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JEL Classification: G11, G23, N20, R30

Keywords: real estate, income growth, income yields, property prices, long-run returns

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The Rate of Return on Real Estate: Long-Run Micro-Level Evidence*

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1 Introduction

Real estate appears to have delivered attractive investment returns over the past few decades (e.g., Favilukis et al. (2017), Ghent et al. (2019), Giglio et al. (2018)).[1] Yet, we possess only a limited understanding of its longer-term track record, especially compared to our knowledge of historical bond and equity returns (e.g., Jorion and Goetzmann (1999), Dimson et al. (2002)). Recent research by Jordà et al. (2019a) suggests that *residential* real estate has been a stellar investment in a wide range of advanced economies since the late nineteenth century. The authors estimate a geometric (arithmetic) average real net return to housing of 6.6% (7.1%) per year, similar to the performance of equities, with high returns throughout most of the twentieth century.

However, the performance of residential real estate is an inadequate proxy for the performance of direct real estate as a whole. Most obviously, other property types, such as agricultural and commercial real estate, feature prominently in the portfolios of institutional as opposed to individual investors, both today and in the past. Furthermore, estimating the historical performance of direct real estate investments from existing data is fraught with difficulty given the limitations of the available data and the methodological challenges, especially before the late twentieth century. First, available price data generally do not allow for an adequate adjustment for variation in property characteristics. Increases in average prices may thus overstate the capital gains realized by investors if more recently traded properties are of higher average quality. Second, information on the cashflows associated with historical real estate investments is difficult to obtain. When income data exist, they tend to capture contractual instead of realized income, and are not drawn from the same set of properties for which transaction prices are observed. Third, data on the property-level costs associated with real estate ownership are typically not available.

[1] Favilukis et al. (2017) estimate arithmetic average real returns to U.S. housing of 9–10%, before maintenance costs and property taxes, over the 1976–2012 period. For U.K. housing, Giglio et al. (2018) document average real net returns of about 7% over the 1988–2016 period. Ghent et al. (2019) report average *nominal* returns to privately held commercial real estate of 9% over the 1978–2018 period.

In this paper, we overcome these measurement problems, which are presented more formally in Section 2, by exploiting a unique empirical setting where we observe transaction prices, rental income, and costs for the same sample of individual properties. Specifically, we construct a data set of the property holdings and transactions starting from the early twentieth century for King's College and Trinity College in Cambridge and Christ Church and New College in Oxford. These four prominent colleges were among the wealthiest and largest property owners in each university around 1900—and some of them are still economically important real estate investors today (The Guardian, 2018). Historically, these colleges have invested in agricultural and commercial real estate as well as housing. Their property portfolios have been professionally managed in pursuit of long-term returns, and were free of major legal or other investment constraints over our sample period.

Our data cover the period 1901–1983 and are hand-collected from the archives of the four Oxbridge colleges. Access to archival records after 1983 is restricted due to the ongoing commercial sensitivity of their data. We source data on acquisitions and disposals from transaction ledgers and on rental income and costs from rent books. We match transactions to the corresponding income records based on property address, tenant name, and other identifying characteristics. In the case of the two Cambridge colleges, the archival sources enable us to assemble the full history of rental income across all property holdings for the entire sample period. For the two Oxford colleges, we collect income data on transacted properties for periods following purchases and preceding sales where possible. Our final data set contains more than 50,000 income observations at the property-year level, and we observe a purchase or sale for nearly 1,800 property-year combinations. At the start of the twentieth century, both the King's and Trinity portfolios were heavily concentrated in agricultural real estate, which generated more than three-quarters of total gross income. Over the course of the sample period, we document a shift away from agricultural in favor of commercial real estate.

We start the empirical analysis of our novel data set by constructing quality-adjusted rental income indices over the 1901–1983 period. Our indices capture the growth in realized income of the property holdings of institutional investors, rather than the growth in average or aggregate contractual rental income in the economy. This distinction is important because market-wide income may increase as new, higher-quality properties are added to the existing stock, while the income for any previously-constructed property may not evolve in the same way. We document that real income growth exhibits substantial cyclicality, mirroring inflation and deflation patterns in the U.K. economy. Annualized real growth rates are close to zero for all property types: +0.3% for agricultural, -0.3% for commercial, and -1.0% for residential real estate. These results imply limited capital gains, unless income yields were substantially compressed.

We estimate gross yields associated with matched real estate transactions by dividing the annual gross income generated by a property after a purchase or before a sale by its transaction price. Pooling over all observations, we find a mean gross yield of slightly less than 5%, with more than nine out of ten yields remaining below 8%. Our estimates suggest that the average yields of residential, commercial, and agricultural properties are similar until WWII, fluctuating around 5%. Thereafter they diverge, with yields for agricultural and residential real estate declining, and yields for commercial real estate increasing. Over the final two decades of our sample period, the average yields for agricultural and residential properties are approximately 3%, while the mean yield for commercial real estate exceeds 6%.

Some properties may generate significantly less income than expected, and when transacting some may sell for considerably less (or more) than anticipated. We find substantial cross-sectional variation in yields across individual properties, with an average difference of about two percentage points between the first and third quartiles of the income yield distribution in any given period for each property type. This result highlights the importance of asset-level risks in real estate investment.

Next, we analyze the holding costs associated with real estate investments. Commercial real estate exhibits the lowest average annual expense-to-income ratio (19.4%), especially in the final decades of our study period. Agricultural (28.7%) and residential real estate (32.0%) have higher cost ratios. At the level of individual properties, we document that the impact of costs increases the volatility in property-level net income streams relative to that of gross income streams. Ignoring holding costs can thus lead to a substantial underestimation of the riskiness of real estate investments. In our sample, for a given property-year, the probability of a drop in *net* income of 10% or more exceeds one in five.

In the case of housing, our estimates of average income growth and net income yields—even when focusing on the same geography and time period—are substantially below those reported in Jordà et al. (2019a). The differences are most striking for the decades following WWII. Over the years 1941–1960, we find an annualized real income growth rate of -0.7%, compared to +3.7% in Jordà et al. (2019a). Post 1945, 84% of our individual yield observations for residential properties lie below their aggregated average yield series. To generate estimates of annual total returns, including capital gains, we assume that the U.K. price series used in Jordà et al. (2019a) is perfectly correlated with true price levels, while allowing for the possibility of a constant (upward or downward) bias. Taking our income index as given, we then identify the average yield series (and the associated price index) that best fits our observed individual yields. Using this approach, we find a geometric average real net total return of 2.3% for U.K. residential real estate over the 1901–1983 period, compared to the estimate of Jordà et al. (2019a) of 4.7%. The difference stems not just from lower geometric average income yields (3.0% vs. 4.0%), but also from lower annualized capital gain estimates (-0.7% vs. +0.7%).

Prior estimates of historical income growth rates and returns for agricultural and commercial properties are difficult to find. However, for agricultural real estate, our estimates of income changes and price trends are consistent with the previous research by Lloyd (1992) and

Jadevicius et al. (2018). One possible explanation for the greater consistency with earlier studies is that temporal variation in average quality is less of a concern for farmland than for residential real estate. Our results imply an annualized net total return for agricultural real estate of 4.5% over our sample period, boosted by the slightly positive real income growth mentioned before.

For commercial real estate, we are not aware of any income or price index that covers even most of our time period. Nonetheless, our estimates of net yields around 5% for the end of our sample period are broadly consistent with prior findings. By contrast, prior to the 1970s, a large majority of our yield observations fall below the selective (initial contractual) yields reported in the historical study of Scott (1996). While we cannot construct an annual time series of returns for commercial real estate, the combination of negative income growth and substantial income yield expansion implies negative price changes over our time period—mirroring the earlier findings of Wheaton et al. (2009) for Manhattan—and thus an annualized total return below the average income yield. Our results therefore suggest a total rate of return for commercial property between those of residential and agricultural real estate.

In sum, our results indicate that direct real estate may be a poorer long-term investment than is suggested by the existing academic literature on housing—either studies covering only more recent time periods, or those covering a longer history but combining income and price data from different sources and unable to adjust adequately for quality improvements.

The remainder of this paper is structured as follows. In the next section, we introduce a definition of total returns, review the measurement problems in prior research, and explain how we overcome those methodological issues. Section 3 presents the empirical setting and discusses its representativeness. Section 4 describes our data collection, the resulting data sets, and summary statistics. Section 5 presents our main findings on income growth and income yields. Section 6 discusses our results in the context of the existing literature, and also compares the implied total returns to those in prior research. Section 7 concludes.

2 Measuring the Returns to Real Estate Investments

2.1 Return Definitions and Decomposition

To understand the nature of direct property investments, we present a decomposition of total returns. We begin by defining the total return to holding property i between time $t-1$ and t, net of the costs associated with property ownership, as:

$$r_{i,t} = \frac{P_{i,t} + (1 - c_{i,t})Y_{i,t}}{P_{i,t-1}} - 1, \tag{1}$$

where $P_{i,t}$ denotes the market value of property i at time t. While $P_{i,t}$ is not continuously observable, it can be proxied by the transaction price $P^*_{i,t}$ if a transaction takes place at time t. $Y_{i,t}$ is gross rental income and $c_{i,t}$ is the cost-to-income ratio for property i at time t, respectively.

We can decompose $r_{i,t}$ from Eq. (1) into its constituent elements, namely net income yield and capital gain, as follows:

$$\begin{aligned} r_{i,t} &= \frac{P_{i,t}}{P_{i,t-1}} \times \left[1 + \frac{P_{i,t-1}}{P_{i,t}} \times \frac{(1 - c_{i,t})Y_{i,t}}{P_{i,t-1}}\right] - 1 \\ &= \frac{P_{i,t}}{P_{i,t-1}} \times \left[1 + \frac{(1 - c_{i,t})Y_{i,t}}{P_{i,t}}\right] - 1 \\ &= (1 + \underbrace{k_{i,t}}_{\text{capital gain}}) \times \left[1 + \underbrace{(1 - c_{i,t})y_{i,t}}_{\text{net income yield}}\right] - 1, \end{aligned} \tag{2}$$

where $k_{i,t}$ and $y_{i,t}$ are the capital gain and the gross rental yield of property i in year t, respectively. Eq. (2) can be expressed in nominal or in real terms; accounting for inflation affects the computation of the capital gain between $t-1$ and t (i.e., $k_{i,t}$), but not the measurement of the income yield at time t (i.e., $y_{i,t}$).

The total return $r_{\eta,t}$ to the overall market or a specific property type η (i.e., agricultural, commercial, or residential) can then be defined as the aggregated total return over all assets

$i = 1, 2, ..., N$ that are part of η at time $t-1$. We then have that:

$$r_{\eta,t} = (1 + k_{\eta,t}) \times \Big[1 + (1 - c_{\eta,t}) y_{\eta,t}\Big] - 1. \tag{3}$$

Because of infrequent trading and temporal variation in average property quality, capital gains $k_{\eta,t}$ may be difficult to estimate without bias from transaction prices (cf. infra). Therefore, it is useful to rewrite Eq. (2) as follows, using $P_{i,t} = \frac{Y_{i,t}}{y_{i,t}}$:

$$\begin{aligned} r_{i,t} &= \frac{Y_{i,t}}{Y_{i,t-1}} \times \frac{y_{i,t-1}}{y_{i,t}} \times \Big[1 + (1 - c_{i,t}) y_{i,t}\Big] - 1 \\ &= (1 + \underbrace{g_{i,t}}_{\text{income growth}}) \times \underbrace{\frac{y_{i,t-1}}{y_{i,t}}}_{\text{yield change}} \times \Big[1 + \underbrace{(1 - c_{i,t}) y_{i,t}}_{\text{net income yield}}\Big] - 1, \end{aligned} \tag{4}$$

where $g_{i,t}$ denotes the property-level income growth rate between $t-1$ and t. Assuming that the yields that can be computed from transaction data, namely $y^*_{i,t} \equiv \frac{Y_{i,t}}{P^*_{i,t}}$, are representative for the asset class in any period, we can compute a property category's net total return from the observed aggregate income growth rates, changes in gross income yields, and aggregate cost ratios as follows:

$$r_{\eta,t} = (1 + g_{\eta,t}) \times \frac{\overline{y^*_{t-1}}}{\overline{y^*_t}} \times \Big[1 + (1 - c_{\eta,t}) \overline{y^*_t}\Big] - 1. \tag{5}$$

Eqs. (4) and (5) highlight the importance of income growth in long-term real estate returns. Absent (future) income growth, price increases will imply higher capital gains today, but lower income yields going forward. Absent relative price (i.e., yield) changes, capital gains will equal real income growth rates. Given that yields cannot increase or decrease *ad infinitum*, long-run average income growth rates must necessarily be an important determinant of long-run average capital gains.

2.2 Measurement Problems in Prior Literature

The existing literature on the long-term financial characteristics of real estate investments mainly focuses on housing as an asset class. In addition, much of the existing work estimates a time series of average capital gains $k_{\eta,t}$, while time series of income yields $y_{\eta,t}$ or total returns $r_{\eta,t}$ are estimated less frequently. Guided by the decomposition of the net total returns to individual property investments shown in the previous subsection, we can summarize the measurement problems faced by prior studies estimating the long-run performance of real estate as follows:

Capital gains. Many studies document the historical evolution of aggregate house price indices, based on average transaction values $\overline{P_t^*}$ observed in different housing markets. Important contributions include Eichholtz (1997) for Amsterdam, Shiller (2000) for twenty cities in the U.S., and Knoll et al. (2017) for fourteen different countries. However, a time series of changes in average observed transaction prices $\frac{\overline{P_t^*}}{\overline{P_{t-1}^*}}$ misestimates the average capital gains realized by investors if it does not adequately control for changes in the quality composition of the traded real estate stock. In particular, if new properties are of higher average quality than existing ones, then average transaction prices will increase at a rate that exceeds the capital gains of existing investors. This is a well-known problem encountered in empirical studies of housing price trends. For example, the U.K. house price index of Knoll et al. (2017) "does not control for quality changes prior to 1969" (appendix p. 114); more generally, the authors acknowledge that "accurate measurement of quality-adjustments remains a challenge" (p. 342). Next, investors will only realize capital gains in line with a quality-adjusted price index if they maintain their property; however, maintenance expenditures are not always taken into account in the literature. Finally, there exists a "superstar city bias" in that many historical studies—even of "national" housing prices—focus on capitals and other large cities (Dimson et al., 2018), which are known to have had a higher-than-average rate of price appreciation historically (Gyourko et al., 2013).

