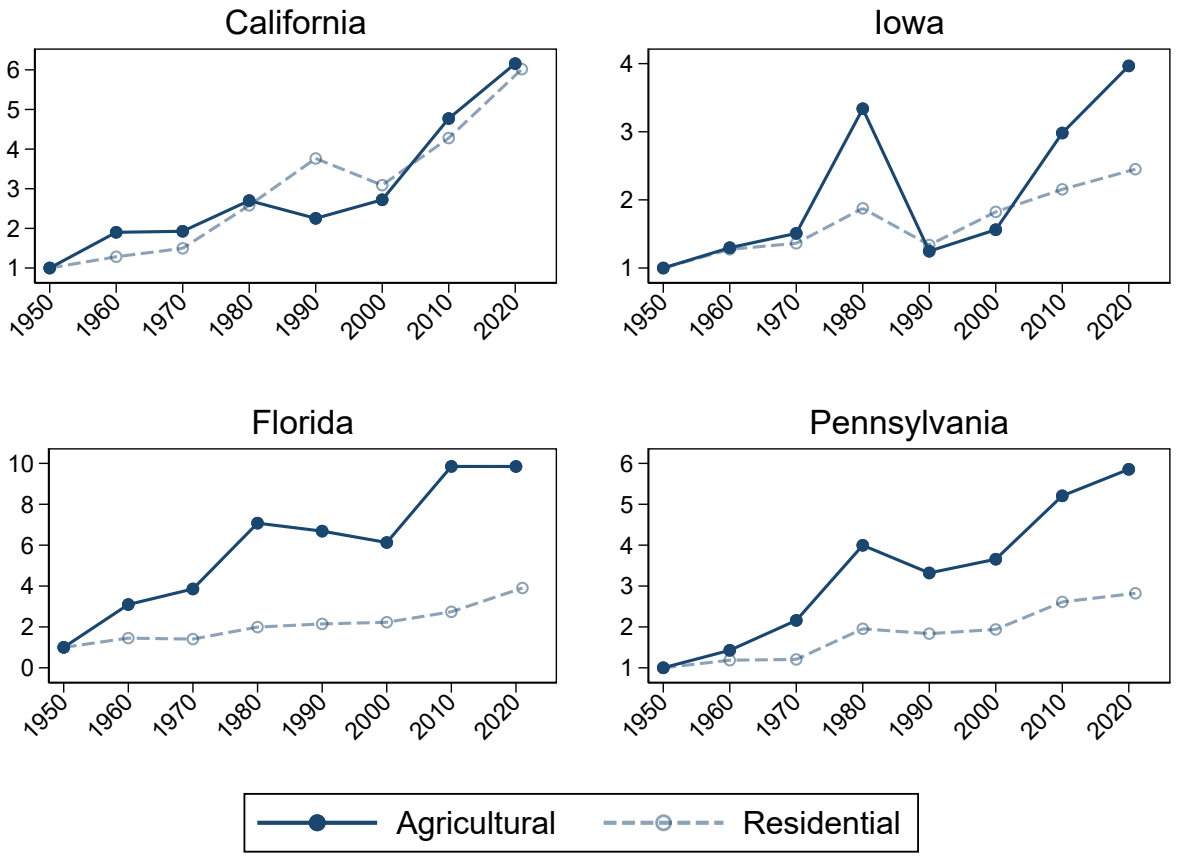
Figures and Tables

Figure 1: U.S. Agricultural and Residential Real Estate Values.



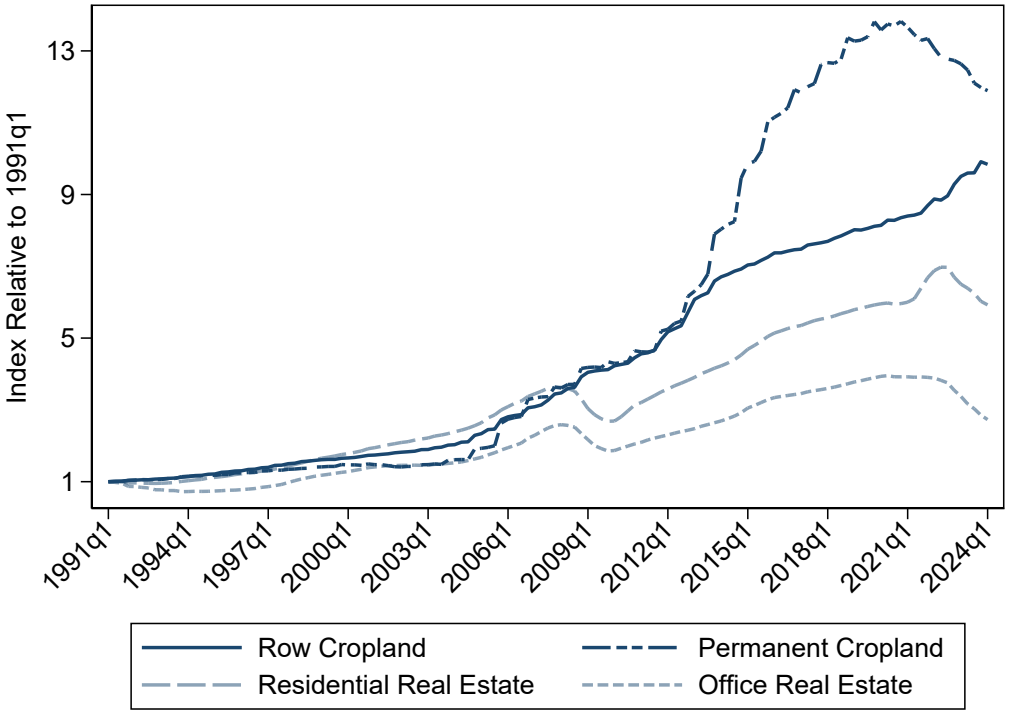
Note: This figure plots the real value of U.S. agricultural and residential real estate. Data on agricultural real estate values are from the USDA and are defined as the value of U.S. agricultural land, including buildings, in dollars per acre. Data on residential real estate values are from the Shiller (2005) nominal house price index and begin in 1890. Appendix A.2 describes the methodology used to compute the index. Nominal real estate values are converted to real values using the Federal Reserve Bank of Minneapolis' long-run consumer price index, described in Appendix A.3. The figure normalizes each series to equal one in 1890.

Figure 2: Real Agricultural and Residential Real Estate Values for Selected States



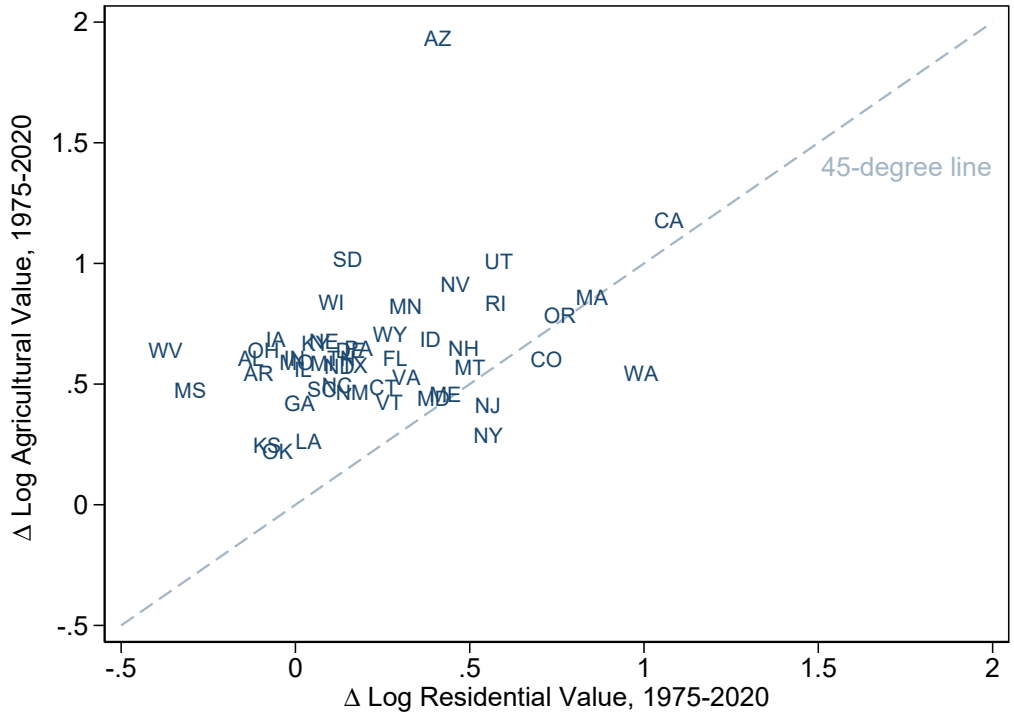
Note: This figure is analogous plots the real value of agricultural and residential real estate from 1950 through 2021. These values are shown for the state with the most agricultural output in each of the four U.S. census divisions. Agricultural output is measured based on cropland sales in the USDA's most recent agricultural census (2022). The four states are California (West Division, #1 nationally), Iowa (Midwest Division, #2 nationally), Florida (South Division, #11 nationally), and Pennsylvania (Northeast Division, #23 nationally). Data on agricultural real estate values come from the USDA's Annual Survey and are in units of dollars per acre. Data on residential real estate values are from the decennial census and are in units of median home value, in dollars. Dollars are converted to real values using CPI. All series are normalized to equal one in 1951.

