How Tax Reform Could Affect Commercial Real Estate [*]

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Abstract:

Major changes in taxes can affect commercial real estate (CRE), as in the boom and bust of the 1980s and 1990s, respectively, through possibly altering not only the present value of tax depreciation for commercial real estate, but also interest rates and employment, all of which affect the present value of existing properties. Simulating a system of equations that empirically incorporates some of the features of the DiPasquale and Wheaton (1992) four-quadrant model of CRE markets, we assess scenarios of how recent federal tax legislation could affect commercial office prices and construction.

JEL Codes: R33, H20, E37

Key Words: Tax reform, commercial real estate, Tobin's q

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1. Introduction

There is an increased recognition that problems in real estate can have large effects on U.S. business cycles and financial stability (see Bordo and Haubrich, 2015, Browne and Case, 1992, and Crowe, et al., 2013, *inter alia*), either as an impulse for downturns, (e.g., the Great Recession) or an amplifier of them (e.g., the Great Depression, Green and Wachter, 2007). Swings in commercial real estate (CRE) prices have been large (see Figure 1), and sharp downturns in them played a large role in the recessions of 1990 and 2007-09 and the sluggish recoveries from them. This partly reflects that CRE prices have significantly affected business investment (Chaney, Sraer, and Thesmar, 2012). And losses on commercial real estate loans (inclusive of residential construction and land development loans) and commercial mortgage-backed securities (CMBS) have played a large, but less-well recognized, role in U.S. bank failures during the recent Great Recession and recovery (Antoniades, 2014).

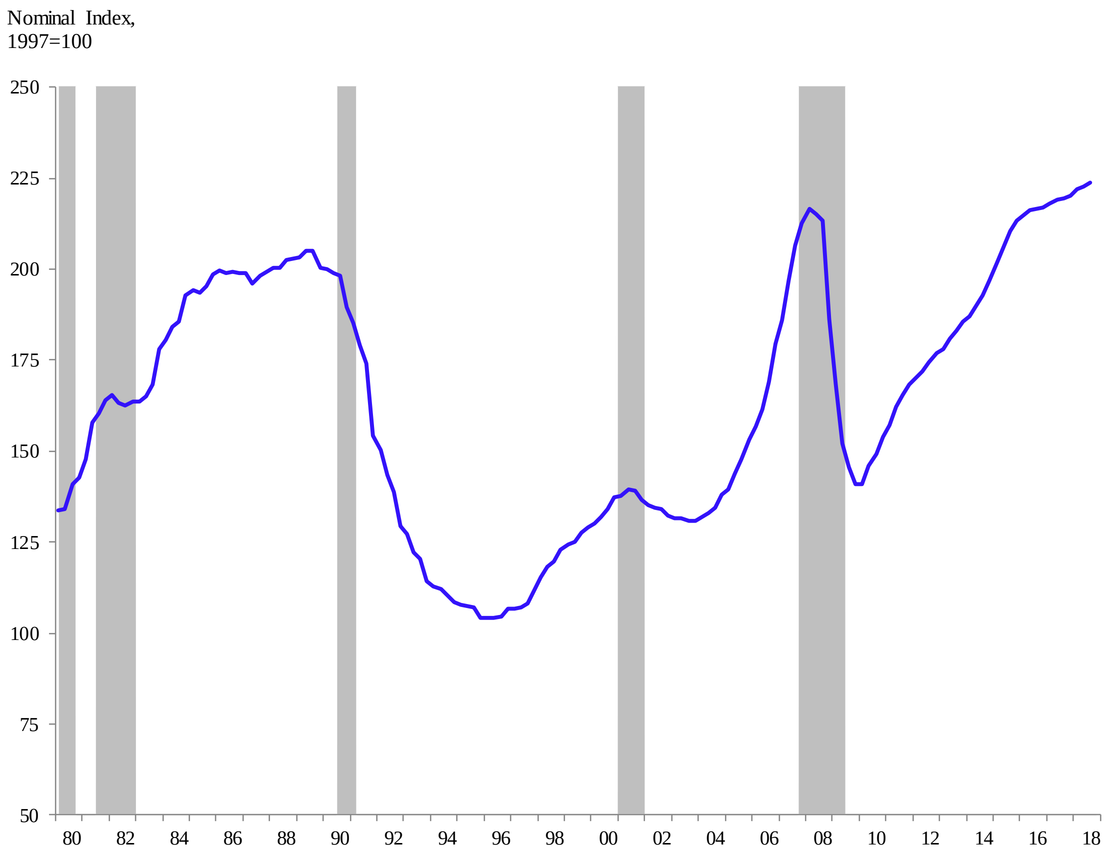

Figure 1: Commercial Office Prices Have Boomed and Busted
(Source: NCREIF. Recessions are shaded.)