Income yields. Modern financial institutions invest in real estate expressly in pursuit of high rental yields (Hudson-Wilson et al., 2005). However, existing empirical studies on the investment performance of real estate largely ignore the rental yield component of total returns. Rental yields are absent from prior research in part because data on the cashflows from real estate investments are difficult to obtain. Unlike transaction prices, rental income observations are not systematically or centrally recorded. Furthermore, existing data tend to capture *contractual* rental income, which can be significantly higher than *realized* income due to rent arrears and temporary voids, and thus lead to overstated rental yields. The ratio of contractual rents to market rents may also be highest at the time of establishing the contract, which is typically when it is observed.

Where income data are available for property samples, transaction prices are not typically observed for the same properties. As a result, researchers often combine income and price data from different sources to estimate yields and total returns. For example, Nicholas and Scherbina (2013) compute total returns to Manhattan real estate investments between 1920 and 1939 by adding survey data on contractual rents from 54 income-producing local properties to their price index estimated over a different property sample. Brounen et al. (2014) combine the long-run Amsterdam price index from Eichholtz (1997) with the rent index from a different set of properties constructed by Eichholtz et al. (2012) to estimate total returns. Most recently, Jordà et al. (2019a) provide total return estimates on housing for fourteen countries by combining price indices from Knoll et al. (2017) and rental income indices estimated from aggregate national statistics in Knoll (2017). However, all those methods introduce a measurement error in the resulting time series of income yield estimates if the underlying price and rent observations are obtained from properties with different (quality) characteristics (Eichholtz et al., 2018). Moreover, using historical income and price change estimates to extrapolate backward from a contem-

porary rent-to-price ratio over long periods of time, as in Brounen et al. (2014) and Jordà et al. (2019a), carries the risk of compounding measurement errors over time (Dimson et al., 2018).

Finally, the data underlying existing long-run studies typically do not account for the actual asset-level costs of property ownership and operation which have to be borne by the investor and which can materially affect the net income generated from direct real estate investment.

Income growth. An accurate measurement of historical rental income growth rates can inform the analysis of long-term real estate returns. As mentioned before in the context of yield estimation, some prior studies construct market-level housing rent indices. However, as with price indices, controlling for changes in the quality mix of properties over time remains a challenge. The issue may be particularly relevant when indices are based on aggregate national statistics, for example when Knoll (2017) mainly relies on the rent component of cost-of-living and consumer price indices. In a recent contribution, Eichholtz et al. (2018) explicitly tackle the issue of quality adjustments using new historical data and conclude that "most of the increase in housing expenditure that did occur is attributable to increasing housing quality rather than rising rent."[2]

Idiosyncratic risks. Most research focuses on aggregate capital gains or total returns, mainly in the housing market. However, the return on an individual property $r_{i,t}$ may be substantially above or below the aggregate return for its property type $r_{\eta,t}$ for several reasons. First, "transaction-specific risk" is non-negligible: if property i transacts in year t, this may happen at a particularly low or high price $P^*_{i,t}$ that is different from the (unobservable) $P_{i,t}$—an idea dating back to at least Shiller and Case (1987), and discussed more recently in Lovo and Spaenjers (2018), Giacoletti (2019), and Sagi (2020). Second, for any given property and in any

[2]Note that income from ownership of a fixed set of properties may increase even more slowly than the quality-adjusted average rental income in the broader economy. This would be the case if the income associated with a property tends to jump when ownership changes, or if newly leased properties have higher average rents even after adjusting for their higher quality. Such scenarios are not unlikely if there exist constraints on the ability of owners to update rents, for example because of legal or contractual limits on rent reviews.

given year, the gross income $Y_{i,t}$ may be lower than anticipated (i.e., contracted) or costs $c_{i,t}$ may exceed expectations for that year. This last source of idiosyncratic risk—and in particular the possibility that annual returns may be volatile because of variation in expenses—has not been explored in prior literature. For example, the discussion of idiosyncratic risks as a potential explanation for the "housing risk premium puzzle" in Jordà et al. (2019b) focuses only on individual house *price* volatility.

Property types other than housing. Residential real estate accounts for almost three-quarters of the US$230 trillion global market (Tostevin, 2017). However, only one third of that share is investable, compared to two thirds of commercial.[3] As a result, an analysis of housing alone ignores the substantial opportunity set of commercial and agricultural property available to institutional investors. It is therefore problematic to draw inferences about the investment performance of real estate from the performance of residential property alone. To date, only a limited number of long-run studies focus on property types other than housing. Examples include research on historical trends of U.K. agricultural income (Lloyd, 1992) or prices (Jadevicius et al., 2018), commercial property prices in Manhattan (Wheaton et al., 2009), or commercial real estate income yields in the U.K. (Scott, 1996). These studies provide useful benchmarks for different dimensions of our findings.

2.3 This Paper

In our hand-collected data set, described in Section 4, we directly observe income $Y_{i,t}$, income growth $g_{i,t}$, and costs $c_{i,t}Y_{i,t}$ across individual properties of different types η. We can also

[3]Most residential real estate is held by entities, operators, and owner-occupiers whose main purpose is not investment. In the U.S.—the largest institutional real estate market worldwide—16% of the housing stock is institutionally owned (U.S. Department of Housing and Urban Development, 2015), compared to 78% of commercial real estate (Ling and Archer, 2018). In the U.K., the second-largest institutional real estate market, 4% of the housing stock is held by institutions; in contrast, institutions invest over twelve times that amount in U.K. commercial property (Mitchell, 2017).

compute the gross income yield $y^*_{i,t}$ if property i transacts in year t. These data enable us to shed more light on historical income growth, yields, and ultimately total returns for different property types. In addition, we are able to document cross-sectional variation at the property level in yields and in net income growth rates.

3 Oxbridge Colleges as Real Estate Investors

Our data set draws upon the real estate investments held by some of the most prominent Oxford and Cambridge colleges. U.K. institutional investors have a long record of investing in real estate, and the oldest Oxbridge college endowments have held property for at least five centuries. For example, King Henry VIII founded Trinity College, Cambridge, and Christ Church, Oxford, in 1546 and conferred on both colleges a diversified agricultural real estate portfolio. At the start of the twentieth century, their portfolios consisted almost exclusively of real estate (Chambers et al., 2013). This stands in contrast to the largest U.S. university endowments, which allocated only 10% of their assets to direct real estate in the early twentieth century (Goetzmann et al., 2010); U.S. institutional investors in general did not begin to make a substantial allocation to real estate until the 1970s and 1980s (Eagle, 2013). Notwithstanding diversification into stocks and bonds in the twentieth century, the oldest and wealthiest of the Oxbridge colleges still allocate over 40% of their endowment to real estate today (Cambridge Associates, 2018).

The starting point of our empirical approach was to identify substantial investors in U.K. real estate in 1900 with a diversified portfolio of properties and with, crucially, comprehensive and accessible archival records of their rents and transactions. As a result, our sample consists of a small set of investors. Yet, we have reasons to believe that the colleges that we study are sufficiently representative of the population of wealthy institutional investors that they are drawn from.

First, the biggest Oxbridge colleges were able to devote substantial resources to the professional management of their property portfolios—and their endowments more generally—over our sample period. This is particularly apparent in the cases of Trinity and King's College in Cambridge (Nicholas, 1960; Neild, 2008; Chambers et al., 2013). The senior bursars (or treasurers) of the colleges—equivalent to the roles of chief financial officer and chief investment officer combined into one—were typically academics without much experience of finance and investment. (John Maynard Keynes, the bursar at King's from 1921 to 1946, as an economist and accomplished investor, was very much the exception (Chambers et al., 2015).) Nonetheless, they brought an open-minded intellect to managing the endowment and the role was full-time. In addition, the bursars received considerable support from two sources. First, advice and expertise came from alumni with relevant finance and real estate experience who sat on the estates committees (responsible for property management) and the finance committees (responsible for overall financial and investment policy). For example, Anthony de Rothschild, head of the family merchant bank in London, sat on the Trinity finance committee from 1930 onward (Neild, 2008). These committees met regularly throughout the academic year and frequently produced memos on investment strategy as well as reviews of investment performance. Second, the bursars were professionally advised by specialist estate agents such as Bidwells, Savills, and Smith Woolley. (In some cases, colleges also appointed a dedicated estates bursar with professional property qualifications and experience.) As to the question of whether academic institutions are better investors than non-academic institutions, the evidence is mixed. Some studies have argued that the wealthiest U.S. university endowments are better investors (Lerner et al., 2008), while others claim the opposite (Ennis, 2020).

Second, these colleges faced no major constraints on their ability to manage their investment properties—the subject of our study—as distinct from their operating properties. As such, they were no different to any other institutional investor with an allocation to direct property.

More specifically, from the late 1850s onward, colleges were allowed to sell their originally endowed real estate and reinvest in new properties, and they were able to charge market rents (Dunbabin, 1975; Neild, 2008).

Third, whilst the college portfolios had historically been heavily reliant upon agricultural property as a result of their legacy endowments, the regional distribution of their portfolios in 1901 does not suggest a significant geographical bias in the quality of farmland as measured by crop yields (Collins, 2000). Moreover, the adverse impact of a severe agricultural depression in the latter half of the nineteenth century had made clear the need to manage their portfolio more actively. By the early part of our sample period, therefore, the colleges were already investing to improve the quality of tenants and raise rents, and had begun disposing of farms with relatively poor rental growth prospects. They were also now diversifying into commercial property for the first time. More generally, the endowments were clearly being managed in the pursuit of long-term investment returns.

4 Income and Transaction Data

4.1 Data Collection

We study King's College, Cambridge (founded in 1441), and Trinity College (founded in 1546), Cambridge, as well as Christ Church (founded in 1546 also) and New College (founded in 1379), Oxford. These colleges were among the oldest and wealthiest Oxbridge colleges at the beginning of the twentieth century (Dunbabin, 1975).

Our data collection starts in 1901 and continues until 1983 (except for New College, where we only have data until 1955). Access to archival records after 1983 is restricted by the colleges, due to the ongoing commercial sensitivity of their data, given in particular the long-term

relationships they have with some of their tenants. Nonetheless, our sample period is sufficiently long to enable us to draw meaningful comparisons with earlier research.

Our focus is on the investment properties held in college endowments. We ignore operational properties outside the endowments, which are typically not for sale and are not let at market rents. Similarly, we do not consider furnished lettings and lodging houses in Cambridge and Oxford, as they were used to house faculty or students. We also exclude non-standard rent types, typically associated with very small sums, such as rentcharges and wayleaves.

We compile an unbalanced panel data set of property-year observations on rental income received, costs incurred, and transaction values realized, alongside a number of property and transaction characteristics, as follows.

For King's College, Cambridge, we collect annual property-level realized rental income and costs incurred over the years 1901–1983 from the annual volumes of the so-called "Mundum Books". Transactions of properties over the same period are found in the "Ledger Books". We record transaction type (purchase or sale), transaction amount, and year. These records further allow us to identify partial transactions (part of a property) and portfolio sales (more than one property), as well as instances where the use of the property has changed—often agricultural land was sold for residential development. Where available, we collect information on location, size, and other characteristics of the property. We manually match income and cost records with transaction records based on the common property name.[4]

Figure 1 presents an example of a matched transaction for King's College. Subfigures 1A and 1B show the income and cost record for a farm property called "Middle Cliston" located in the village Sampford Courtenay in the county of Devon, in the South West of England. In the financial year 1926, the property generated a rental income of £152 in two semi-annual

[4]The recorded transaction year may not coincide with the first or last calendar year for which we observe an income or cost observation. One reason is that a property may be vacant for some months (or even years) leading up to a sale or remain vacant for some time after it has been purchased by a college. In such cases, we match the transaction to the last or first available income observation.

payments, while the costs (including for "ironmongery" and a "carpenter") amounted to slightly more than £19 in total. Subfigure 1C shows part of the document recording the transaction for the same property, which was sold in 1927 for £2,552.

FIGURE 1 ABOUT HERE.

For Trinity College, Cambridge, we collect annual realized property-level rental income and costs incurred from the "Rent Books" over the period 1901–1983. (A missing volume in the archives means we lack the records for some residential properties for the period 1966–1971. We impute income and costs for properties with records in 1965 and 1972 through geometric interpolation.) Unlike at King's, annual income and cost data is reported by tenant name, instead of property name. When several tenants occupy a property, we aggregate income across all tenants in the property in a given year. We collect data on transactions over the same period from the summaries in the annual college accounts and the "Sealed Books". Transactions are reported by property name. Matching tenant-level income data with property-level transaction data is challenging, particularly in the earlier part of our sample period, as there is no common identifier between the property on which the college receives rent from a tenant and the property transacted. In such cases, we match the Trinity income and transaction records by identifying unique property characteristics, such as exact address and property type information.

In the case of Christ Church and New College in Oxford, there are some gaps in the archival records, particularly with respect to rents, due to volumes being destroyed or lost. For Christ Church (New College), we collect data on transactions over the period 1901–1983 (1901–1955).[5] We then collect income and cost data for the year of the transaction and for the two years before (after) a sale (purchase). For New College, we obtain information on contractual income

[5]On occasion the transaction records include a property, such as a large piece of farmland or a residential property with multiple tenants, which is sold not in a single transaction but in a series of transactions in the same year. In such instances, we merge all related transactions into a single transaction with a unique identifier and aggregate all the associated rental income streams into one.

where records for realized income are missing (less than 20% of all observations for the college). Data on transactions and annual property-level income are obtained from the sources outlined in Appendix A. Properties are identified by name in all sources, allowing us to match income and cost as well as transaction records. Property and transaction characteristics are collected from all sources as available.

4.2 Resulting Data Sets and Descriptive Statistics

The data collection described above produces two data sets. The first is a database of 52,761 annual property-level observations on income, cost and property characteristics, mainly based on records from King's and Trinity College.[6] The unit of observation is a unique property-year combination, i.e., property i in year t. The data set covers 3,046 different properties.