Figure 3: Real Institutional Total Returns to Agricultural and Other Real Estate.



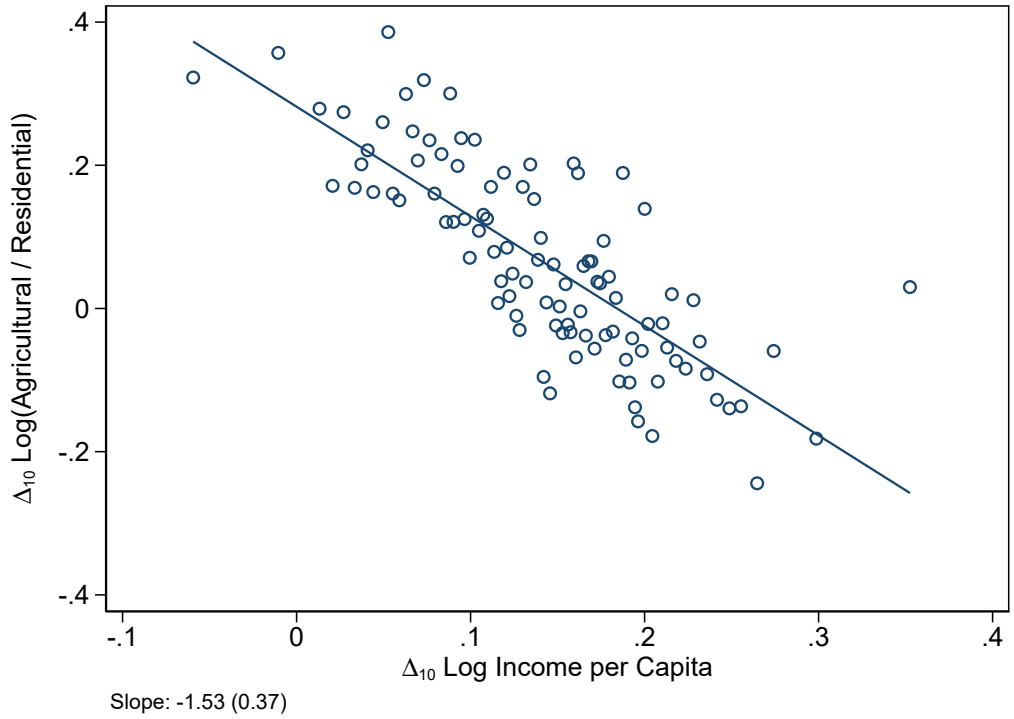
Note: This figure plots cumulative real returns to permanent and row cropland and to other forms of real estate. Returns are total returns and equal the sum of price appreciation and income return. All series are normalized to equal one in 1991, the earliest year in which the data begin, and are deflated by CPI. Data are from the National Council of Real Estate Investment Fiduciares (NCREIF), which invests on the behalf of large tax-advantaged institutions.

Figure 4: Cross-State Dispersion in Agricultural and Residential Price Return.



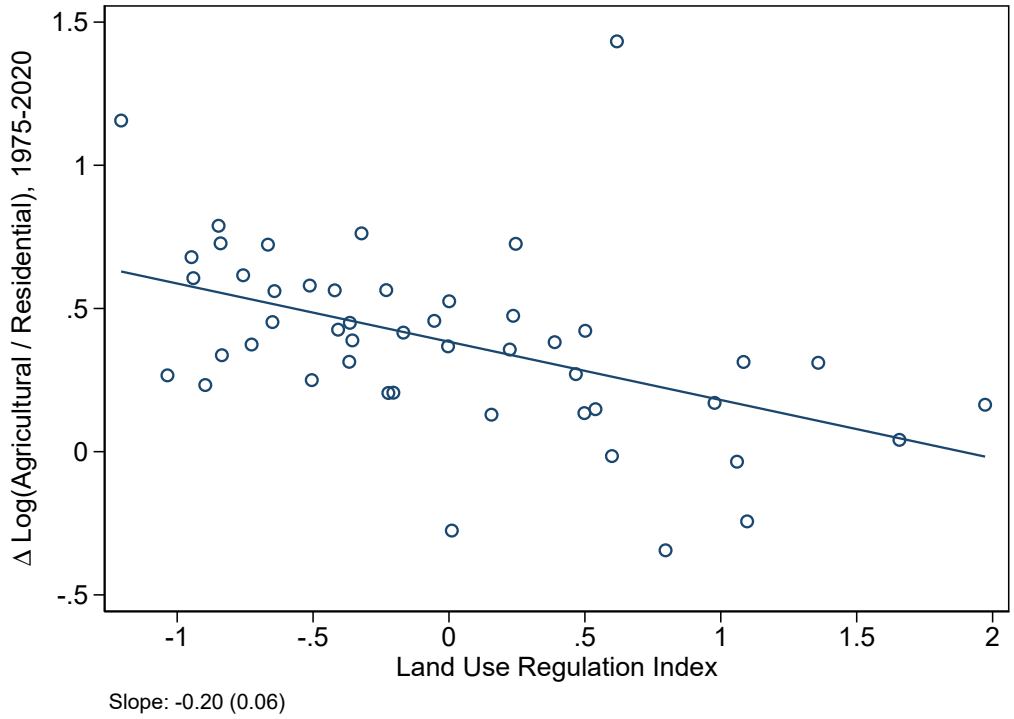
Note: This figure shows the cross-sectional relationship between a state's change in log real residential real estate values, shown on the horizontal axis, and the state's change in log real agricultural real estate values, shown on the vertical axis. The change is from 1975 through 2020. Data on agricultural real estate values come from land appraisals collected by the USDA and are in units of dollars per acre. Residential real estate values are measured using the FHFA All-Transactions Price Index. Variables are converted to real values using U.S. CPI-U, not state-level CPI-U.

Figure 5: Growth in Real Estate Values and State Income.



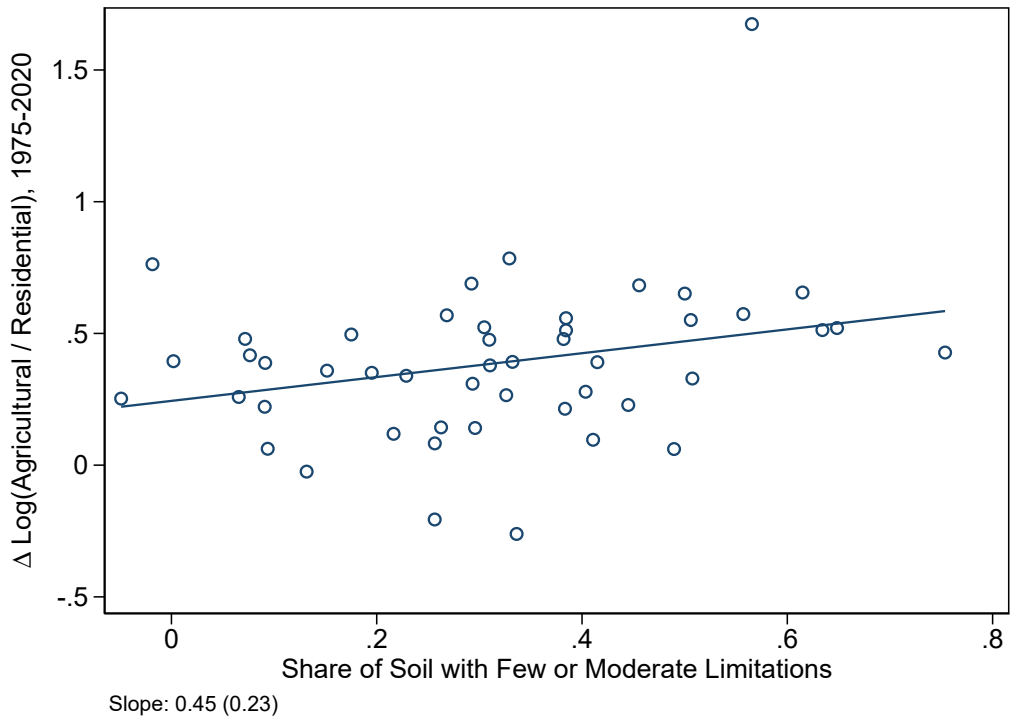
Note: This figure plots the relationship between the 10-year rolling growth rate in log agricultural real estate value minus the same growth rate of residential real estate value (vertical axis) and log income per capita (horizontal axis). Both variables are observed at the state-by-year level, and so each observation is a state-year pair. The plot is binned so that each point is an average of around 20 state-year pairs. The variables on the horizontal and vertical axes are first residualized against a state fixed effect, so that the comparison holds fixed time-invariant characteristics at the state level. Data on agricultural real estate values come from land appraisals collected by the USDA and are in units of dollars per acre. Data on residential real estate values are from the FHFA All-Transactions Price Index. Data on per-capita income are from the Bureau of Economic Analysis. Dollars are converted to real values using U.S. CPI-U, not state-level CPI-U. The figure note at the bottom reports the slope of the best-fit line with the standard error clustered by state.