Most recently, CRE valuations have risen to levels that raise concerns about whether CRE property prices are over-valued and therefore pose risks to financial stability, as highlighted by Federal Reserve Chair Yellen in July 2015.[1] Indeed, a major gauge of CRE valuations from the American Council of Life Insurers (ACLI), earnings-price ratios (or capitalization "cap" rates), have fallen to low levels. Interpreting the cap rate as the nominal rental rate of return (net of operating expenses) on properties, current cap rates adjusted for long-run inflation expectations are at levels that have predated negative appreciation rates of real CRE prices in the late-1980s, and mid-2000s. Against this backdrop, this study investigates the behavior of CRE markets in the U.S. with an eye toward generally assessing how vulnerable recent CRE valuations and office construction are to large downturns.

Major changes in taxes can affect commercial real estate, as in the boom and bust of the 1980s and 1990s, respectively, through possibly altering not only the present value of tax depreciation for commercial real estate, but also interest rates and employment, all of which affect the present value of existing properties (Follain et al., 1992, Hendershott and Kane, 1992). Although The Tax Cuts and Jobs Act of 2017 (TCJA) did alter the tax treatment of commercial real estate (CRE), it appears to have had notable effects on employment and long-term interest rates, both through stimulating aggregate activity and increasing the future path of federal borrowing.[2]

The interest rate effects of this legislation could be particularly telling because in the mid-2010s, commercial real estate prices and earnings-multiples were bolstered by the extraordinary low interest rates that had prevailed. Our earlier analysis of capitalization ("cap") rates (earnings-price ratios) for CRE properties found that CRE property valuations were in line with prevailing fundamentals (Duca, Hendershott, and Ling, 2017, and Duca and Ling, forthcoming). Nevertheless, those fundamentals included extremely low long-term interest rates and implied high levels of duration in CRE valuations. If long-term interest rates move toward more historical norms, there could be substantial upward pressure on cap rates, which would likely manifest in

[1] See the July 2015 Monetary Policy Report of the Board of Governors of the Federal Reserve System (2015). This report noted that these rapid price increases were occurring as "underwriting standards at banks and in commercial mortgage backed securities have been loosening."

[2] Numerous industry publications have summarized the provisions of TCJA (2017) that affect commercial real estate and have speculated on their impact. See, for example, National Association of Realtors (2017), Logan (2017), Odinet (2017), and PWC (2017).

notable downward pressure on CRE prices and have ramifications for commercial construction. To some extent, these effects on CRE building activity may be offset by the stimulus that the 2017 tax cuts provide to office employment.

Assessing such impacts has been hampered by the lack of integrated models of CRE activity that can account for macroeconomic influences in a theoretically cohesive and empirically relevant way. Chaney and Hoesli's (2015) analysis of the Swiss commercial property market is a rare example of an attempt to integrate macroeconomic factors into a model of broad CRE activity. Partly inspired by that study, we develop an empirical model for the U.S. commercial office market that has some of the basic features of the DiPasquale and Wheaton's (1992) four-quadrant model of CRE markets. The resulting multi-equation framework allows us to assess how shifts in the tax code, interest rates, and risk premiums could affect the valuation of CRE properties and thereby impact CRE prices and construction activity.

To accomplish this, our study is organized along the following lines. Section 2 lays out an equilibrium model of the office market through specifying sensible equilibrium relationships for the major components of the markets embedded in the DiPasquale-Wheaton four-quadrant model. The empirical analysis begins in Section 3, which provides estimable models of office rents and vacancy rates to establish a baseline model of the space market. Section 4 estimates a baseline model of office cap rates to formulate the asset market relationships of the DiPasquale-Wheaton four-quadrant framework, which model the major initial and direct channel through which interest rates affect CRE prices and valuations. Section 5 then estimates a Tobin's q model of office construction. From these baseline specifications for the component markets, Section 6 builds a multi-equation system that can be used to estimate how macro-economic and financial factors can affect CRE activity. In particular, we focus on assessing scenarios of how recent federal tax legislation could affect CRE prices and construction. In a future version of the paper, we plan to compare the plausible impact of recent tax changes with those of earlier major tax code changes. Our final section concludes by providing perspective on our findings.