The second is a database of 1,769 matches between our property-level income data and transaction records, which is used in our estimation and analysis of income yields. This total does not count transactions of parts of properties; however, we keep track of them when estimating income indices so that we can exclude income changes over years in which such partial transactions occurred. This matched database includes income data as well as corresponding property and transaction characteristics. Here, the unit of observation is a property-transaction combination, i.e., the purchase or sale of property i in transaction x. (Every transaction is associated with a certain year t.) Since some transactions involved more than one property identifiable in the rental income records, our final matching of property records corresponds to 1,359 distinct transactions.

Table 1 summarizes for the income database the number of property-year income observations, and the number of distinct properties that these observations relate to, by decade

[6]For both King's and Trinity, some properties show temporary deviations in income in 1925–1926 that appear to be related to changes in accounting methods. In such cases, we impute income based on the available income data for the surrounding years.

(Panel A), by college and property type (Panel B), and by region (Panel C). Our data are spread quite evenly over time, although we see a decline in the number of properties in later decades. Based on the qualitative descriptions of the dominant use provided in the archival records, we classify properties into one of four main types. "Agricultural" refers to land used for farming and represents approximately 35% of the sample. "Commercial" refers to any property let to a retail, office, industrial or other commercial business and represents 17% of our income observations. "Residential" refers to any residential property or building and contributes about 39% of the data. "Other"—by far the smallest category—refers to schools, government buildings, gardens, etc. The Oxford colleges have lower numbers of observations due to the restrictions we face on data availability and sampling.

TABLE 1 ABOUT HERE.

Panel C of Table 1 shows that the Oxbridge colleges were diversified geographically, although the largest portfolio shares were located in the more prosperous East and South of England (including London). Figure 2 shows a more granular breakdown of the portfolio holdings of King's and Trinity College, Cambridge by aggregate income in the counties of England, Scotland, and Wales, at the beginning and end of our sample period—in 1901 (Subfigure 2A) and in 1983 (Subfigure 2B) respectively.

FIGURE 2 ABOUT HERE.

Table 2 reports on the composition of our sample of properties where we are able to match rental income to a transaction. Although matched property sales outnumber purchases by a factor of about 2:1, we will see in Table 3 that the average real purchase price is about three times the average sale price. Panels A–C summarize the distribution of matched property-transaction records by purchase and sale over time, by college, and by property type. The final column in each panel shows the number of distinct transactions—some of which involved

more than one property identified in the rental income records—corresponding to each row. We observe the highest trading volume in agricultural real estate, particularly in terms of sales. In Panel D, we show the breakdown of matched observations between transactions of a single property and those of a portfolio of multiple properties.

TABLE 2 ABOUT HERE.

Table 3 provides summary statistics on nominal and real income and transaction prices over time. We use inflation data from Dimson et al. (2020) to convert nominal values into real (begin-2020) terms. In Panel A, we report for each decade the number of non-missing (gross) income observations, together with means and medians. In real terms, mean income decreased over the initial years of the twentieth century, but increased substantially in later decades. However, *median* real income only bottomed out in the 1960s. The substantial increases in mean and median income in the later part of our time frame can largely be explained by the increasing relative importance of commercial real estate in the college portfolios (cf. infra). In Panel B, we show for each decade the mean and median purchase and sale price levels. In this panel, the unit of observation is a transaction, so that each portfolio transaction is only counted once. Mean purchase prices are substantially higher than sale prices in all decades after the first one. Although mean prices are higher at the end of our sample period than at the beginning, there exists no monotonic trend over time.

TABLE 3 ABOUT HERE.

4.3 The Evolution of Real Estate Portfolios

We can analyze how the nature of institutional real estate investment has changed over time by charting the evolution of the King's and Trinity property portfolios, for which we have a near-complete history of holdings and associated rental income. Figure 3 graphs the evolution

of the two portfolios. Subfigures 3A and 3B show the time series of the number of income-generating properties by property type for both colleges. Subfigures 3C and 3D display the evolution of real (inflated to year-2020 British pounds) income along the same dimensions. Taken together, the two Cambridge colleges always had several hundred properties in their portfolio. By the end of our sample period, their aggregated income amounted to about ten million pounds in year-2020 terms.

FIGURE 3 ABOUT HERE.

The portfolios of these institutions have always encompassed all three property types. At the start of the twentieth century, both colleges were heavily concentrated in agricultural real estate, which generated more than three-quarters of total gross income. This allocation reflects the nature of their original endowments received centuries earlier and the low turnover during the intervening period. Yet, from the little that is known of other institutional property portfolios at the very start of the twentieth century, a heavy portfolio allocation towards agricultural real estate was not unusual (Dunbabin, 1975). Subsequently, over our sample period there was a significant shift in the portfolio holdings of the two colleges—in terms of both the number of properties and total rental income—away from agricultural and towards commercial real estate. In later decades, commercial real estate is the most important property type held by both institutions. The growing importance of commercial real estate is most striking when studying the evolution of income rather than the number of properties, as average income is higher for a commercial property than for a residential dwelling. Our findings underscore the need to include property types other than housing in order to accurately estimate the long run performance of the direct real estate asset class as viewed by institutional investors.

5 Estimates of Income Growth and Income Yields

5.1 Gross Income Growth Over Time

Aggregate rental income by property type shifts over time at least in part due to the composition of the college portfolios. In order to estimate quality-controlled (gross) income indices over our sample period, we proceed as follows. In every year t and for each property type, we consider all Cambridge properties that are present in our income database both in year $t-1$ and in year t. To avoid mismeasurement of income trends due to properties that have just entered or are about to exit the portfolio, we exclude from the analysis any properties for which we observe a (non-partial or partial) transaction between $t-2$ and $t+1$, and properties that first appear in the data set in $t-2$ or $t-1$ or last appear in the data set in t or $t+1$. Next, we compute for every year t the percentage change in aggregate income. Finally, we chain-link the estimated time-series of income growth rates. Our method thus explicitly controls for changes in the quality composition of the portfolio of properties over time, in a way similar to repeat-sales regressions in the estimation of capital gains on properties. Figure 4 presents the resulting deflated indices for each of the three main property types alongside annual inflation rates.

FIGURE 4 ABOUT HERE.

The figure shows substantial time-series and cross-sectional variation in real income growth. Real rental income decreased dramatically for all property types between 1913 and 1920 due to the high inflation during the war and its immediate aftermath; it then rebounded in the early 1920s as a result of the subsequent price deflation induced by a policy of returning the pound sterling to the gold standard. Income for all property types decreased in the second half of the 1930s, as inflation started to rise again. Between 1940 and 1960, there is very little real income growth, partially reflecting the introduction of rent controls (Knoll, 2017). After

1960, agricultural and commercial income indices increase substantially, while the residential income index trends downwards.

Table 4 presents annualized real income growth rates over our complete sample period 1901–1983, and for four different sub-periods: 1901–1920, 1921–1940, 1941–1960, and 1961–1983. Considering the full sample period, we estimate that real income growth is close to zero for all property types. The annualized real growth rates based on the indices shown in Figure 4 are +0.3% for agricultural, -0.3% for commercial, and -1.0% for residential real estate. The latter result implies that the colleges could only have achieved capital gains in excess of inflation on their commercial and residential real estate investments in a situation where gross income yields declined over time.

TABLE 4 ABOUT HERE.

5.2 Gross Income Yields

Based on our matched rental income and transaction data, we estimate gross income yields. We only consider transaction values exceeding £100 in year-1901 terms (approximately £6,600 at the start of 2020) and ignore partial transactions. Additionally, we exclude cases where the income only constitutes ground rents (i.e., rents paid by the owner of a building to the owner of the land), transactions associated with a change of use (e.g., land being sold for commercial development), and properties classified under the "other" category. (In Appendix B, we plot the yields for all these dropped transactions, which are relatively low on average) For a property bought (sold) in year t, we use the maximum real income generated by the property over the calendar years t until $t+2$ ($t-2$ until t). We exclude cases where this maximum equals zero. We consider these two-year windows before (after) a disposition (acquisition) to minimize the effect of transaction-related temporary voids on income and thus estimate the income generating capacity of a given

property under normal conditions. Next, we divide real income by the real transaction price.[7] In the case of portfolio transactions, we only observe a single transaction price for the entire portfolio. To compute yields on portfolio transactions, we aggregate income over all properties reported as being bought or sold in the same transaction. We classify the transaction under a single property type (agricultural, commercial, or residential) according to which property type generates the largest share of total income. We truncate the lowest and highest 2.5% yield estimates.

Figure 5 shows a scatter plot of all resulting individual yield estimates for agricultural, commercial, and residential real estate. Table 5 presents summary statistics by property type for gross income yields, estimated over the same subperiods shown in Table 4 and over the full 1901–1983 period.

FIGURE 5 AND TABLE 5 ABOUT HERE.

Pooling over all observations in Figure 5, we compute a mean gross yield of 4.7%. More than nine out of ten yields are below 8%. However, there is some variation in mean yields across property types and over time. In Table 5, agricultural and residential yield estimates hover around 5% before WWII and decline thereafter. Commercial yields trend upward in each successive sub-period. Towards the end of our sample period, the contrast between the low observed yields for agricultural (mean of 2.8% over 1961–1983) and for residential real estate (mean of 3.2% over 1961–1983) and the high yields for commercial real estate (mean of 6.5% over 1961–1983) is particularly striking.

At the same time, Figure 5 and Table 5 also highlight cross-sectional variation in realized yields across individual real estate assets, even within a certain time period and property type. Table 5 exhibits an average difference of about 2 percentage points between the first and the third quartiles of income yields for any 20-year period and property type. This finding

[7]For purchases, we add costs spent in the year of purchase and the year thereafter to the acquisition price in order to capture any renovations that improve the property's quality.

underlines the importance of asset-level risks in real estate investments. Transaction prices can be lower or higher than anticipated, as studied in more depth by Giacoletti (2019) and Sagi (2020). Moreover, gross yields can be (temporarily) depressed by rental voids or low-quality tenants.

5.3 The Impact of Costs

We now analyze the extent to which costs—mainly repairs and improvements, but also property taxes and rates, payments to estate agents or brokers, and insurance—reduce realized income yields. To assess the importance of costs, we compare them to realized income (in the following year) aggregated across the two Cambridge colleges. Similar to our income index estimation, we exclude from the analysis any properties for which we observe a (non-partial or partial) transaction between $t-1$ and $t+1$, and properties that first appear in the data set in $t-1$ or t or last appear in the data set in t or $t+1$.

Figure 6 displays the resulting time series by property type. The figure shows that cost ratios are typically around 20%–30%. The downward trend in costs for commercial real estate near the end of our time frame could be related to the greater incidence of contract types where the tenant is responsible for maintenance and repairs. The spikes in residential real estate cost-to-income series near the end of our sample period are due to the impact of a small number of substantial renovations.

FIGURE 6 ABOUT HERE.

Table 6 shows the associated time-series averages. Over the whole sample period, commercial real estate is associated with the lowest average cost ratio (19.4%), especially in the final decades of our study period. Agricultural (28.7%) and especially residential real estate (32.0%) have higher relative costs, driving a larger wedge between gross and net yields for these property types. Compared to modern estimates for the U.S., these estimates are arguably on

the low side. Eisfeldt and Demers (2018) report an average contribution of expenses to gross yields of 41% for single-family rentals over the period 1986–2014. For twenty-first century commercial real estate, NCREIF data show an average expense-to-income ratio of about 35%.

TABLE 6 ABOUT HERE.

Figure 6 focuses on aggregate costs. The substantial variation across properties and over time in the impact of costs means that property-level net income streams will be much more volatile than gross income streams. This finding is illustrated in Figure 7 which shows the annual distribution of property-level gross and net income changes over the prior year across five categories: a decrease of 10% or more, a decrease of less than 10%, no change, an increase of less than 10%, or an increase of 10% or more. Subfigure 7A shows that sharp decreases or increases in gross income are relatively uncommon. (We find that income drops to zero in about 0.5% of all observations.) Subfigure 7B tells a completely different story once costs are taken into account. When pooling data across years, we estimate that the probability of a property-level decrease in net income of 10% or more exceeds 20%. Ignoring costs thus leads to a substantial underestimation of the volatility of real estate income streams.

FIGURE 7 ABOUT HERE.

6 Discussion and Total Return Estimates

In this section, we discuss our findings on historical income growth rates and income yields for residential and non-residential real estate in the context of the existing empirical evidence. We also provide total return estimates and, where possible, benchmark them against prior research.

6.1 Residential Real Estate

Most of the existing empirical work on the performance of real estate investments relates to the history of the housing market. We directly compare our index of residential rental income to the rental index in Jordà et al. (2019a) based on Knoll (2017) and to the quality-adjusted real rent index for London estimated recently by Eichholtz et al. (2018) by plotting the different series in Subfigure 8A for all available years starting in 1901. Note that Eichholtz et al. (2018) use a methodology similar to ours for most of the overlapping time period, relying on repeated individual rent observations taken from the archives of actual real estate investors. By contrast, the estimates used in Jordà et al. (2019a) are constructed using aggregate data on average rents and on the rent component in consumer price indices that do not adjust for variation in quality. Importantly, the primary data are particularly thin for the 1939–1954 period; Knoll (2017) even notes that "to the best of [her] knowledge, no data on rents exist between 1946 and 1954" (p. 247).[8]

FIGURE 8 ABOUT HERE.

In Table 4, we reported an estimated *decline* of 1.0% per year in real income for U.K. residential property over the 1901–1983 period. By contrast, the index of Jordà et al. (2019a) *grows* by 0.9% per year on average. Our estimate is closer to that of Eichholtz et al. (2018), who compute an annualized decline in real housing rents for London of 0.6% per year over the same period. Figure 8 shows a substantial gap in estimates for the period between the start of WWII and the early 1960s. Panel A of Table 7 shows that, over the years 1941–1960, we find an annualized real income growth rate of -0.7%, compared to +3.7% in Jordà et al. (2019a). The difference in income growth estimates between our results and those presented in Jordà

[8]We represent their rent index as derived from the house price index and rental yields as used in Jordà et al. (2019a). The resulting income index shows a gap over the WWII years, which we geometrically interpolate here.

et al. (2019a) underscores the importance of controlling for variation in housing characteristics when estimating long-run rental growth figures for residential real estate.

TABLE 7 ABOUT HERE.