Figure 6: Growth in Real Estate Values and State Land Use Regulation.



Note: This figure plots the relationship between the change in state-level log agricultural real estate value over 1975-2020 minus the same change in log residential real estate value (vertical axis) and the degree of land use regulation in that state (horizontal axis). Each point is a state. Land use regulations are measured using the Wharton Residential Land Use Regulation Index developed by Gyourko, Saiz and Summers (2008). The raw index is standardized to have a mean of zero and variance of one, and it is observed at the level of a local jurisdiction. We aggregate the index to the state level, weighting jurisdictions by their inverse probability of appearing in the metropolitan sample, using the weights computed and recommended by Gyourko, Saiz and Summers (2008). The variables on the horizontal and vertical axes are first residualized against the change in log income per capita, from the Bureau of Economic Analysis, and share of soil on potential cropland with few or moderate limitations on crop use, defined in detail in the note to Figure 7 and based on data from the USDA's Soil Survey Geographic Database (SSURGO). Data on agricultural real estate values come from land appraisals collected by the USDA and are in units of dollars per acre. Data on residential real estate values are from the FHFA All-Transactions Price Index.

Figure 7: Growth in Real Estate Values and State Soil Capability.



Note: This figure plots the relationship between the change in state-level log agricultural real estate value over 1975-2020 minus the same change in log residential real estate value (vertical axis) and the share of soil on potential cropland that has few or moderate limitations on crop use (horizontal axis). Each point is a state. Data on soil capability are from the USDA's Soil Survey Geographic Database (SSURGO). The denominator, potential cropland, is defined based on a soil capability score of 1 ("soils have few limitations that restrict their use") through 5 ("soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat"). The numerator is defined as the share of land with a soil capability score of 1 or 2 ("soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices"). The soil capability data include irrigated and non-irrigated land and are observed as a raster with 400m^2 resolution. We aggregate to the state level across each 400m^2 pixel. The variables on the horizontal and vertical axes are first residualized against the change in log income per capita, from the Bureau of Economic Analysis, and the Wharton Residential Land Use Regulation Index, defined in detail in the note to Figure 6. Data on agricultural real estate values come from land appraisals collected by the USDA and are in units of dollars per acre. Data on residential real estate values are from the FHFA All-Transactions Price Index.

Table 1: Average Annual Agricultural and Residential Real Estate Returns.

Datasets	Time Period	Agricultural Real Estate	Residential Real Estate	Difference
		Panel A. Average Price Return		
USDA Dollars/Acre (A) and FHFA House Price Index (R)	1975-2020	1.41%	0.95%	0.46%
USDA Dollars/Acre (A) and Shiller Index (R)	1890-2020	1.26%	0.60%	0.66%
USDA Dollars/Acre (A) and Jordá et al Index (R)	1890-2010	1.20%	0.59%	0.61%
USDA Dollars/Acre (A) and Census Median Home Value (R)	1950-2020	2.14%	1.75%	0.39%
NCREIF All-Cropland (A) and NCREIF Multifamily Index (R)	1991-2020	1.72%	-0.17%	1.89%
		Panel B. Average Total Return		
NCREIF All-Cropland (A) and NCREIF Multifamily (R)	1991-2020	8.01%	6.00%	2.01%
NCREIF Row Cropland (A) and NCREIF Multifamily (R)	1991-2020	7.14%	6.00%	1.14%
NCREIF Permanent Cropland (A) and NCREIF Multifamily (R)	1991-2020	8.83%	6.00%	2.83%

Note: This table summarizes several measures of return to agricultural and residential real estate using various datasets. Panel A summarizes average annual price return over the indicated time period. Panel B summarizes average total return, which is the sum of price return and income return. The sources of data for agricultural and residential real estate are denoted by (A) and (R), respectively. "USDA Dollars/Acre" denotes the value of U.S. agricultural land, including buildings, in dollars per acre, from the USDA. "Shiller Index" denotes the Shiller (2005) house price index. "FHFA House Price Index" denotes the All-Transactions Price Index from the FHFA. "Jordá et al Index" denotes the cumulative capital gain on residential real estate ("housing") from Jordà et al. (2019), which begins in 1891 and is observed annually. "Census Median Home Value" denotes median home value, in dollars, from the decennial census. The NCREIF "All-Cropland", "Row Cropland", "Permanent Cropland", and "Multifamily" indices are the Capital Return (panel A) and Total Return (panel C) for the indicated type of real estate in the portfolio managed by institutions in the National Council of Real Estate Investment Fiduciares (NCREIF), which invest on the behalf of large tax-advantaged institutions. The averages in Panel A for rows where the time period begins in 1950 or earlier are computed as the average of the annualized 10-year change in log real estate values from census year to census year. This ensures equal weighting across time periods, since data for the earlier parts of the sample for some of these series are only observed every ten years. All other averages in the table are averages of 1-year returns. All price returns except for those from the NCREIF data are geometric. For rows where the time period begins in 1950 or earlier, nominal real estate values are converted to real values using the Federal Reserve Bank of Minneapolis' long-run consumer price index. For other rows, real values are computed using CPI-U. Details are in Appendix A.

Table 2: Dispersion in Agricultural and Residential Price Returns over 1975-2020.

	Agricultural Real Estate (%)	Residential Real Estate (%)	Difference
	Panel A. Across State Variation		
Average Return	1.41%	0.55%	0.86%
Std Deviation of Return	0.61%	0.7%	-0.09%
Std Deviation / Average	0.43	1.26	-0.83
Number of States: 48			
	Panel B. Aggregate Variation		
Average Return	1.41%	0.95%	0.46%
Std Deviation of Return	5.72%	3.8%	1.92%
Std Deviation / Average	4.06	4.04	0.02
Number of Years: 45			

Note: This table summarizes the dispersion in agricultural and residential real estate price returns. Panel A summarizes real annualized geometric price growth over 1975-2020 across the contiguous U.S. states. The panel reports the across-state average, across-state standard deviation, and the ratio of across-state standard deviation to across-state average. Panel B summarizes aggregate real annualized geometric price growth over 1975-2020 based on the datasets in the first row of Table 1. In particular, data are from the USDA for agricultural real estate and the FHFA for residential real estate. Returns are converted from nominal values to real values using U.S. CPI-U, not state-level CPI-U. The remaining notes are the same as in Table 1.

Online Appendix

Appendix A describes our data. Appendix B contains additional theoretical results as well as proofs of our main theoretical results in the text.

A Data Appendix

A.1 Agricultural Real Estate

We primarily measure the value of agricultural real estate using data from the USDA's Annual Survey, which is conducted annually beginning in 1910 and decennially from 1850 through 1910. Our variable of interest is the value of agricultural land, including buildings, in dollars per acre. The USDA defines the numerator of this variable as "the value at which all land and buildings used for agricultural production, including dwellings, could be sold under current market conditions, if allowed to remain on the market for a reasonable amount of time." Beginning in the 1950s, we observe this variable at the state-by-year level from the same Annual Survey.

The USDA describes its method of data collection as follows. The raw estimates of land values are based mostly on the USDA's June Area Survey, conducted during the first two weeks of June. This annual survey uses a complete, probability-based land-area sampling frame. A sample of approximately 9,000 segments of land is selected, each approximately one square mile in size. Enumerators collecting data for the June Area Survey contact all agricultural producers operating land within the boundaries of the sampled land segments and record land value information for cropland and pasture within these segments. They also collect an estimated value of all land and buildings for the operator's entire farming operation and the estimated percent change from the previous year.

In addition to measuring agricultural real estate values using the USDA's Annual Survey, we also rely on appraised values from institutional investment in cropland as described in Appendix A.3 below.

A.2 Residential Real Estate

Data on long-run residential real estate ("housing") values primarily come from Shiller (2005). The series span 1890 through the present. Shiller (2005) constructs the data as follows: the

index for the period 1890-1934 relies on house prices from Grebler, Blank and Winnick (1956); the index for the period 1934-1953 relies on a five-city average of home sale prices collected by Shiller (2005) from newspaper articles; the index for the period 1953-1975 relies on the owner-occupied housing component of CPI; the index for the period 1975-1987 relies on the OFHEO price index; and the index for the remaining periods is the Case-Shiller-Weiss index. See Davis, Ortalo-Magne and Rupert (2007) for additional description.

As described in the text, we also measure residential real estate values using the dataset constructed by Jordà et al. (2019), using median U.S. home values from the decennial Census, using data on returns to institutional investment in residential real estate described in Appendix A.3 below, and using the Federal Housing Finance Authority's All-Transactions Index, which applies a repeat-sales methodology to adjust for quality. The Jordà et al. (2019) dataset contains the price return for U.S. real estate from 1891 through 2015 at the annual frequency. We transform this annual price return into an index by computing the cumulative geometric return from 1891 through 2015.

A.3 Additional Datasets

Institutional Investment Returns

Data on returns to institutional investment in cropland, residential real estate, and office real estate are from the National Council of Real Estate Fiduciaries (NCREIF) property indices. NCREIF is an industry group consisting of large fiduciaries that invest largely on the behalf of tax-advantaged institutions (e.g., pensions). NCREIF invests in cropland specifically, but not necessarily other forms of agricultural land. We obtain data on cropland returns from the NCREIF Farmland Index, which begins in 1991. The price returns for cropland in the NCREIF portfolio are based on quarterly appraisals performed by professional rural land appraisers associated with the American Society of Farm Managers and Rural Appraisers (ASFMRA). We can query the data to obtain returns on sub-portfolios within the NCREIF cropland portfolio as, for example, when studying geographic heterogeneity in Appendix Figure A.4. Sherrick (2020) provides a summary of the NCREIF data and its use in studying cropland investing. We obtain data on residential and office returns from the NCREIF Property Index. Plazzi, Torous and Valkanov (2010) provide an example of NCREIF's use in studying residential and office real estate returns. All NCREIF returns are computed on an unleveraged basis.

Soil Capability

Data on soil capability are from the USDA's Soil Survey Geographic Database (SSURGO). As mentioned in the text, this database contains information on limitations on the types of crops that can be grown on a given piece of land. We observe this value as of 2023. Data are collected from the field using soil samples and other measurements. The soil capability data include irrigated and non-irrigated land and are observed as a raster with 400m^2 resolution. A given 400m^2 pixel is associated with a particular soil type. Each soil type is assigned a soil capability score ranging from 1 to 8 as described in the next paragraph. The soil capability score depends on the physical and chemical attributes of the soil in a given pixel as well as the climate. In particular, each soil type is also assigned a primary risk factor that explains why it receives a given score. The risk factors are: risk of erosion unless close-growing plant cover is maintained; water in or on the soil interferes with plant growth or cultivation; the soil is limited mainly because it is shallow, droughty, or stony; or the chief limitation is climate that is very cold or very dry. American Farmland Trust (2020) describes the data in detail and provides an example use case from the industry.

We aggregate to the state level across each 400m^2 pixel. The empirical proxy for θ is the ratio of two objects. The denominator, potential cropland, is defined based on a soil capability score of 1 ("soils have few limitations that restrict their use") through 5 ("soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat"). The numerator is defined as the share of land with a soil capability score of 1 or 2 ("soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices").

Consumer Prices

In most results, real values are computed by deflating nominal values using the Consumer Price Index for All Urban Consumers (CPI-U), which we refer to loosely as CPI in the text. For the long-run series shown in Figure 2, real values are computed using the Federal Reserve Bank of Minneapolis' long-run price index, constructed using: for 1800-1851, an index of prices paid by Vermont farmers for family living; for 1851-1890, the Consumer Price Index by Ethel D. Hoover; for 1890-1912, the Cost of Living Index by Albert Rees; and for 1913 through the present, the Bureau of Labor Statistics' Consumer Price Index (CPI).

B Theory Appendix

B.1 Proofs of Main Results

B.1.1 Proof of Proposition 1

First consider the derivative, $\frac{\partial}{\partial \overline{L}}\left[r_{j,t}^{C}-r_{j,t}^{H}\right]$. Using Lemma 2, we have

$$\frac{\partial r_{j,t}^{H}}{\partial \overline{L}}=0. \tag{B1}$$

Moreover,

$$\begin{aligned}
\frac{\partial r_{t}^{C}}{\partial \overline{L}} &= \frac{\partial}{\partial \overline{L}}\left(-\frac{e^{\theta_j t}p_t}{\int_t^{T_j} e^{-r(\tau-t)}e^{\theta_j\tau}p_\tau d\tau + e^{-r(T_j-t)}\int_{T_j}^{\infty} e^{\theta_j\tau}e^{-r(\tau-T_j)}p_\tau d\tau}\right) && \text{(B2)}\\
&= \frac{\partial T_j}{\partial \overline{L}}\left[e^{-(r-\theta_j)(T_j-t)}p_{T_j}-e^{-(r-\theta_j)(T_j-t)}e^{\theta_j T_j}p_{T_j}\right]\Xi_L && \text{(B3)}\\
&\ldots+\left[e^{-(r-\theta_j)(T_j-t)}\int_{T_j}^{\infty} e^{-(r-\theta_j)(\tau-T_j)}\frac{\partial p_\tau}{\partial \overline{L}}d\tau\right]\Xi_L && \text{(B4)}\\
&= -\frac{e^{-(r-\Delta\theta_j)(T-t)}}{r-\Delta\theta_j-\eta-g}\frac{L_t}{\overline{L}^2}\Xi_L && \text{(B5)}\\
&< 0, && \text{(B6)}
\end{aligned}$$

where

$$\Xi_L = p_t\left[\frac{1}{\int_t^{T_j} e^{-r(\tau-t)}p_t d\tau + e^{-r(T_j-t)}\int_{T_j}^{\infty} e^{-r(\tau-T_j)}p_t d\tau}\right]^2 \tag{B7}$$

Turning to the first part of the proposition, first note

$$\begin{aligned}
\lim_{\overline{L}\to 0}\left[r_{j,t}^{C}-r_{t}^{H}\right] &= \lim_{\overline{L}\to 0} r_{j,t}^{C} && \text{(B8)}\\
&= r-\\
&\ldots\lim_{\overline{L}\to 0}\left[\int_t^{T_j} e^{-(r-\Delta\theta_j-\eta-g)(\tau-t)}\left(\frac{L_\tau}{L_t}\right)^{-1}d\tau + e^{-(r-\Delta\theta_j)(T_j-t)}\frac{L_t/\overline{L}}{r-\Delta\theta_j-\eta-g}\right]^{-1}\\
&= r\\
&> 0
\end{aligned}$$

using the assumption that $\lim_{\overline{L}\to 0} T_j < \infty$.

Consider two cases. The first is that $\lim_{\overline{L}\to\mathcal{L}} \left[r^C_{j,t} - r^H_{j,t}\right] > 0$. In this case, combining the results that $\frac{\partial}{\partial \overline{L}} \left[r^C_{j,t} - r^H_{j,t}\right] < 0$ and $\lim_{\overline{L}\to 0} \left[r^C_{j,t} - r^H_{j,t}\right] > 0$ implies that $r^C_{j,t} - r^H_{j,t} > 0$ for any $\overline{L} > 0$,and so it suffices to set any $\tilde{L}_t < \mathcal{L}$. The second case is that $\lim_{\overline{L}\to\mathcal{L}} \left[r^C_{j,t} - r^H_{j,t}\right] \leq 0$. In this case, combining the results that $\frac{\partial}{\partial \overline{L}} \left[r^C_{j,t} - r^H_{j,t}\right] < 0$, $\lim_{\overline{L}\to 0} \left[r^C_{j,t} - r^H_{j,t}\right] > 0$, and the Intermediate Value Theorem imply that there exists a unique $\tilde{L}'_t < \mathcal{L}$ such that $r^C_{j,t} = r^H_{j,t}$ when $\overline{L} = \tilde{L}'_t$. In this case, it suffices to set any $\tilde{L}_t < \tilde{L}'_t$.

B.1.2 Proof of Proposition 2

First consider the derivative, $\frac{\partial}{\partial \psi_j} \left[r^C_{j,t} - r^H_{j,t}\right]$. Since $r^C_{j,t}$ does not depend on ψ_j, from Lemma 2, it suffices to compute

$$\frac{\partial}{\partial \psi_j}\left(r^H_{j,t}\right) = -\frac{\partial}{\partial \psi_j}\left(\left[\int_t^\infty e^{-(r-\eta_j-g_j)(\tau-t)}\left(\int_t^\tau \left[1+\frac{I^H_{j,\nu}}{K_{j,t}}\right]d\nu\right)^{-1} d\tau\right]^{-1}\right). \tag{B9}$$

We can compute the sign of $\frac{\partial I^H_{j,\nu}}{\partial \psi_j}$ by applying Topkis's Monotonicity Theorem to the HJB equation from Lemma 1,

$$rV^H(K_{j,t}) = \max_{I^H_{j,t}} \left[q_{j,t}K_{j,t} - \frac{\psi_j}{2}(I^H_{j,t})^2 + Q_{j,t}I^H_{j,t}\right]. \tag{B10}$$

which implies

$$\frac{\partial I^H_{j,\nu}}{\partial \psi_j} \propto -I^H_{j,t} < 0, \tag{B11}$$

and so

$$\frac{\partial}{\partial \psi_j}\left(r^H_{j,t}\right) = -\left[\int_t^\infty e^{-(r-\eta_j-g_j)(\tau-t)}\left(\int_t^\tau \frac{\partial I^H_{j,\nu}}{\partial \psi_j}\frac{1}{K_{j,t}}d\nu\right)\left(\int_t^\tau \left[1+\frac{I^H_{j,\nu}}{K_{j,t}}\right]d\nu\right)^{-2}\right]\Xi_\psi \tag{B12}$$

$$> 0, \tag{B13}$$

where

$$\Xi_\psi = \left[\int_t^\infty e^{-(r-\eta_j-g_j)(\tau-t)}\left(\int_t^\tau \left[1+\frac{I^H_{j,\nu}}{K_{j,t}}\right]d\nu\right)^{-1} d\tau\right]^{-2}. \tag{B14}$$

So $\frac{\partial}{\partial \psi_j} \left[r^C_{j,t} - r^H_{j,t}\right] < 0$.