The large gap in income growth estimates between our results and Jordà et al. (2019a) for the post-WWII years coincides with substantial differences in the income yield estimates.[9] In Subfigure 8B we graph our individual yield observations, converted to *net* yields by assuming the average cost ratio reported in Table 6. We also plot the average yield series of Jordà et al. (2019a). We find that, overall, 74% of our individual yield observations are below their series; this fraction increases to 84% for the post-1945 period.[10] Overall, Jordà et al. (2019a) estimate a (geometric and arithmetic) average aggregate *net* yield of 4.0% over our period, while we reported a simple mean *gross* yield of 4.3% computed across all individual yield observations in Table 5 and a cost-to-income ratio close to one-third in Table 6, implying much lower net numbers.

Our finding that residential income declined by half in real terms over our sample period, while income yields decreased less, implies negative capital gains—and therefore average total returns lower than average income yields. Whilst the relatively high frequency of our rental data allow a precise estimation of annual income growth, our transaction price data do not permit the direct estimation of an annual capital gains series (i.e., $k_{\eta,t}$ in Eq. (3)) with sufficient precision. However, using Eqs. (4) and (5), we demonstrated that the time series of income growth and average yield estimates can help us generate an estimate of historical capital gains. Having already reported our income index, the remaining challenge is to extract from our sample of individual yield observations estimates of the annual series of average yields (i.e., $\overline{y_t^*}$),

[9] This being said, replacing the income growth estimates in Jordà et al. (2019a) by lower ones would lead to even *higher* yield estimates for much of our time frame because of their method of backward extrapolation.

[10] When doing a decade-by-decade analysis, we find that a 95% confidence interval around the means of our net yields does not include any of the annual yield estimates of Jordà et al. (2019a) for the 1940s, 1950s, 1960s, and 1980s.

and thereby to construct an annual series of all return components that can be compared to the results of Jordà et al. (2019a). Since we only observe a limited number of transaction data points in each time period, we discipline the estimation of the average yield series as follows. We assume that the estimated U.K. housing price index of Jordà et al. (2019a), which is based on Knoll et al. (2017), is perfectly correlated with the true underlying price index over our sample period, but that annual changes in their index may over- or underestimate true capital gains by some constant parameter.[11] Taking our income index as given, we can then find the average yield series that best fits our observed individual yields. We do so through a simple regression model in which we estimate two coefficients: one related to the relative average level of income to prices, and one related to the degree to which the benchmark price index over- or underestimates annual price changes. We provide more details on our procedure in Appendix C.

Subfigure 8B plots the resulting fitted series of average income yields. It tracks that of Jordà et al. (2019a) rather closely until the start of WWII, but then diverges substantially. In Subfigure 8C, we benchmark the estimated capital gains series against each other. The price index values of Knoll et al. (2017) used in Jordà et al. (2019a) imply a positive average real capital gain over the 1901–1983 period. (We geometrically interpolate their missing price index values over the WWII period.) By contrast, we find that real price levels have gone down over our sample period. The same subfigure also shows our resulting total returns index, and compares it to that of Jordà et al. (2019a). In Panel B of Table 7, we report the associated mean statistics. In sum, we find lower geometric average capital gains (-0.7% vs. +0.7%) and net income yields (3.0% vs. 4.0%) than Jordà et al. (2019a), leading to an annualized net total return estimate of 2.3%, compared to their 4.7%. This substantial difference in

[11] It is important to note that we are using the price index of Jordà et al. (2019a) to inform our estimates of *year-on-year variation* in price changes. We are not assuming or imposing any particular bias in their annualized capital gains estimate ex ante. Our estimate of the long-term average capital gain—and thus of the annual bias in Jordà et al. (2019a)—is driven by the long-run trends in income and observed yields in our data. The assumption that the (potential) bias is constant over time is necessary to make the problem tractable.

the two headline results likely arises from the greater precision of income growth and yield estimates enabled by our granular property-level data set. Also, our empirical strategy avoids the compounding of errors over time that is inherent in the backwards extrapolation, starting from contemporary yields, employed by Jordà et al. (2019a).

Finally, we note that, in the study of Jordà et al. (2019a), the U.K. is associated with some of the *lowest* estimates—out of a sample of sixteen countries—of the net returns to housing. For the period 1901–1983, averaging across the country-level geometric mean net return estimates gives a value of 6.3%, which is substantially above the U.K. estimate. Therefore, we believe that the discrepancies that we document are unlikely to be due to U.K.-specific measurement error in Jordà et al. (2019a).[12]

6.2 Agricultural Real Estate

Estimates of historical income growth rates are more difficult to find for agricultural property. Nonetheless, we compare our income index to the agricultural land rent index constructed from survey data in the little-known study of Lloyd (1992). We graph the results in Subfigure 9A. Overall, the two series appear quite consistent. This finding provides additional comfort regarding the representativeness of our agricultural income data.

FIGURE 9 ABOUT HERE.

In Subfigure 9B, we plot our individual yield observations, but now converted to net yields by applying the sample-period-mean cost ratio of 28.7% (cf. Table 6). Although we lack a comparable series for our entire sample period, our estimated yields for the early 1980s are broadly consistent with the earliest numbers reported by IPD.

[12] In parallel work, Eichholtz et al. (2020) use property-level archival data from Paris and Amsterdam to estimate the historical investment performance of residential real estate. Their estimates of annualized real total net returns are 1.4% (Paris 1871–1943) and 2.2% (Amsterdam 1900–1979) below those reported by Jordà et al. (2019a) for the same locations and periods.

In order to construct a fitted net yield index following the same approach outlined above, we make use of the farmland price index in Jadevicius et al. (2018), which relies heavily on a farm auction price series constructed at Oxford University. Interestingly, we do not need to (significantly) adjust their annualized capital gain estimate of 1.1% downwards to obtain the best fit of our observed yields, as indicated in Panel B of Table 7 and also illustrated by the nearly-coinciding price series in Subfigure 9C.

It thus seems that our estimates agree with the (limited) previous research on agricultural real estate in capturing income and price trends. Most likely, temporal variation in average property quality is less of a concern for agricultural than for residential real estate. More importantly, our research is novel in that we can produce estimates of agricultural yields and thus also total returns. From the fitted index in Subfigure 9B, we estimate the average income yield on agricultural real estate over our sample period to be 3.4%. Subfigure 9C shows the total returns index that results from our analysis. Panel B of Table 7 reports an annualized net total return of 4.5% over our sample period, substantially exceeding that of residential real estate.

6.3 Commercial Real Estate

In the case of commercial real estate, we are not aware of any income or continuous price index that covers even most of our time period. Figure 10 displays our individual yields, again converted to net numbers in the same way as before, and compares them to the annual average yields reported for shops and offices in Scott (1996). For the period 1971–1983, we also show the yield estimates from IPD.

FIGURE 10 ABOUT HERE.

Our estimated net yields of around 5% at the end of our sample period are broadly consistent both with Scott (1996) and with the earliest-available data on U.K. commercial

property provided by IPD. However, prior to 1970, a large majority of our yield observations fall below those reported in Scott (1996). A possible explanation for this difference is that Scott (1996) reports initial contractual yields on property investments, which are arguably an upper bound estimate of actual income yields realized later in the holding period.[13] In addition, some of the data in Scott (1996) come from information collected on investment purchases by financial institutions and from investment property newspaper advertisements, both of which may overstate the yields achieved by the average institutional investor.

While we cannot construct an annual time series of commercial real estate returns, the combination of negative income growth documented previously and substantial income yield expansion implies negative price changes over our time period. This result is consistent with earlier findings of Wheaton et al. (2009), who estimated that Manhattan office property values were substantially lower in 1999 than in 1899 (based on a small sample of repeat-sales transactions). We can therefore consider the average net income yield of about 4.5% reported in Table 5 to be an upper bound estimate of total returns. Our results thus suggest a performance in between that of residential and agricultural real estate.[14]

7 Conclusion

In this paper, we construct a unique data set from the archival records of a group of important U.K. institutional real estate investors—the endowments of four large Oxbridge Colleges—which contains granular information on realized rental income, costs, and transaction prices at the level of individual properties over the period 1901–1983.

[13] In our own data set, we compute yields using both purchase and sale transactions, and purchases are indeed associated with slightly higher yields than sales.

[14] We can do a simple back-of-the-envelope calculation of the average capital gain as follows. If real income over our time period dropped by about a quarter (cf. Figure 4), and yields increased by about half (cf. Table 5), then this would imply an annualized real price change of about -0.8% (similar to that of residential).

The evolution of our sample of direct property portfolios over this time period is indicative of the greater importance of non-residential compared to residential real estate for U.K. institutional investors. In order to better understand the past performance of direct real estate as an asset class, we thus also need to examine agricultural and commercial real estate. Our data set allows us to estimate for all three property types not only realized income growth over time, but also income yields, cost-to-income ratios, and net total returns.

The main empirical results can be summarized as follows. First, long-term real rental income growth is close to zero for all major property types. Second, average gross yields fluctuate around 5% for most of the study period. Significant yield compression in agricultural and residential real estate occurred during the last decades of our sample period, while commercial yields display the opposite trend. Third, operating costs lower gross yields by 20%–30%, and significantly increase the volatility of the net income from real estate. Fourth, our estimates of income and yield dynamics imply very limited (or even negative) long-run capital gains, and annualized real net total returns of between 2.3% (residential) and 4.5% (agricultural).

Overall, our results suggest that the investment performance of direct real estate assets in the long run is less attractive than previously thought.

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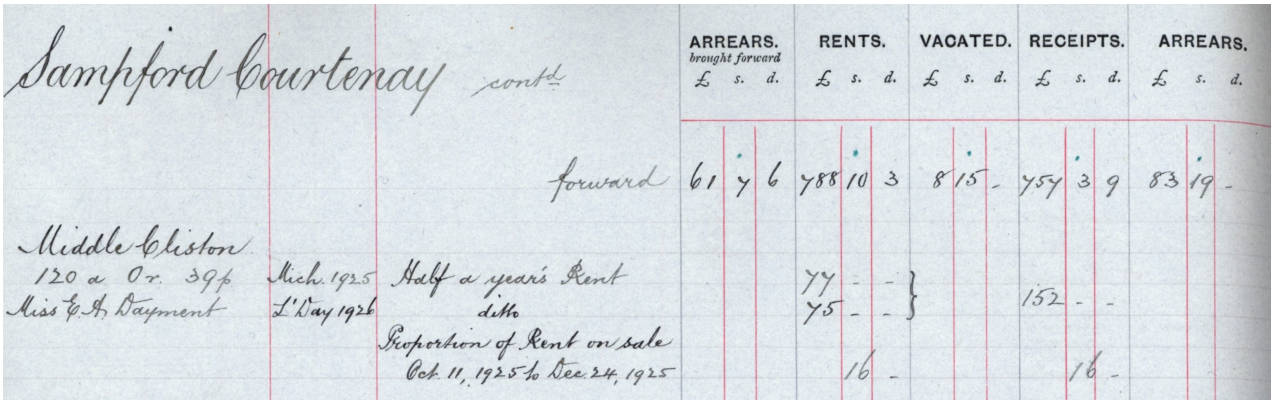
Figure 1. Example of data

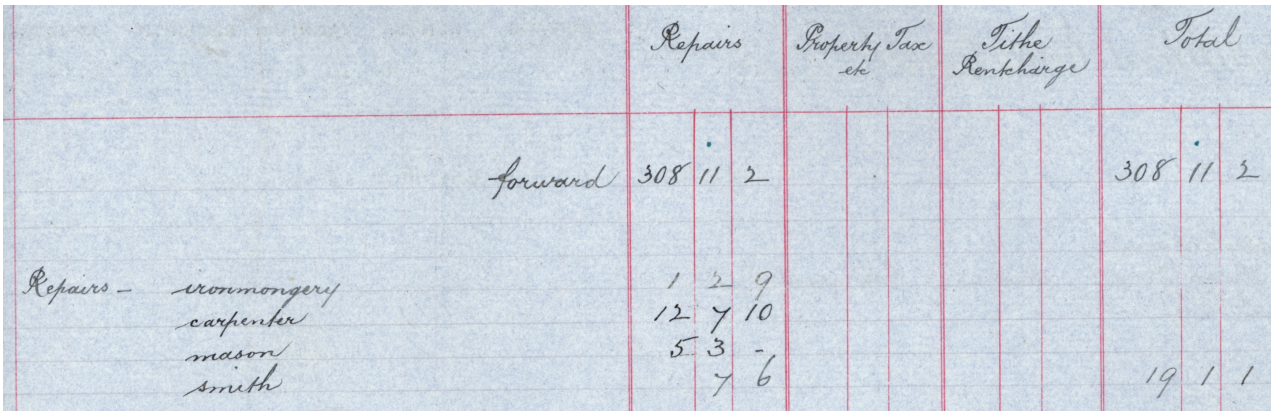
This figure illustrates our data collection. Subfigures 1A and 1B show the year-1926 income and costs for a farm property called "Middle Cliston" (source: King's College Archives, KCAR/4/1/1/1926/1 opening 75). Subfigure 1C shows an excerpt from the year-1927 transaction record for the same property—a sale at £2,552 (source: King's College Archives, KCAR/3/3/1/1/26 folio 24).