Next consider the derivative, $\frac{\partial}{\partial g_j} \left[r^C_{j,t} - r^H_{j,t}\right]\Big|_{y_{j,t}}$. Recall that economy j is sufficiently

small such that $\frac{\partial g}{\partial g_j} = 0$. So, Lemma 2 implies that $r^C_{j,t}$ does not depend on g_j. It then suffices to compute

$$\frac{\partial}{\partial g_j}\left(r^H_{j,t}\right)\Big|_{y_{j,t}} = -\frac{\partial}{\partial g_j}\left(\left[\int_t^\infty e^{-(r-\eta_j)(\tau-t)}e^{g_j\tau-\log(y_{j,t})}\left(\int_t^\tau\left[1+\frac{I^H_{j,\nu}}{K_{j,t}}\right]d\nu\right)^{-1}d\tau\right]^{-1}\right) \tag{B15}$$

$$= \left[\int_t^\infty \tau e^{-(r-\eta_j)(\tau-t)}e^{g_j\tau-\log(y_{j,t})}\left(\int_t^\tau\left[1+\frac{I^H_{j,\nu}}{K_{j,t}}\right]d\nu\right)^{-1}d\tau\right]\Xi_g$$

$$... - \left[\int_t^\infty e^{-(r-\eta_j)(\tau-t)}e^{g_j\tau-\log(y_{j,t})}\left(\int_t^\tau\frac{\partial I^H_{j,\nu}}{\partial Q_{j,\nu}}\frac{\partial Q_{j,\nu}}{\partial g_j}\frac{1}{K_{j,t}}d\nu\right)\Phi_g d\tau\right]\Xi_g, \tag{B16}$$

where

$$\Xi_g = \left[\int_t^\infty e^{-(r-\eta_j)(\tau-t)}e^{g_j\tau-\log(y_{j,t})}\left(\int_t^\tau\left[1+\frac{I^H_{j,\nu}}{K_{j,t}}\right]d\nu\right)^{-1}d\tau\right]^{-2}, \tag{B17}$$

$$\Phi_g = \left(\int_t^\tau\left[1+\frac{I^H_{j,\nu}}{K_{j,t}}\right]d\nu\right)^{-2}. \tag{B18}$$

We can compute the sign of $\frac{\partial I^H_{j,\nu}}{\partial Q_{j,\nu}}$ by applying Topkis's Monotonicity Theorem to the HJB equation (B10), which implies

$$\frac{\partial I^H_{j,\nu}}{\partial Q_{j,\nu}} > 0. \tag{B19}$$

Using the housing inverse demand curve, $q_{j,\nu} = \frac{\alpha e^{(\eta+g_j)\nu}}{K_{j,\nu}}$, we can further compute

$$\frac{\partial Q_{j,\nu}}{\partial g_j} = \int_\nu^\infty e^{-r(\upsilon-\nu)}\frac{\partial}{\partial g_j}\left[\frac{\alpha e^{(\eta_j+g_j)\nu}}{K_{j,\nu}}\right] > 0. \tag{B20}$$

So, the expression in equation (B16) consists of the sum of a positive and a negative term. Suppose, that the negative term has a larger absolute value, so that $\frac{\partial}{\partial g_j}\left(r^H_{j,t}\right)\Big|_{y_{j,t}} \leq 0$. Since $\frac{\partial}{\partial g_j}\left(r^H_{j,t}\right)\Big|_{y_{j,t}} = \frac{q_{j,t}}{Q^2_{j,t}}\frac{\partial Q_{j,t}}{\partial g_j}$, this would imply that $\frac{\partial Q_{j,t}}{\partial g_j} \leq 0$, a contradiction of equation (B20). So, we conclude $\frac{\partial}{\partial g_j}\left(r^H_{j,t}\right)\Big|_{y_{j,t}} > 0$ and, thus, $\frac{\partial}{\partial g_j}\left[r^C_{j,t} - r^H_{j,t}\right]\Big|_{y_{j,t}} < 0$.

Finally, consider the derivative, $\frac{\partial}{\partial \theta_j}\left[r^C_{j,t} - r^H_{j,t}\right]$. Since $r^H_{j,t}$ does not depend on θ_j, from

Lemma 2, it suffices to compute

$$\frac{\partial}{\partial\theta_j}\left(r^C_{j,t}\right) = -\frac{\partial}{\partial\theta_j}\left(\frac{p_t}{\int_t^{T_j} e^{-(r-\theta_j)(\tau-t)}p_t d\tau + e^{-(r-\theta_j)(T_j-t)}\int_{T_j}^{\infty} e^{-(r-\theta_j)(\tau-T_j)}p_t d\tau}\right) \tag{B21}$$

$$\propto \int_t^{T_j}(\tau-t)e^{-(r-\theta_j)(\tau-t)}p_t d\tau + \int_{T_j}^{\infty}(\tau-t)e^{-(r-\theta_j)(\tau-t)}p_t d\tau \tag{B22}$$

$$> 0 \tag{B23}$$

using Leibniz rule that $\lim_{t\uparrow T_j} p_t = p_T = \lim_{t\downarrow T_j} p_t$.

B.2 Additional Theoretical Results

B.2.1 Statement and Proof of Lemma 1

Lemma 1 *For $t \leq T_j$, agricultural land ($L^*_{j,t}$) and the housing stock ($K^*_{j,t}$) in j evolve according to the solutions to*

$$r\dot{L}_{j,t} = \ddot{L}_{j,t} + e^{\theta_j t}\frac{(1-\alpha)e^{(g+\eta)t}}{e^{\theta t}L_t}, \tag{B24}$$

$$r\psi_j\dot{K}_{j,t} = \psi_j\ddot{K}_{j,t} + \frac{\alpha e^{(g_j+\eta_j)t}}{K_{j,t}} \tag{B25}$$

Proof. Equation (B24) follows from the first order condition associated with the problem in equation (7) for the case in which the land constraint (8) does not bind, $\lambda_t = 0$. Express $V^C(L_{j,t})$ as a Hamilton-Jacobi-Bellman equation,

$$rV^C(L_{j,t}) = \max_{I^C_{j,t}}\left[p_t e^{\theta_j t}L_{j,t} - \frac{1}{2}(I^C_{j,t})^2 + \lambda_t[\overline{L} - L_{j,t} - I^C_{j,t}] + \frac{\partial V^C(L_{j,t})}{\partial L_{j,t}}I^C_{j,t}\right]. \tag{B26}$$

From the envelope theorem,

$$\frac{\partial V^C(L_{j,t})}{\partial L_{j,t}} = \frac{\partial}{\partial L_{j,t}}\int_t^{\infty} e^{-r(\tau-t)}\left[p_\tau e^{\theta_j\tau}L_{j,\tau} - \frac{1}{2}(I^C_{j,\tau})^2 + \lambda_\tau[\overline{L} - L_{j,\tau} - I^C_{j,\tau}]\right]d\tau \tag{B27}$$

$$= \int_t^{\infty} e^{-r(\tau-t)}e^{\theta_j\tau}p_\tau d\tau - \int_t^{\infty} e^{-r(\tau-t)}\lambda_\tau d\tau. \tag{B28}$$

Let $P^\lambda_{j,t}$ denote $\frac{\partial V^C(L_{j,t})}{\partial L_{j,t}}$. Then, for $t \leq T_j$,

$$\dot{P}^\lambda_{j,t} = rP^\lambda_{j,t} - e^{\theta_j t}p_t \tag{B29}$$

using the fact that $\lambda_t = 0$ for $t \leq T_j$. Returning to equation (B26), the first-order condition with respect to $I^C_{j,t}$ for $t \leq T_j$ is

$$I^C_{j,t} = \frac{\partial V^C(L_{j,t})}{\partial L_{j,t}} = P^\lambda_{j,t}. \tag{B30}$$

Recalling the law of motion $\dot{L}_{j,t} = I^C_{j,t}$, implies that agricultural land L^*_t at time t solves

$$\dot{L}_{j,t} = P^\lambda_{j,t} \tag{B31}$$

$$\dot{P}^\lambda_{j,t} = rP^\lambda_{j,t} - e^{\theta_j t} p_t. \tag{B32}$$

Aggregating the individual demand curve in equation (2) gives

$$C^*_t = \int_j C^*_{j,t} dj = \frac{(1-\alpha)e^{(g+\eta)t}}{p_t}. \tag{B33}$$

Equating aggregate demand (B33) with aggregate supply from the production function, $C_t = e^{\theta t} L_t$, gives

$$p_t = \frac{(1-\alpha)e^{(g+\eta)t}}{e^{\theta t} L_t}, \tag{B34}$$

so that

$$\dot{P}^\lambda_{j,t}, = rP^\lambda_{j,t} - e^{\theta_j t} \frac{(1-\alpha)e^{(g+\eta)t}}{e^{\theta t} L_t}. \tag{B35}$$

Lastly, noting $\ddot{L}_{j,t} = \dot{P}^\lambda_{j,t}$ and substituting into equation (B32) gives

$$\ddot{L}_{j,t} = r\dot{L}_{j,t} - e^{\theta_j t} \frac{(1-\alpha)e^{(g+\eta)t}}{e^{\theta t} L_t} \tag{B36}$$

giving equation (B24) after rearranging both sides of the equation.

Next, equation (B24) follows from expressing the problem in equation (15) as

$$rV^H(K_{j,t}) = \max_{I^H_{j,t}} \left[q_{j,t} K_{j,t} - \frac{\psi_j}{2} (I^H_{j,t})^2 + \frac{\partial V^H(K_{j,t})}{\partial K_{j,t}} I^H_{j,t} \right]. \tag{B37}$$

Again using the envelope theorem,

$$\frac{\partial V^H(K_{j,t})}{\partial K_{j,t}} = \frac{\partial}{\partial K_{j,t}}\left[\max_{\{I^H_{j,\tau}\}} \int_t^\infty e^{-r(\tau-t)}\left[q_{j,\tau}K_{j,\tau} - \frac{\psi_j}{2}(I^H_{j,\tau})^2\right] d\tau\right] \tag{B38}$$

$$= \int_t^\infty e^{-r(\tau-t)} q_{j,\tau} d\tau \tag{B39}$$

$$= Q_{j,t} \tag{B40}$$

as also defined in equation (19). Note from equation (20) that

$$\dot{Q}_{j,t} = rQ_{j,t} - q_t. \tag{B41}$$

The first-order condition for equation (B37) with respect to $I^H_{j,t}$ is

$$\psi I^H_{j,t} = Q_{j,t}. \tag{B42}$$

Using the law motion $\dot{K}_{j,t} = I^H_{j,t}$ and the law of motion for $Q_{j,t}$ implies that K^*_t solves

$$\dot{K}_{j,t} = Q_{j,t}, \tag{B43}$$

$$\dot{Q}_{j,t} = rQ_{j,t} - q_t. \tag{B44}$$

Aggregating the individual demand curve in equation 3) gives

$$H^*_{j,t} = \frac{\alpha e^{(g_j+\eta_j)t}}{q_{j,t}}. \tag{B45}$$

Using the production function to obtain $H_{j,t} = K_{j,t}$, equation (B45) then implies

$$q_{j,t} = \frac{\alpha e^{(g_j+\eta_j)t}}{K_{j,t}}, \tag{B46}$$

so that

$$\dot{Q}_{j,t}, = rQ_{j,t} - \frac{\alpha e^{(g_j+\eta_j)t}}{K_{j,t}}. \tag{B47}$$

Lastly, noting $\psi\ddot{K}_{j,t} = \dot{Q}_{j,t}$ from equation (B42) and substituting into equation (B41) gives

$$r\psi_j\dot{K}_{j,t} = \psi_j\ddot{K}_{j,t} + \frac{\alpha e^{(g_j+\eta_j)t}}{K_{j,t}} \tag{B48}$$

giving equation (B25) after rearranging both sides of the equation.

B.2.2 Statement and Proof of Lemma 2

Lemma 2 *The price return to agricultural and residential real estate can be written*

$$r_{j,t}^H = r - \left[\int_t^\infty e^{-(r-\eta_j-g_j)(\tau-t)} \left(\int_t^\tau \left[1 + \frac{I_{j,\nu}^H}{K_{j,t}} \right] d\nu \right)^{-1} d\tau \right]^{-1}, \tag{B49}$$

$$r_{j,t}^C = r - \left[\int_t^{T_j} e^{-(r-\Delta\theta_j-\eta-g)(\tau-t)} \left(\frac{L_\tau}{L_t} \right)^{-1} d\tau + e^{-(r-\Delta\theta_j)(T_j-t)} \frac{L_t/\overline{L}}{r-\Delta\theta_j-\eta-g} \right]^{-1}, \tag{B50}$$

where $\Delta\theta_j = \theta_j - \theta$.

Proof. Note that

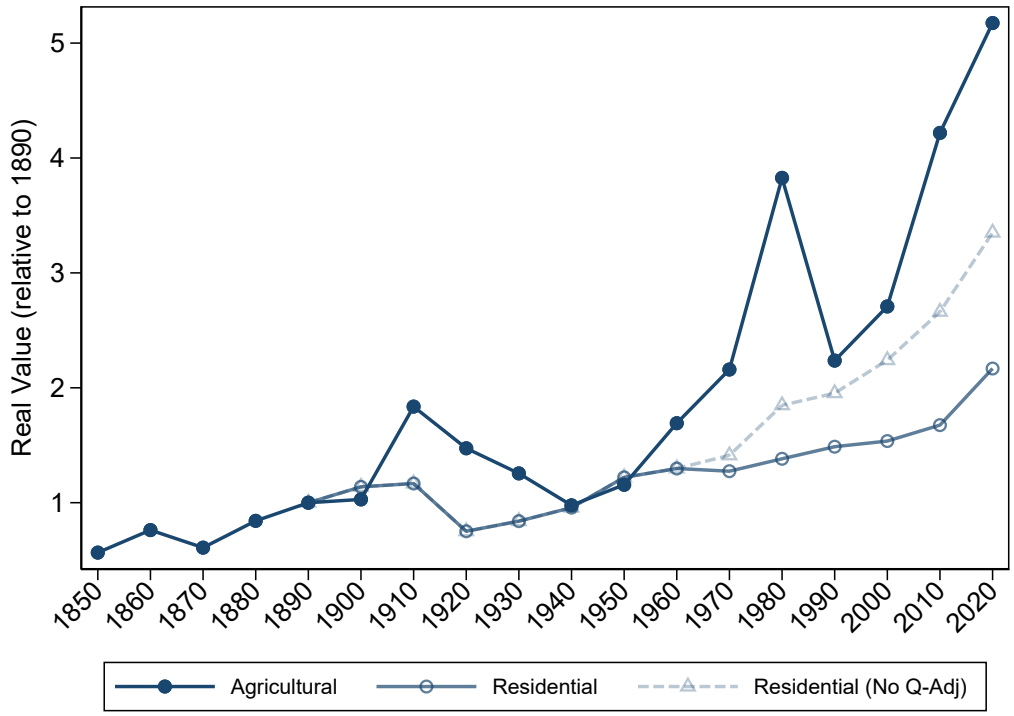
$$\begin{aligned} r_{j,t}^H &= \dot{Q_{j,t}}/Q_{j,t} && \text{(B51)} \\ &= r - \frac{q_{j,t}}{\int_t^\infty e^{-r(\tau-t)} q_{j,\tau} d\tau} && \text{(B52)} \\ &= r - \left[\int_t^\infty e^{-(r-\eta_j-g_j)(\tau-t)} \left(\frac{K_{j,\tau}}{K_{j,t}} \right)^{-1} d\tau \right]^{-1} \\ &= r - \left[\int_t^\infty e^{-(r-\eta_j-g_j)(\tau-t)} \left(\int_t^\tau \left[1 + \frac{I_{j,\nu}^H}{K_{j,t}} \right] d\nu \right)^{-1} d\tau \right]^{-1}. && \text{(B53)} \end{aligned}$$

Next note that

$$\begin{aligned} r_{j,t}^C &= \dot{P_{j,t}}/P_{j,t} && \text{(B54)} \\ &= r - \frac{e^{\theta_j t} p_t}{\int_t^{T_j} e^{-r(\tau-t)} e^{\theta_j \tau} p_\tau d\tau + e^{-r(T_j-t)} \int_{T_j}^\infty e^{\theta_j \tau} e^{-r(\tau-T_j)} p_\tau d\tau} && \text{(B55)} \\ &= r - \frac{p_\tau}{\int_t^{T_j} e^{-(r-\theta_j)(\tau-t)} p_\tau d\tau + e^{-(r-\theta_j)(T_j-t)} \int_{T_j}^\infty e^{-(r-\theta_j)(\tau-T_j)} p_\tau d\tau} && \text{(B56)} \\ &= r - \left[\int_t^{T_j} e^{-(r-\Delta\theta_j-\eta-g)(\tau-t)} \left(\frac{L_\tau}{L_t} \right)^{-1} d\tau + e^{-(r-\Delta\theta_j)(T_j-t)} \frac{L_t/\overline{L}}{r-\Delta\theta_j-\eta-g} \right]^{-1}. && \text{(B57)} \end{aligned}$$

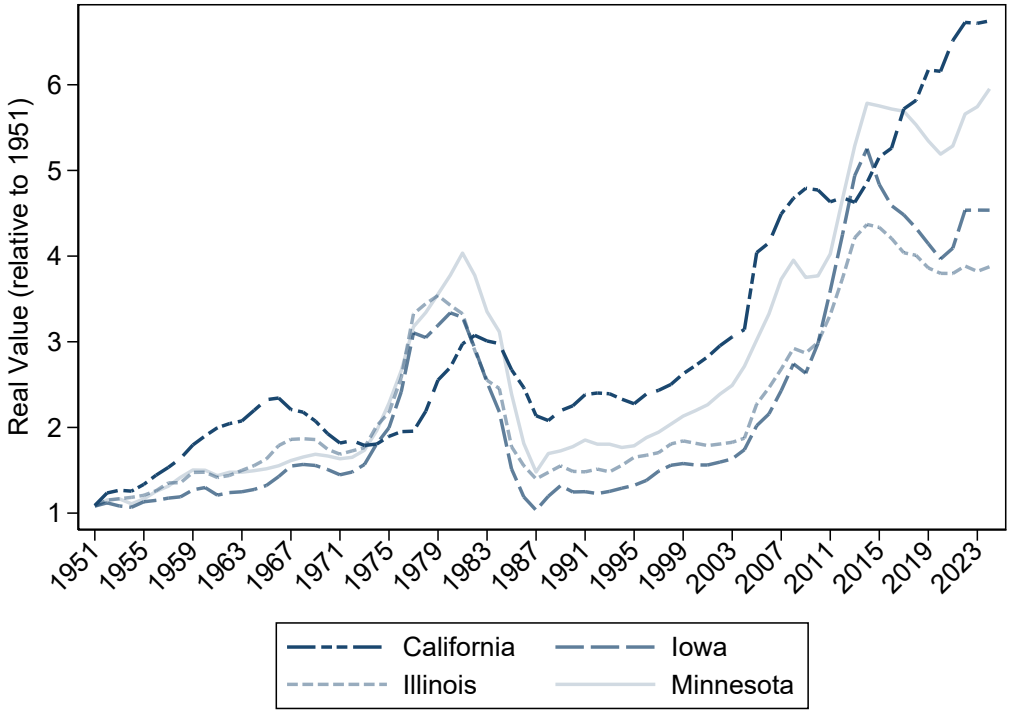
Additional Figures and Tables

Figure A.1: Residential Real Estate Values with and without Quality Adjustment.