Sampford Courteney cont'd

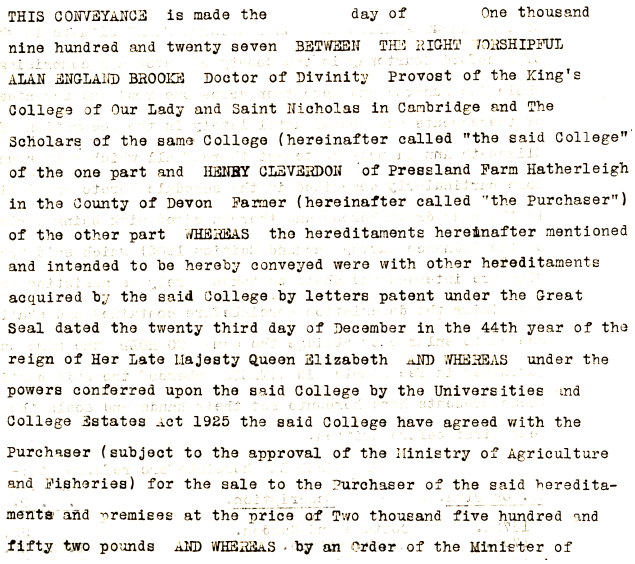
			ARREARS. brought forward £ s. d.	RENTS. £ s. d.	VACATED. £ s. d.	RECEIPTS. £ s. d.	ARREARS. £ s. d.
forward			61 7 6	788 10 3	8 15 -	754 3 9	83 19 -
Middle Cliston 120 a 0r. 39p Miss E.A. Dayment	Mich. 1925	Half a year's Rent		77 - -			
	L'Day 1926	ditto		75 - -		152 - -	
		Proportion of Rent on sale Oct. 11, 1925 to Dec. 24, 1925		16 -		16 -	

(A) Income



		Repairs	Property Tax etc	Tithe Rentcharge	Total
forward		308 11 2			308 11 2
Repairs –	ironmongery	1 2 9			
	carpenter	12 7 10			
	mason	5 3 -			
	smith	7 6			19 1 1

(B) Costs

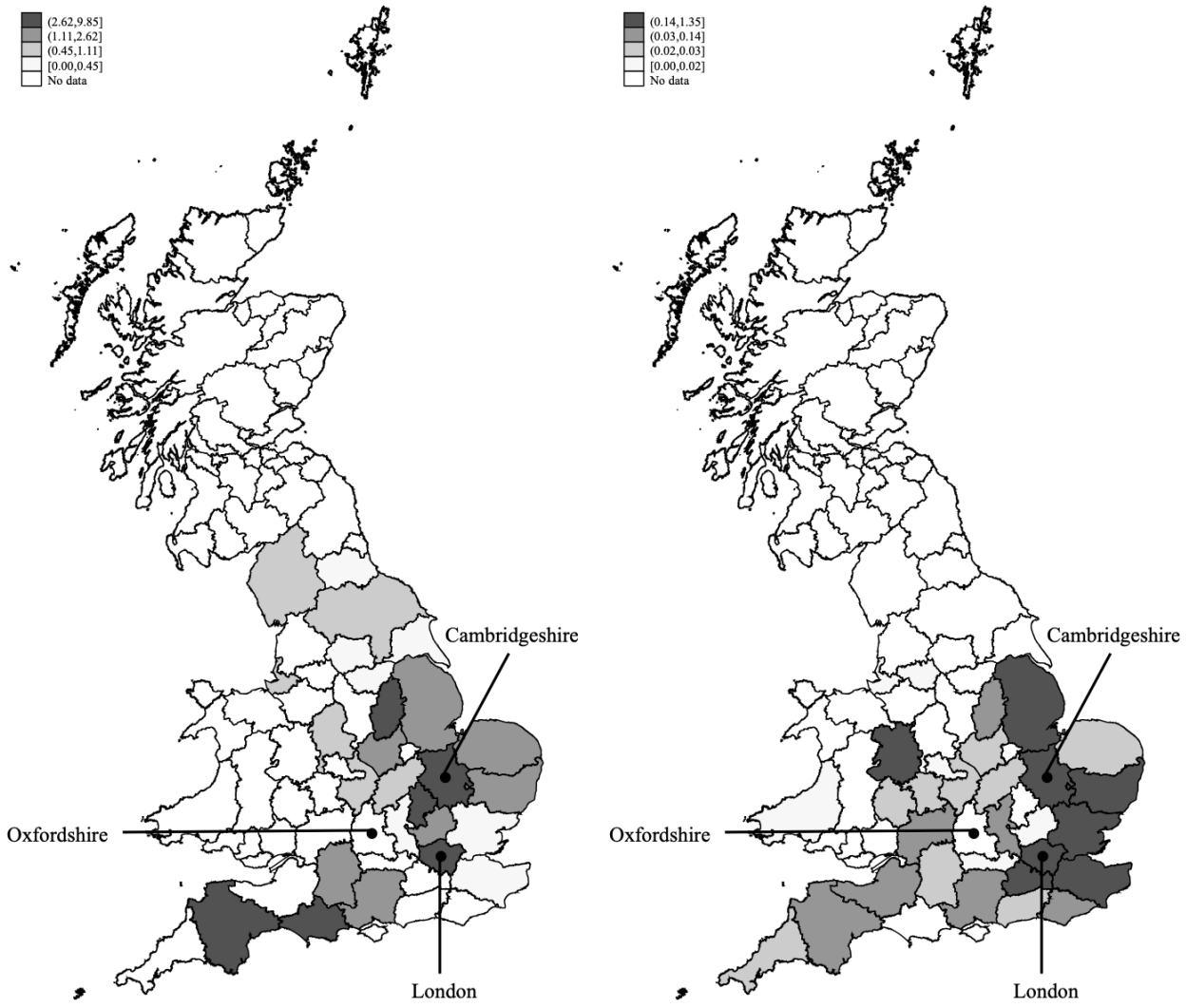


THIS CONVEYANCE is made the day of One thousand nine hundred and twenty seven BETWEEN THE RIGHT WORSHIPFUL ALAN ENGLAND BROOKE Doctor of Divinity Provost of the King's College of Our Lady and Saint Nicholas in Cambridge and The Scholars of the same College (hereinafter called "the said College" of the one part and HENRY CLEVERDON of Pressland Farm Hatherleigh in the County of Devon Farmer (hereinafter called "the Purchaser") of the other part WHEREAS the hereditaments hereinafter mentioned and intended to be hereby conveyed were with other hereditaments acquired by the said College by letters patent under the Great Seal dated the twenty third day of December in the 44th year of the reign of Her Late Majesty Queen Elizabeth AND WHEREAS under the powers conferred upon the said College by the Universities and College Estates Act 1925 the said College have agreed with the Purchaser (subject to the approval of the Ministry of Agriculture and Fisheries) for the sale to the Purchaser of the said hereditaments and premises at the price of Two thousand five hundred and fifty two pounds AND WHEREAS by an Order of the Minister of

(C) Transaction record

Figure 2. Geographical distribution of properties

This figure shows the spatial distribution of the property holdings of King's and Trinity College across the counties of England, Scotland, and Wales. Darker shading of the counties in the map indicates a larger amount of aggregate income generated within them. Subfigures 2A and 2B show the geographical spread of the properties in 1901 (income scaled by £1,000) and 1983 (income scaled by £1m), respectively.

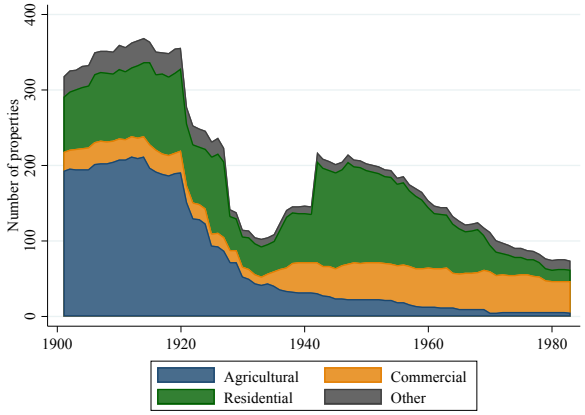


(A) Portfolios in 1901

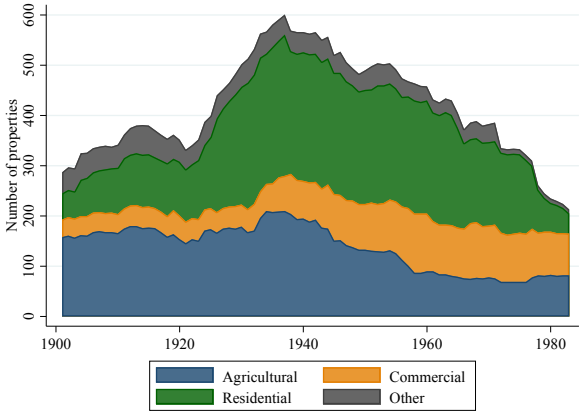
(B) Portfolios in 1983

Figure 3. Evolution of portfolios

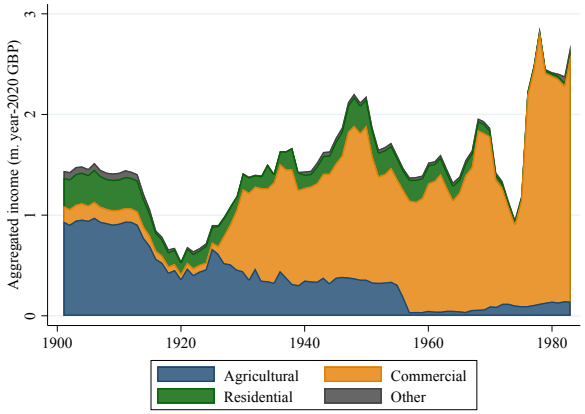
This figure illustrates the evolution of the King's and Trinity College portfolios over our sample period in terms of numbers of properties (Subfigures 3A and 3B) and real (gross) income (Subfigures 3C and 3D). Each figure shows the relative importance of agricultural, commercial, residential, and other real estate.



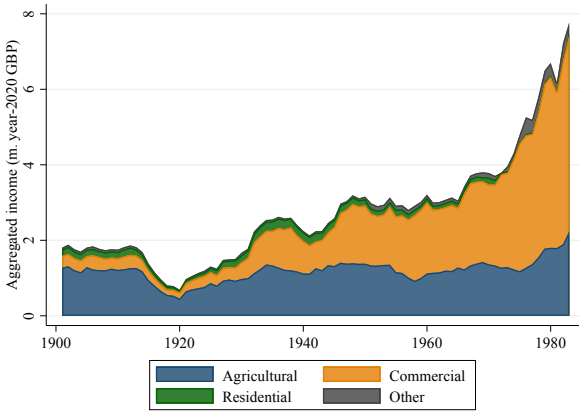
(A) King's: number of properties



(B) Trinity: number of properties



(C) King's: real income



(D) Trinity: real income

Figure 4. Real income indices

This figure graphs the estimated real gross income indices over our sample period for agricultural, commercial, and residential real estate. It also shows annual inflation rates from Dimson et al. (2020) against the right axis.

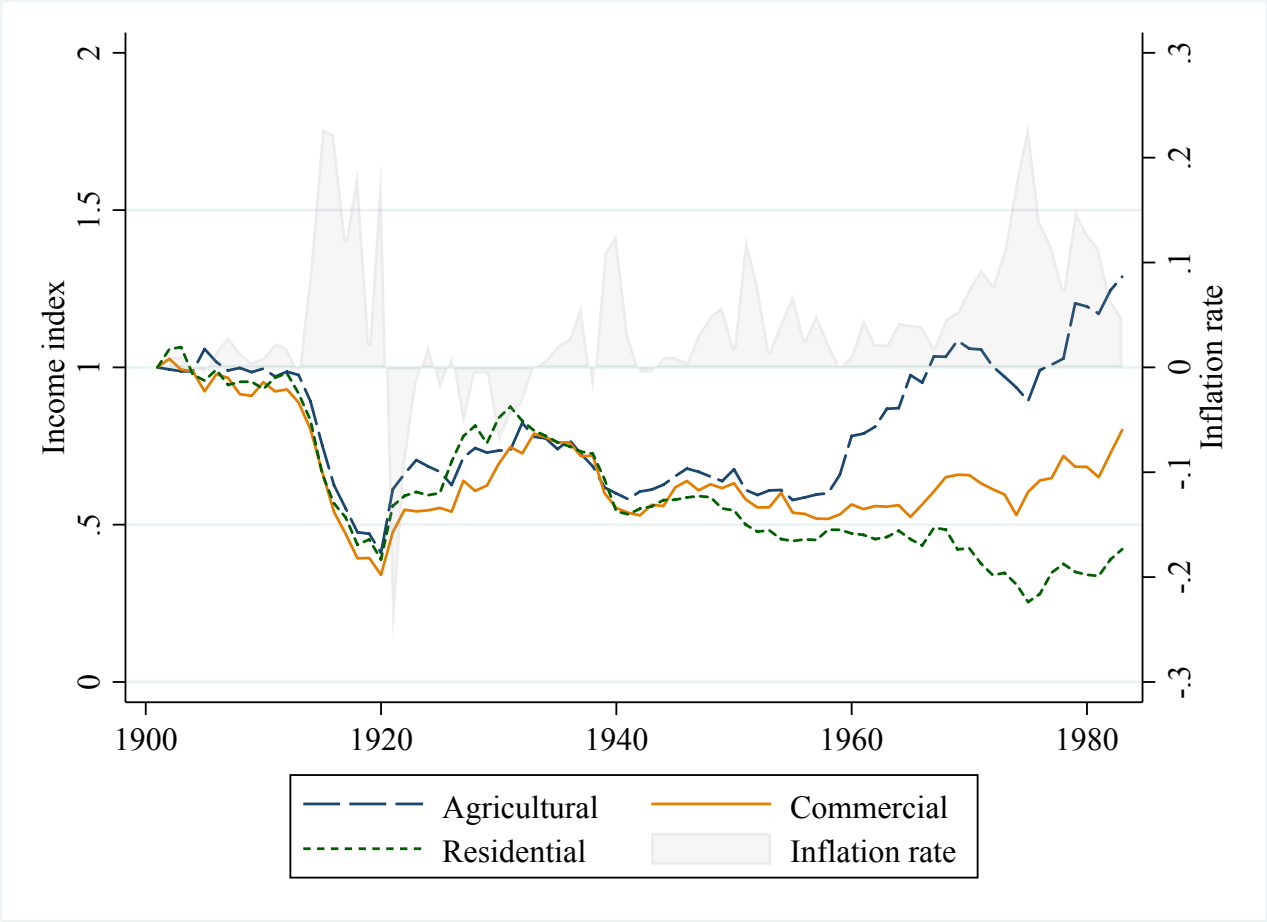


Figure 5. Income yields

This figure graphs the estimated property-level gross income yields associated with transactions of agricultural, commercial, and residential properties.