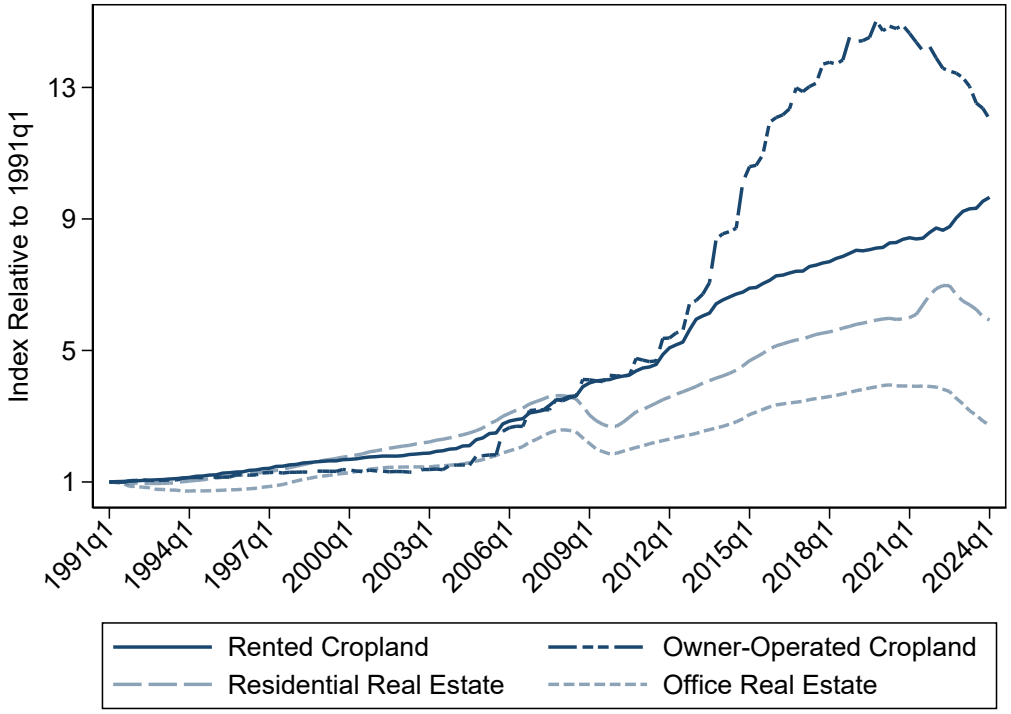
Note: This figure is analogous to Figure 1, except that it also plots the real value of residential real estate without the Shiller (2005) quality adjustment. Specifically, the series denoted "No Q-Adj" is the same as in Figure 1 up to 1960, and in 1960 it is replaced by the median home value from the decennial census. The original Shiller (2005) series transitions to CPI-U's quality-adjusted housing index beginning in 1953, and it subsequently transitions to other quality-adjusted measures for the remainder of the sample period as described in Appendix A.3. For reference, the figure also plots the same two series from Figure 1, denoted Agricultural and Residential, respectively. The remaining notes are the same as in Figure 1.

Figure A.2: Using Annual Frequency to Study Agricultural Real Estate Values by State.



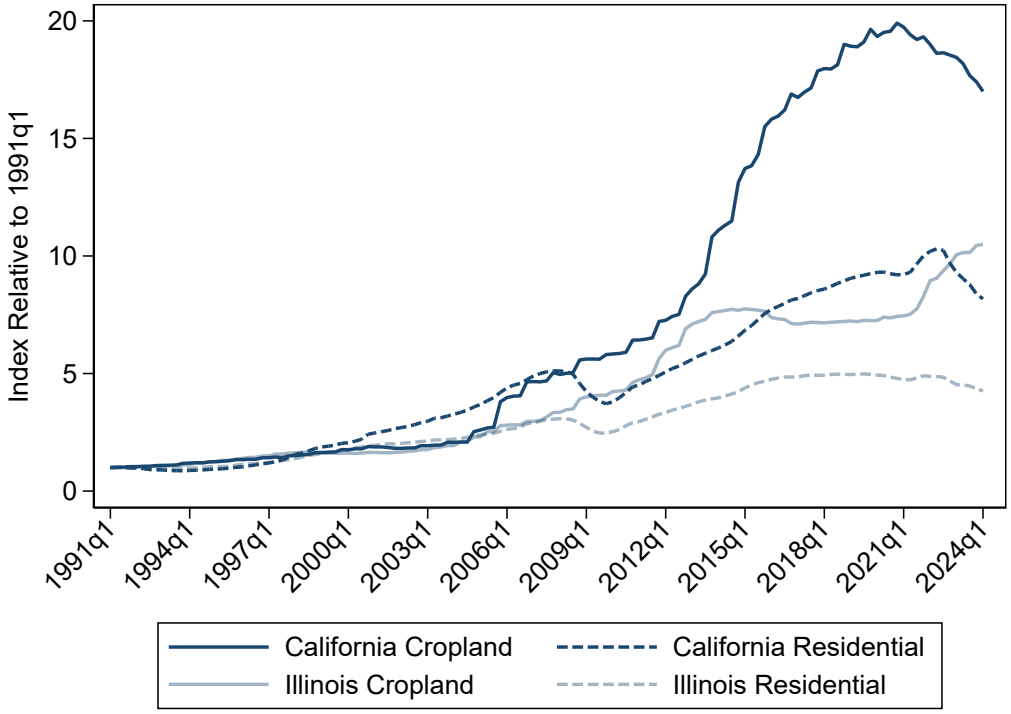
Note: This figure is analogous to Figure 2 except in terms of an annual frequency and omitting real home values, which are only observed every ten years for years prior to 1975. Real agricultural real estate values are shown for the four states that ranked highest in terms of cropland sales in the USDA's most recent agricultural census (2022). Data on agricultural real estate values come from the USDA's Annual Survey. All series are deflated by CPI and normalized to equal one in 1950.

Figure A.3: Institutional Returns to Rented or Directly-Operated Agricultural Real Estate.



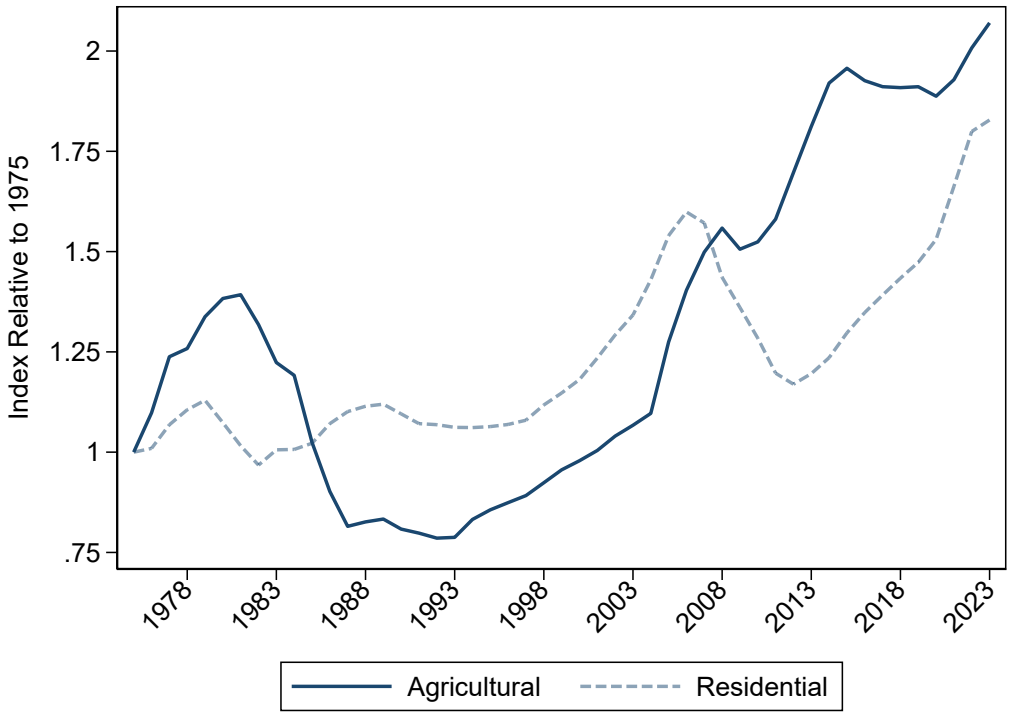
Note: This figure is analogous to Figure 3 except that it separately plots returns to cropland that is rented versus directly operated by the owner. As in Figure 3, data are from the National Council of Real Estate Investment Fiduciares (NCREIF), which invests on the behalf of large tax-advantaged institutions. The remaining notes are the same as in Figure 3.

Figure A.4: Real Institutional Returns by Type of Real Estate and State.



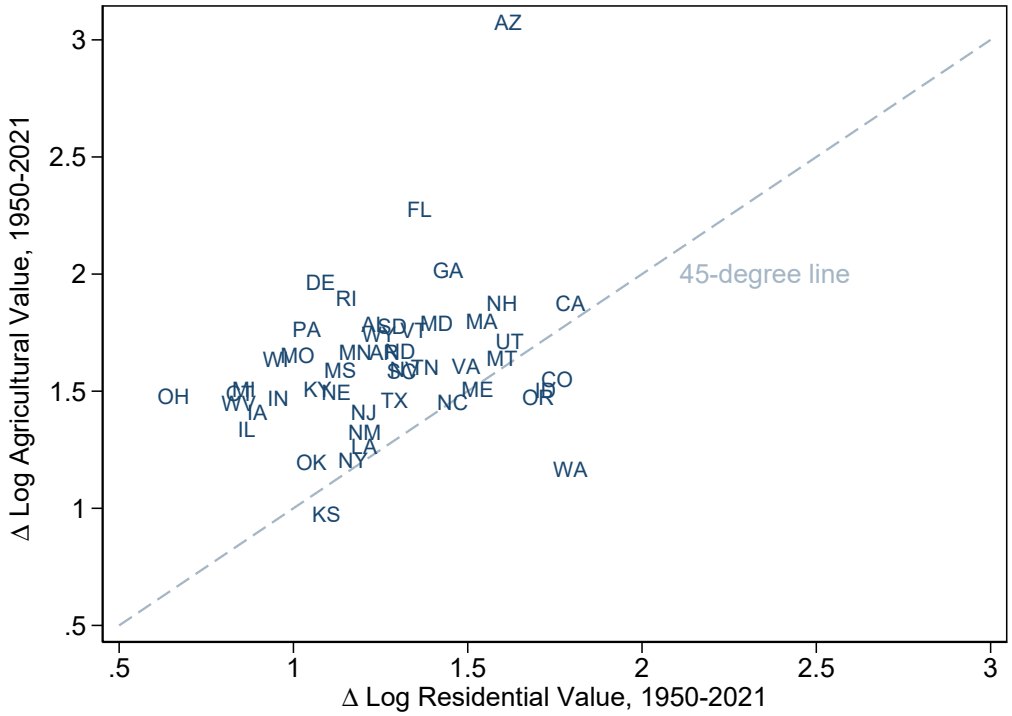
Note: This figure is analogous to Figure 3 except that it shows total real returns separately for the NCREIF sub-portfolios consisting of California cropland and residential real estate and similarly for Illinois. The remaining notes are the same as in Figure 3.

Figure A.5: Using the FHFA Index to Measure Residential Real Estate Values.



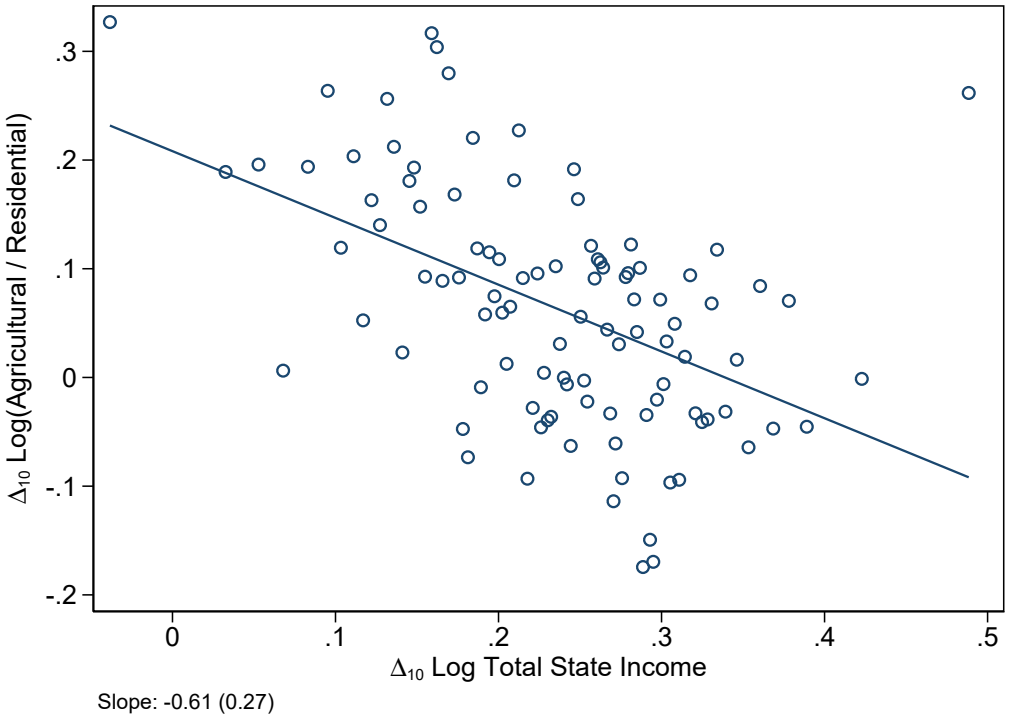
Note: This figure plots the real value of agricultural and residential real estate, and it is similar to Figure 1 except that residential real estate is measured using the FHFA's All-Transactions Price Index, which begins in 1975 and is observed at the annual frequency. Agricultural land is measured as in Figure 2. Both series are normalized to equal one in 1975. The remaining notes are the same as in Figure 2.

Figure A.6: Growth in Residential Real Estate by State with Census Data



Note: This figure is analogous to Figure 4 except that residential real estate is measured using home values are from the decennial census, which are in units of median home value, in dollars, and not based on transactions-level data. The data are observed every 10 years, and we plot the change in log real home values from the 1950 census to the 2021 census. The remaining notes are the same as in Figure 4.

Figure A.7: Growth in Real Estate Values and Aggregate State Income.



Note: This figure is analogous to Figure 5 except that the variable on the horizontal axis is the change in log total personal income, not per-capita income. Data are also from the Bureau of Economic Analysis. The remaining notes are the same as in Figure 5.

Table 3: State-Level Agricultural and Residential Returns over 1975-2020.

State	Agricultural Real Estate (%)	Residential Real Estate (%)	Difference	State	Agricultural Real Estate (%)	Residential Real Estate (%)	Difference
AL	1.35	-0.28	1.63	NC	1.10	0.27	0.83
AR	1.21	-0.23	1.44	ND	1.27	0.28	0.99
AZ	4.30	0.91	3.39	NE	1.51	0.18	1.32
CA	2.62	2.38	0.24	NH	1.44	1.07	0.37
CO	1.34	1.60	-0.26	NJ	0.91	1.23	-0.31
CT	1.08	0.56	0.51	NM	1.03	0.36	0.67
DE	1.42	0.35	1.07	NV	2.03	1.02	1.01
FL	1.35	0.64	0.71	NY	0.64	1.23	-0.59
GA	0.93	0.03	0.91	OH	1.42	-0.20	1.62
IA	1.53	-0.13	1.65	OK	0.49	-0.11	0.60
ID	1.52	0.86	0.66	OR	1.74	1.69	0.05
IL	1.24	0.05	1.19	PA	1.44	0.40	1.03
IN	1.35	-0.01	1.35	RI	1.85	1.28	0.58
KS	0.55	-0.18	0.73	SC	1.06	0.17	0.89
KY	1.48	0.13	1.35	SD	2.26	0.33	1.93
LA	0.58	0.08	0.50	TN	1.35	0.29	1.06
MA	1.91	1.89	0.02	TX	1.28	0.37	0.91
MD	0.98	0.88	0.10	UT	2.24	1.30	0.95
ME	1.02	0.96	0.06	VA	1.17	0.71	0.47
MI	1.30	0.17	1.13	VT	0.95	0.60	0.35
MN	1.82	0.70	1.12	WA	1.21	2.20	-0.99
MO	1.31	0.01	1.30	WI	1.86	0.23	1.63
MS	1.05	-0.67	1.73	WV	1.42	-0.83	2.24
MT	1.26	1.11	0.15	WY	1.57	0.60	0.96
Average	1.41 (A)	0.55 (R)					
Std Deviation	0.61 (A)	0.70 (R)					
Std Deviation / Average	0.43 (A)	1.26 (R)					

Note: This figure expands on Figure 2 by showing the average price return over 1975-2020 separately for each contiguous U.S. state. The remaining notes are the same as in Figure 2.