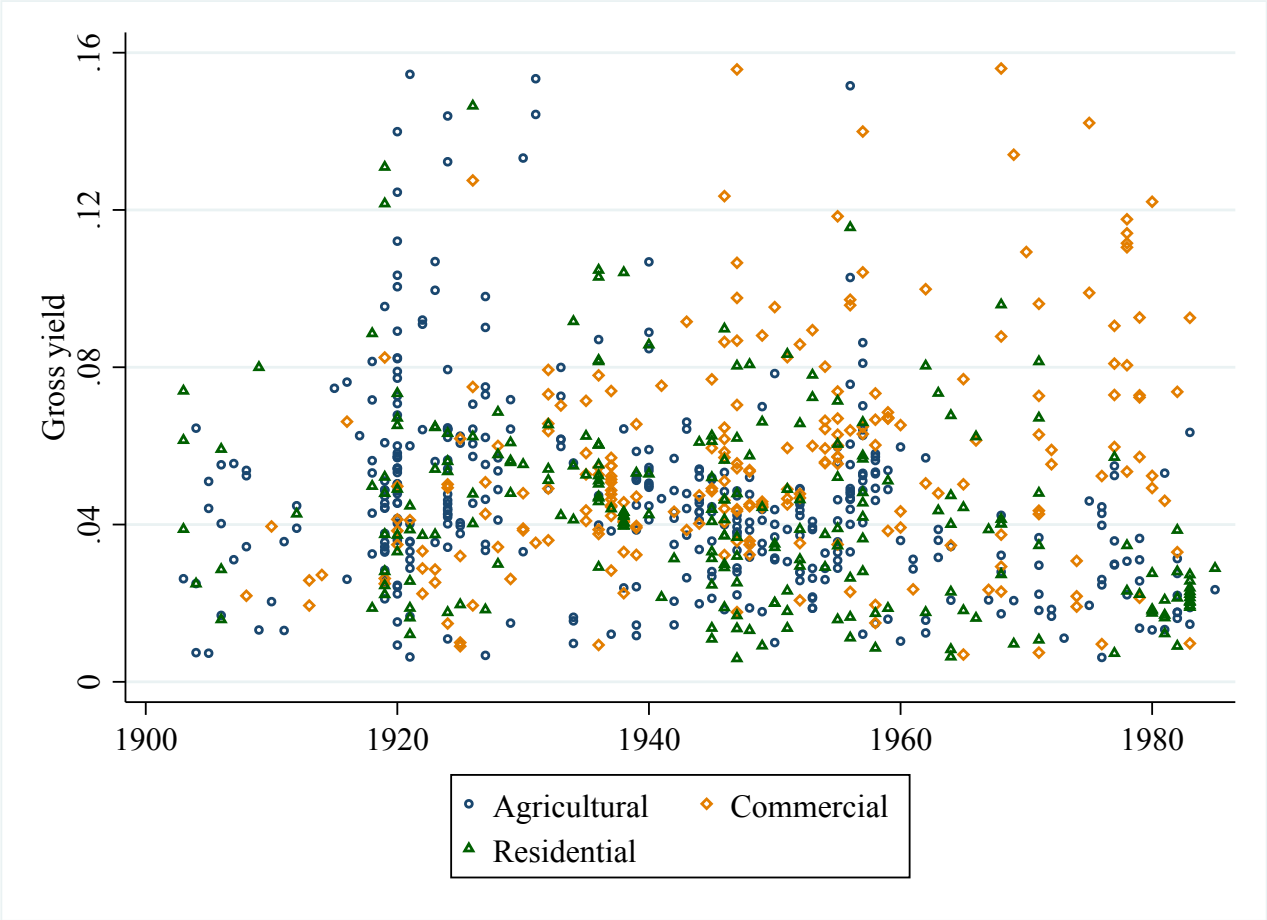


Figure 6. Cost ratios

This figure graphs the yearly total cost-to-income ratio over our sample period, aggregated over the income observations for King's and Trinity College, for agricultural, commercial, and residential real estate.

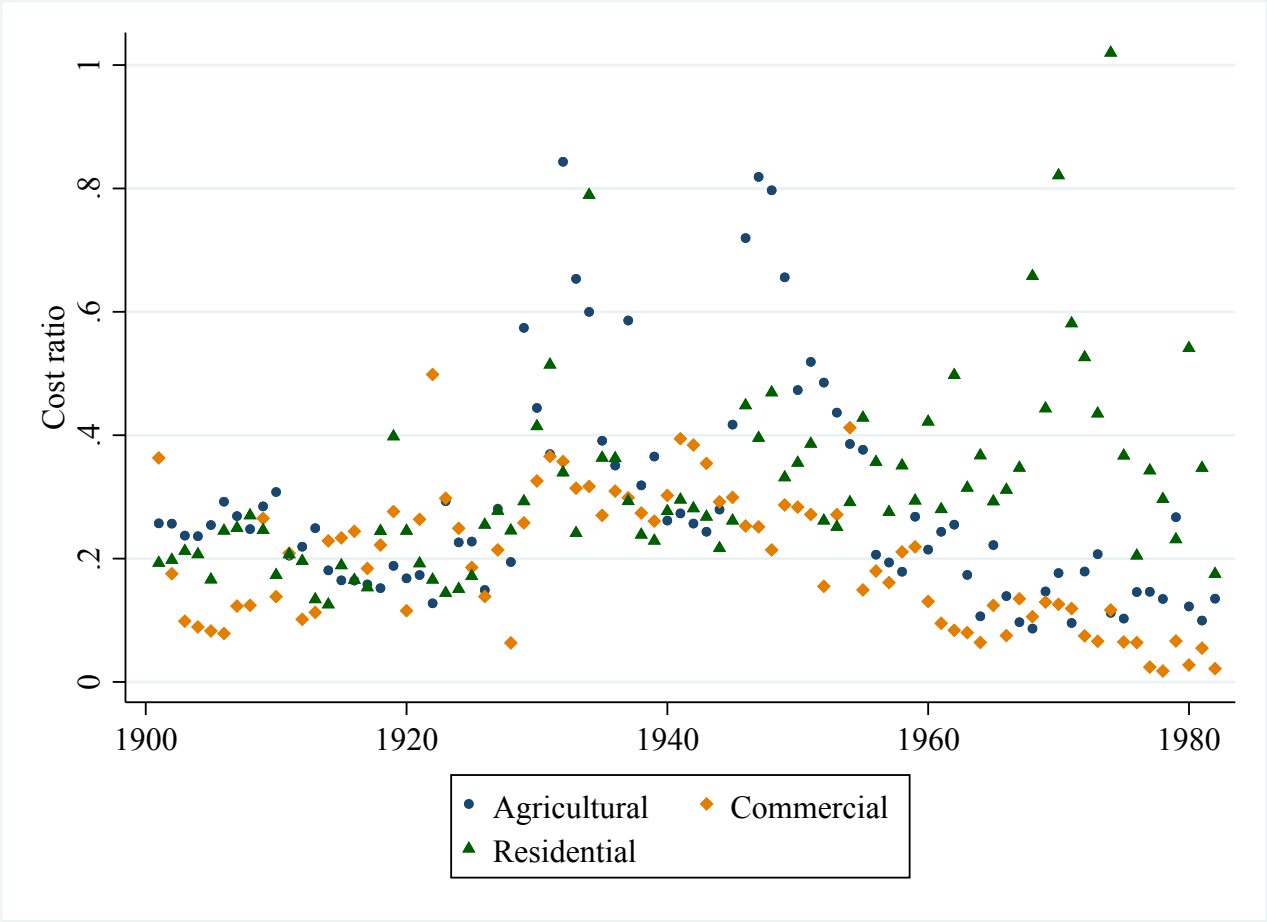
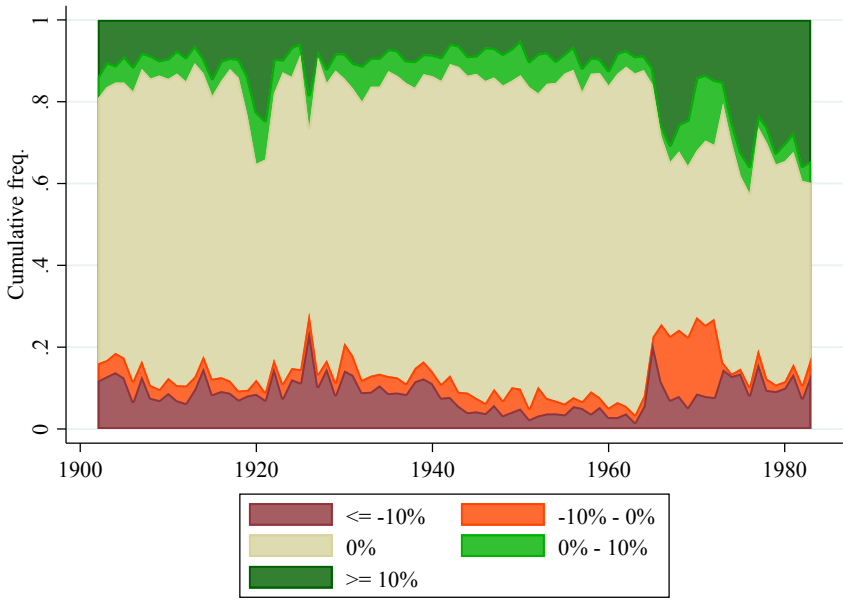
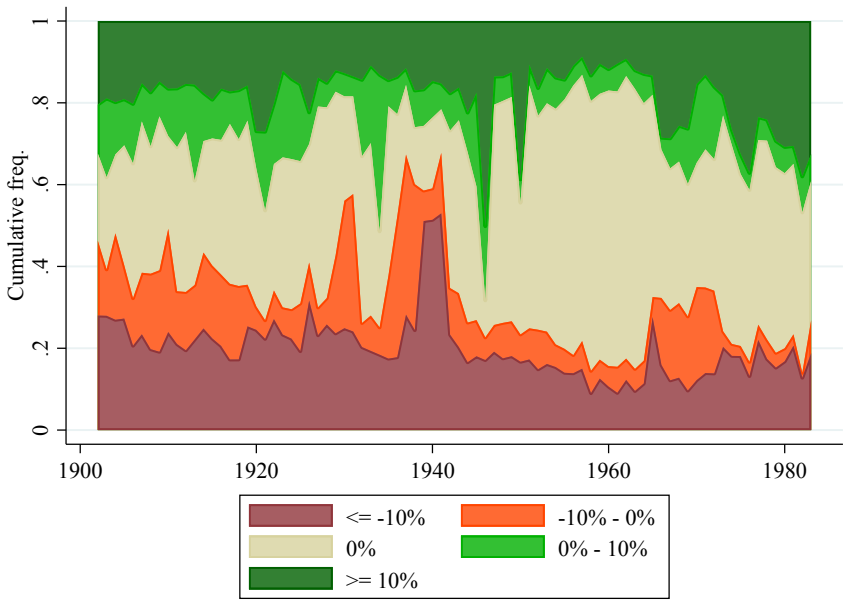


Figure 7. Distribution of changes in income and net income

This figure graphs the yearly distribution of property-level changes in gross income (in Subfigure 7A) and net income (in Subfigure 7B), using data from King's and Trinity College, over our sample period.



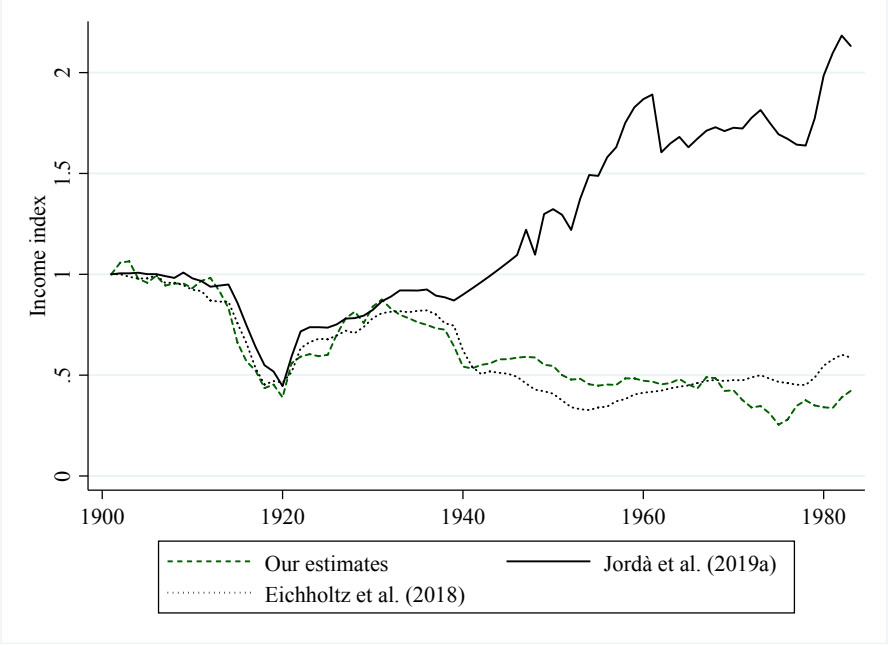
(A) Annual changes in income



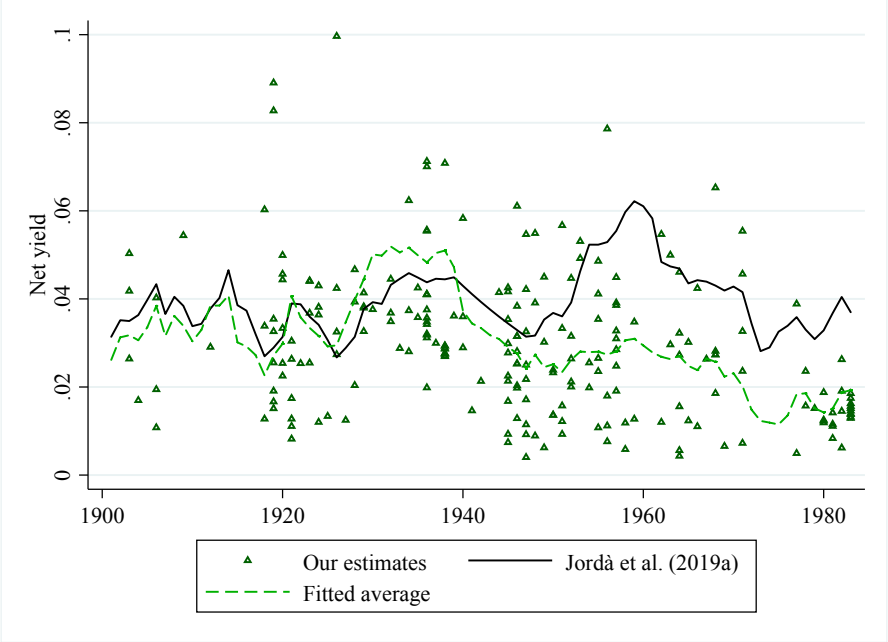
(B) Annual changes in net income

Figure 8. Residential: comparison with existing research and implied total returns

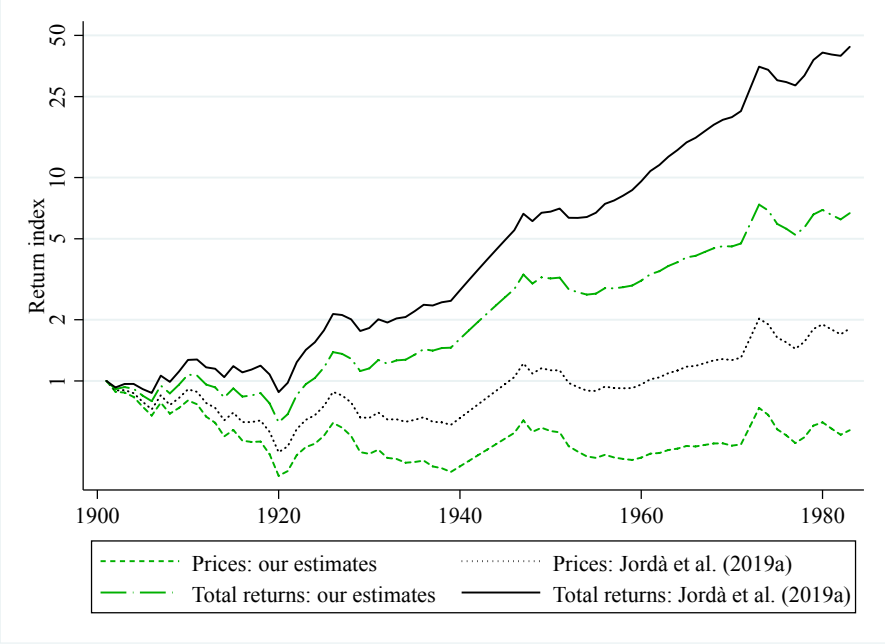
Subfigure 8A repeats our real income index for U.K. residential real estate from Figure 4, and also shows the real housing rental income index for the U.K. used in Jordà et al. (2019a) and the quality-adjusted real housing rental income index for London estimated by Eichholtz et al. (2018) for our sample period. Subfigure 8B repeats the residential real estate observations from Figure 5, but now converted to net yields. It also shows the average net yields for U.K. housing estimated by Jordà et al. (2019a) and our own fitted time series. Subfigure 8C compares our own implied capital gain and total return estimates to those of Jordà et al. (2019a).



(A) Comparison of real income growth estimates



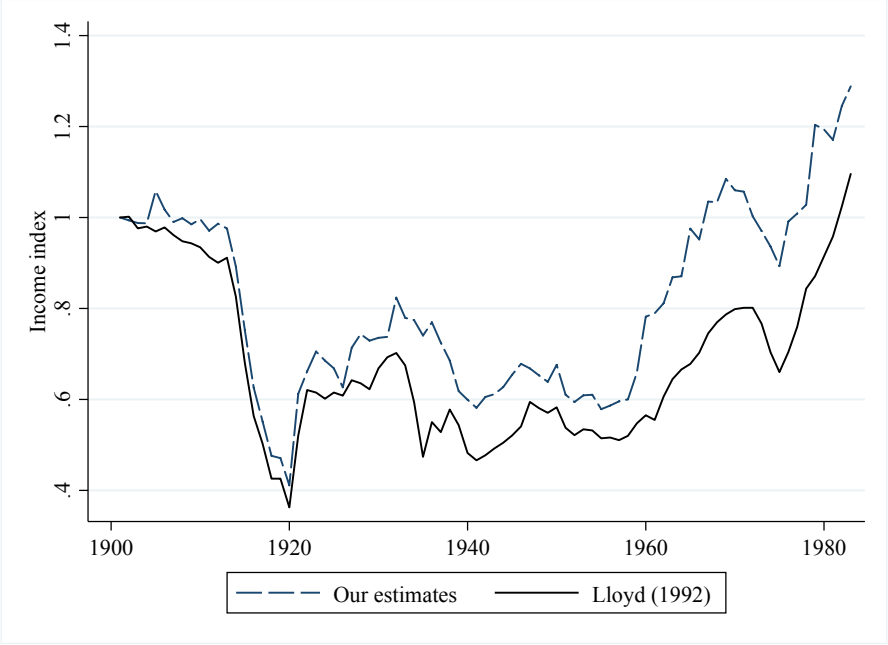
(B) Comparison of net yield estimates and fitted time series



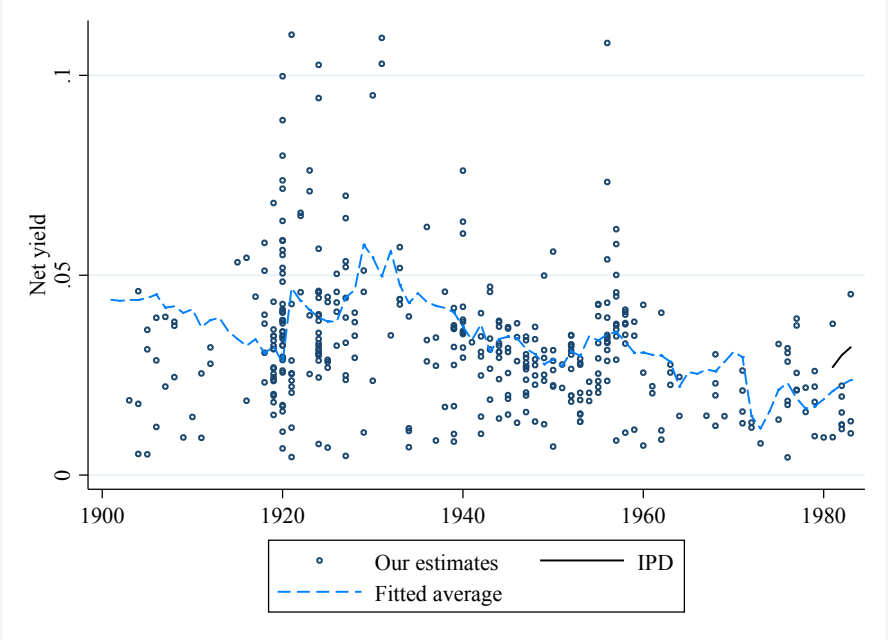
(C) Capital gain and total return estimates

Figure 9. Agricultural: comparison with existing research and implied total returns

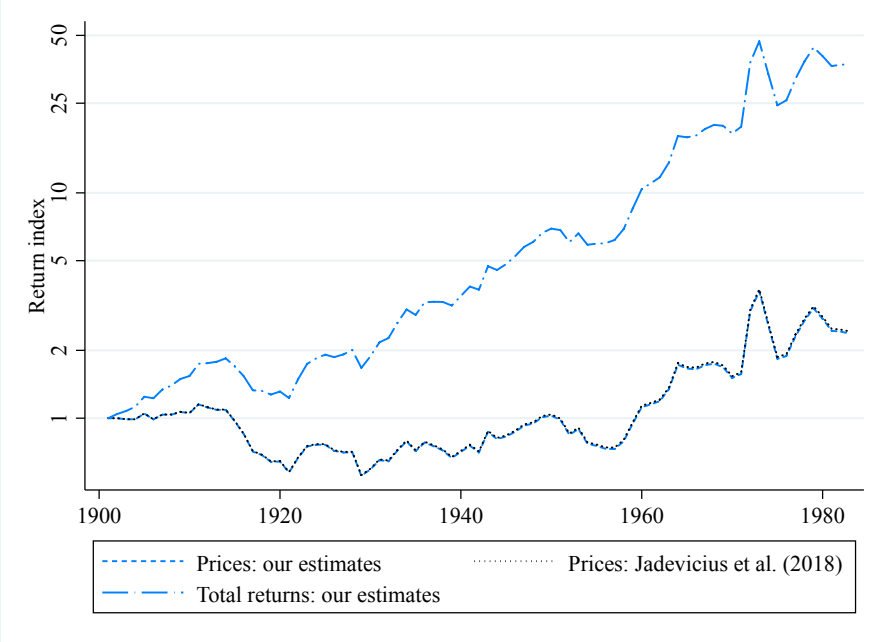
Subfigure 9A repeats our real income index for U.K. agricultural real estate from Figure 4, and also shows the real farmland rental income index for the U.K. constructed in Lloyd (1992) for our sample period. Subfigure 9B repeats the agricultural real estate observations from Figure 5, but now converted to net yields. It also shows the average net yields for U.K. farmland estimated by IPD (for the final years of our sample period) and our own fitted time series. Subfigure 9C compares our own implied capital gain estimates to those of Jadevicius et al. (2018) and also shows our implied total return estimates.



(A) Comparison of real income growth estimates



(B) Fitted net yield estimates



(C) Capital gain and total return estimates

Figure 10. Commercial: comparison with existing research

This figure repeats the commercial real estate observations from Figure 5, but now converted to net yields. It also shows the average net yields estimated by Scott (1996) and by IPD (for the closing years of our sample period).

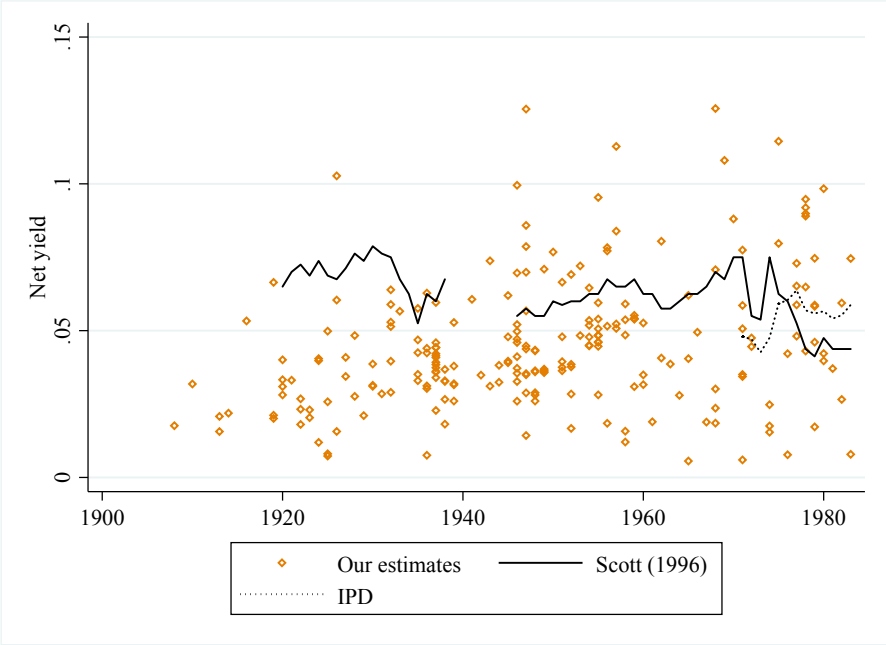


Table 1. Composition of income data set

This table shows the number of property-year income observations and the number of distinct properties per decade (in Panel A), per college and property type (in Panel B), and per region (in Panel C).

Panel A. Distribution over decades

	N	# prop.
1901–1910	6,741	840
1911–1920	7,514	1,021
1921–1930	6,660	1,209
1931–1940	7,023	1,065
1941–1950	7,607	1,092
1951–1960	6,846	957
1961–1970	5,597	731
1971–1980	3,853	592
1981–1983	920	342
Total	52,761	3,046

Panel B. Distribution over colleges and property types

	Agricult.	Comm.	Resid.	Other	Total	# prop.
King's College	5,997	3,016	6,254	1,318	16,585	933
Trinity College	11,481	6,014	14,036	3,053	34,584	1,568
Christ Church	590	150	395	95	1,230	413
New College	186	34	119	23	362	132
Total	18,254	9,214	20,804	4,489	52,761	3,046
# prop.	1,161	509	1,185	391		

Panel C. Distribution over regions

	N	# prop.
East Midlands	8,647	418
East of England	24,396	1,026
London	5,419	343
North East England	61	3
North West England	751	44
Scotland	28	2
South East England	4,406	567
South West England	5,633	361
Wales	15	1
West Midlands	1,706	148
Yorkshire and the Humber	1,699	133
Total	52,761	3,046

Table 2. Composition of matched property-transactions data set

This table shows the number of matched income-transaction observations per decade and transaction type (in Panel A), per college and transaction type (in Panel B), per property type and transaction type (in Panel C), and per contract type and transaction type (in Panel D). In each panel, the last column shows the number of distinct transactions corresponding to each row.

Panel A. Distribution over decades and transaction types

	Purchases	Sales	Total	# trans.
1901–1910	16	30	46	40
1911–1920	30	150	180	145
1921–1930	35	167	202	181
1931–1940	164	106	270	169
1941–1950	193	197	390	212
1951–1960	62	205	267	224
1961–1970	30	143	173	153
1971–1980	37	147	184	178
1981–1983	7	50	57	57
Total	574	1,195	1,769	1,359

Panel B. Distribution over colleges and transaction types

	Purchases	Sales	Total	# trans.
King's College	188	322	510	364
Trinity College	257	536	793	642
Christ Church	88	277	365	271
New College	41	60	101	82
Total	574	1,195	1,769	1,359

Panel C. Distribution over property types and transaction types

	Purchases	Sales	Total	# trans.
Agricultural	155	460	615	496
Commercial	214	168	382	294
Residential	188	504	692	549
Other	17	63	80	71
Total	574	1,195	1,769	1,359

Panel D. Distribution over contract types and transaction types

	Purchases	Sales	Total	# trans.
Single property	307	936	1,243	1,243
Portfolio of properties	267	259	526	116
Total	574	1,195	1,769	1,359

Table 3. Descriptive statistics income and prices

This table reports a number of descriptive statistics (number of observations, median, and mean) per decade for (gross) income (in Panel A, where the unit of observation is a property-year combination), and for purchase and sale prices (in Panel B, where the unit of observation is a transaction).

Panel A. Gross income and net income

		£		2020 £	
Decade	*N*	Mean	Median	Mean	Median
1901–1910	6,740	77	31	4,935	1,954
1911–1920	7,504	78	30	3,215	1,115
1921–1930	6,637	106	25	3,602	856
1931–1940	6,999	149	25	5,625	934
1941–1950	7,588	227	29	6,274	797
1951–1960	6,838	379	30	6,889	556
1961–1970	5,580	692	40	9,053	524
1971–1980	3,853	3,680	500	17,945	2,975
1981–1983	920	11,575	4,250	31,405	11,599
Total	52,659	681	32	6,911	1,108

Panel B. Purchase prices and sale prices

	Purchase prices					Sale prices				
		£		2020 £			£		2020 £	
Decade	*N*	Mean	Median	Mean	Median	*N*	Mean	Median	Mean	Median
1901–1910	16	1,862	1,190	119,025	75,726	24	2,776	1,215	175,058	76,996
1911–1920	14	5,077	2,863	166,898	119,037	131	2,157	1,000	58,863	24,242
1921–1930	35	7,025	1,000	239,983	38,040	146	2,847	1,750	96,471	56,986
1931–1940	93	10,581	7,150	397,689	245,675	76	4,134	873	154,794	30,161
1941–1950	74	23,577	18,720	657,003	490,851	138	6,152	1,863	166,011	51,438
1951–1960	52	17,812	11,051	325,959	193,755	172	10,025	4,000	179,034	70,352
1961–1970	24	21,426	16,250	285,137	225,603	129	12,414	1,250	166,457	16,370
1971–1980	31	188,158	175,000	1,003,782	833,643	147	41,574	3,300	274,118	15,369
1981–1983	7	339,214	300,000	901,743	836,960	50	128,031	22,125	337,754	61,932
Total	346	36,773	10,500	460,885	258,230	1,013	17,539	2,150	167,938	37,184

Table 4. Real income growth rates

This table shows annualized (i.e., geometric average) income growth rates, in real terms, both over our complete sample period and over four different subperiods.

	Agricultural	Commercial	Residential
1901–1920	-4.6%	-5.5%	-4.8%
1921–1940	1.9%	2.5%	1.7%
1941–1960	1.3%	0.1%	-0.7%
1961–1983	2.2%	1.5%	-0.5%
1901–1983	0.3%	-0.3%	-1.0%

Table 5. Income yields

Panel A of this table shows a number of descriptive statistics for the estimated yields for agricultural real estate, both for our complete sample period and for four different subperiods. Panels B and C show results for commercial and residential real estate.

Panel A. Agricultural real estate

	N	Mean	Median	P25	P75
1901–1920	89	5.0%	4.8%	3.4%	5.8%
1921–1940	111	5.6%	5.1%	4.0%	6.4%
1941–1960	141	4.3%	4.2%	3.3%	4.9%
1961–1983	55	2.8%	2.8%	1.8%	3.6%
1901–1983	396	4.6%	4.4%	3.1%	5.5%

Panel B. Commercial real estate

	N	Mean	Median	P25	P75
1901–1920	13	3.8%	3.5%	2.6%	4.1%
1921–1940	67	4.6%	4.5%	3.4%	5.5%
1941–1960	96	6.1%	5.8%	4.5%	6.8%
1961–1983	55	6.5%	5.9%	3.5%	9.3%
1901–1983	231	5.6%	5.1%	3.9%	6.7%

Panel C. Residential real estate

	N	Mean	Median	P25	P75
1901–1920	26	5.3%	4.8%	2.9%	6.7%
1921–1940	68	5.3%	5.1%	4.1%	6.0%
1941–1960	78	4.0%	3.7%	2.3%	5.6%
1961–1983	54	3.2%	2.4%	1.8%	4.0%
1901–1983	226	4.3%	4.1%	2.4%	5.7%

Table 6. Mean cost ratios

This table shows average cost ratios for our different property types, computed as the time-series mean of the annual aggregated cost-to-income ratios for King's and Trinity College shown in Figure 6.

Agricultural	28.7%
Commercial	19.4%
Residential	32.0%

Table 7. Residential and agricultural: comparison with existing research

Panel A of this table compares our estimates of annualized (i.e., geometric average) real income growth rates for residential and agricultural real estate to those in previous research, both over our complete sample period and over four different subperiods. Panel B compares the geometric and arithmetic averages of our implied annual capital gain, income yield, and total return estimates, all in real terms, to those in previous research.

Panel A. Comparison of estimates of real income growth rates

	Residential		Agricultural	
	Our estimates	Jordà et al. (2019a)	Our estimates	Lloyd (1992)
1901–1920	-4.8%	-4.2%	-4.6%	-5.2%
1921–1940	1.7%	3.6%	1.9%	1.4%
1941–1960	-0.7%	3.7%	1.3%	0.8%
1961–1983	-0.5%	0.6%	2.2%	2.9%
1901–1983	-1.0%	0.9%	0.3%	0.1%

Panel B. Comparison of estimates of real returns

	Residential		Agricultural	
	Our estimates	Jordà et al. (2019a)	Our estimates	Jadevicius et al. (2018)
Geometric averages:				
Capital gains	-0.7%	0.7%	1.1%	1.1%
Income yield	3.0%	4.0%	3.4%	
Total returns	2.3%	4.7%	4.5%	
Arithmetic averages:				
Capital gains	-0.3%	1.1%	1.9%	2.0%
Income yield	3.0%	4.0%	3.4%	
Total returns	2.7%	5.1%	5.4%	

Appendix A Archival Sources

Table A.1. Archival sources used in construction of database

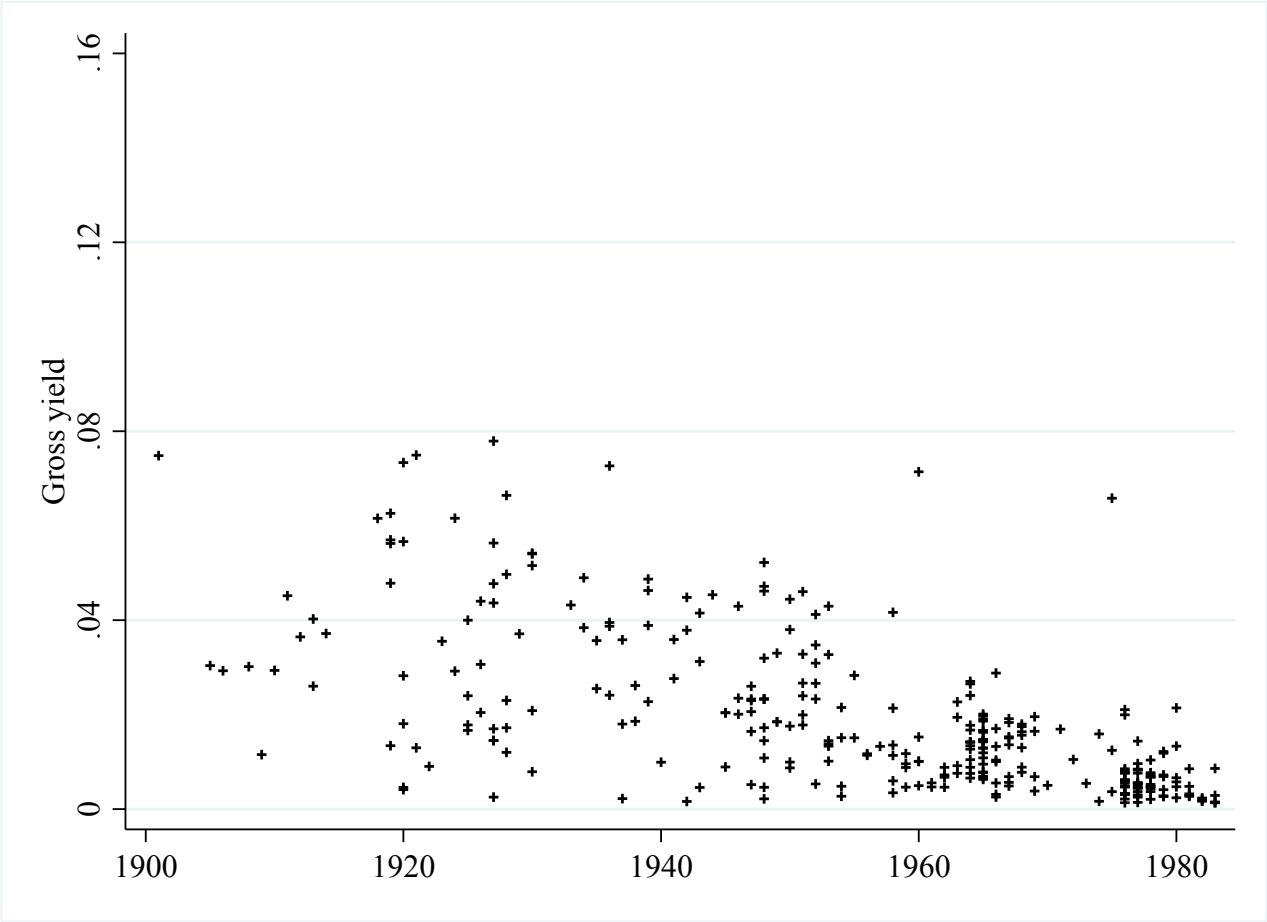
This table reports details on the archival data sources used in the construction of our property database. For King's College, the relevant citation information is: Mundum Part I: KCAR/4/1/1/1901/1 to KCAR/4/1/1/1983/1; Ledger Books: KCAR/3/3/1/1/22 to KCAR/3/3/1/1/36; Estates Committee Minutes Book: KCGB/6/18/1/2 to KCGB/6/18/1/11. For Trinity College: Rent Books 1901-1983; Annual Reports 1901-1983; Sealed Books: 1900-1970. For Christ Church: Rack Rental Ledgers 1900-1911: xxviii.b.1-16; Rack Rental Ledgers 1912-1968: xxviii.c.1-38; Estate Books xxi.b.1-37; Estate Ledgers Books xx.c.45-64. For New College: Rack Rent books 1903-1929: NCA EST/B6, NCA EST/B7, NCA EST/B8; Register of Estates & other properties: NCA 8597-8602: 1927, 1930, 1935, 1939, 1947, 1953. 6 vols; Registers of leases and conveyances: NCA REG/D38- D41: 1904-1925, 1925-1935, 1936-1955, 1955-1973; Registers of land purchases: NCA REG/E7 and NCA REG/E8: 1870-1936 and 1937-1972.

Data item	Source
Panel A: King's College, Cambridge	
Income and cost, actual	Mundum Part I 1901–1983
Transaction value	Ledger Books 1901–1983
Transaction characteristics	Ledger Books 1901–1983
Property characteristics	Estates Committee Minutes Books, Ledger Books, Mundum Part I, all 1901–1983
Panel B: Trinity College, Cambridge	
Income and cost, actual	Rent Books 1901–1983
Transaction value	Annual Reports 1901-1983, Sealed Books 1901–1970
Transaction characteristics	Annual Reports 1901-1983, Sealed Books 1901–1970
Property characteristics	Sealed Books & Rent Books
Panel C: Christ Church, Oxford	
Income, actual	Rack Rental Ledgers & College Ground Rent Books 1901–1968, Register of Estates 1970, 1973, 1978, 1980, 1981, 1982, 1984, Reports of the Estates Committee 1971–1984
Transaction value	Estate Ledgers Books & Estate Books 1901–1970, Register of Estates 1970, 1973, 1978, 1980, 1981, 1982, 1984, Reports of the Estates Committee 1971–1984
Transaction characteristics	Estate Ledgers Books
Property characteristics	Estate Ledgers Books & Estate Books
Panel D: New College, Oxford	
Income, actual	Rack Rent Books 1903–1929
Income, contractual	Register of Estates & Other Properties 1904, 1912, 1922, 1927, 1930, 1935, 1939, 1947, 1953
Transaction value	Registers of Leases & Conveyances; Registers of Land Purchases; and Register of Estates & Other Properties
Transaction characteristics	Registers of Leases & Conveyances; Registers of Land Purchases
Property characteristics	Registers of Leases & Conveyances; Registers of Land Purchases; Register of Estates & Other Properties

Appendix B Yields for Dropped Transactions

Figure B.1. Income yields for dropped transactions

This figure shows the income yields associated with transaction types that we dropped in our analysis, namely ground rents, transactions associated with a change of use, and "other" properties (i.e., properties that cannot be classified as agricultural, commercial, or residential).



Appendix C Estimation of Total Returns

In our empirical analysis, we estimated an income index for each property type. Denote such an index by A_t, and let us assume that it perfectly tracks true average net income $\bar{Y}_t$. We can state that $A_t = a\bar{Y}_t$, where a is unknown. Then take an estimated price index B_t (from previous research) that is supposed to track average quality-adjusted prices in the economy $\bar{P}_t$. Let us allow for the possibility that the index over- or underestimates true price changes by a constant factor d (with $d = 1$ meaning the absence of bias). We can then say that $B_t = b\bar{P}_t \times d^t$, where b and d are unknown parameters.

The average capital gain in year t can then be expressed as follows:

$$\bar{k}_t = \frac{\bar{P}_t}{\bar{P}_{t-1}} \tag{C.1}$$

$$= \frac{1}{d}\frac{B_t}{B_{t-1}}. \tag{C.2}$$

The average income yield in the same year can be expressed as a function of the different indexes and parameters as follows:

$$\bar{y}_t = \frac{\bar{Y}_t}{\bar{P}_t} \tag{C.3}$$

$$= cd^t\frac{A_t}{B_t}, \tag{C.4}$$

where $c \equiv \frac{b}{a}$ captures the relative average level of income to prices, and d can now be seen as the speed at which true yields deviate from the ratio of the income index to the price index.

To obtain estimates of annual capital gains, income yields, and total returns, we first rewrite Eq. (C.4) as a linear function of the unknown parameters by taking natural logs of both sides:

$$\ln(\bar{y}_t) = \ln(c) + t\ln(d) + \ln(\frac{A_t}{B_t}) \tag{C.5}$$

$$\Leftrightarrow \ln(\frac{\bar{y}_t}{A_t/B_t}) = \ln(c) + t\ln(d). \tag{C.6}$$

We then run a regression of the scaled individual yield observations $\ln(\frac{y_{i,t}}{A_t/B_t})$ against a constant and a continuous transaction year variable.

Following Eq. (C.2), our estimates of the capital gains are given by computing the returns on the baseline price index and then dividing by the antilog of the coefficient on the time variable in the estimation of Eq. (C.6).

Our fitted $\bar{y}_t^*$ values are computed as follows. First, we take the antilogs of the sum of (i) the predicted values from Eq. (C.6), and (ii) half of the square of the root mean squared

error of our regression model. The second element corrects for the bias induced by the log transformation. Second, we multiply the resulting values by $\frac{A_t}{B_t}$.