2. An Equilibrium Model of the Office Market

The four-quadrant DiPasquale and Wheaton (1992) diagram describes the equilibrium in real estate markets. The quadrants relate to the space market (rent depending on a demand driver and the stock of space), the asset market (price depending on rent and the cap rate – inverse of the "real interest rate"), construction (depending on the price and cost of building) and a construction-stock link (construction must replace depreciation and discarded space). In equilibrium, the (natural) vacancy rate is constant. To this framework we add the present value of tax depreciation as a determinant of price because it substitutes for rental income (Duca, Hendershott and Ling, 2017). For presenting our equilibrium model of the office market, it is convenient to first present the construction component.

Construction (Supply)

Traditional investment theory suggests new construction (I) occurs when the expected value of a completed project exceeds the all-in cost of developing it. Let P be the current price of a property similar to that being proposed, $\Delta^{exp}P$ be the expected change in price between the start of development and completion, and *RCost* be the all-in (replacement) cost of developing the project.[3] With these assumptions, construction is likely to occur if $(P + \Delta^{exp}P)/RCost = q > 1$, following a Tobin's q argument (Tobin, 1969), and will be greater the more q exceeds unity. That is, desired net investment (I^*) will be greater the higher is the expected value at completion relative to replacement cost. This implies:

$$I^* = f[q + \Delta^{exp}\, q] = f[(P + \Delta^{exp}P)/RCost]. \quad (1)$$

However, the impact of q being greater or less than unity should differ because values greater than 1 should trigger new construction. However, values less than 1 generally do not trigger the removal of existing stock from inventory, although it does decrease on-going maintenance and capital expenditures (Englund et. al., 2005). To account for this asymmetry, we break the q variable into two components. One, *qa*, takes on the value of q when q is above 1, and equals 1 otherwise. The other, *qb*, has the value of q when q is below 1, and equals 1 otherwise. Therefore,

[3] The all-in replacement cost includes land, construction materials, and labor costs, including a competitive return on the developer's (risky) entrepreneurial effort.

$$I^* = \gamma_0 + \gamma_1 qa + \gamma_2 qb + \gamma_3 \Delta^{\exp} P, \tag{2}$$

where γ_1 and γ_3 should be positive with $\gamma_1 > \gamma_2$ and $\gamma_3 > 0$, and $\gamma 2$ may or may not be significant.

The expected change in price between the start and completion of a structure will depend on the views of current and future market conditions and, in general, the supply elasticity of the local market. If market rents (R) are above their equilibrium (required) level (R^*), future real rents (and *NOI*) in a rational model are expected to be lower as the supply of space adjusts upwards, implying a fall in price from current levels would be expected.[4] If vacancies (V) are high relative to their equilibrium value (V^*), then future rents (and *NOI*) will be expected to be lower, implying that a fall in price from current levels would be expected. That is, $\Delta^{\exp} P$ would depend negatively on both $RentGap \equiv R - R^*$ and $VacGap \equiv V - V^*$:

$$I^* = \gamma_0 + \gamma_1 qa + \gamma_2 qb + \gamma_3\, RentGap + \gamma_3 VacGap \tag{3}$$

The Space Market

We model real rents following Hendershott, MacGregor and Tse (2002), who use a long-run equilibrium model of the space market to estimate equilibrium real rent. They specify the long-run demand for office space as a log-linear function of real rent and employment:

In the long-run equilibrium, where the vacancy rate equals the natural rate (v^*), all leases carry the current equilibrium rent, and all required adjustments to the stock have been made, demand will equal total supply minus the equilibrium vacany:

$$D(R^*, E) = (1 - \mathrm{v}^*)S. \tag{4}$$

Hendershott, MacGregor and Tse (2002) specify the long-run demand for office space as a log-linear function of real rent (R) and employment (E):

$$\ln D(R, E) = \lambda_0 + \lambda_R \ln R + \lambda_E \ln E, \tag{5}$$

[4] Hendershott, MacGregor, and Tse (2002) find evidence that investors are not rational in formulating expectations about the level of future rents. In particular, when real rents are above equilibrium levels, investors tend to extrapolate this excess when formulating expectations.

where the price elasticity λ_R is negative and the "income" elasticity λ_E is positive. Actual occupancy may deviate from the demand function because of transaction costs and because tenants are locked into long-term leases.

Taking the logarithm of (4), substituting from (5) with R replaced by R^* and then solving for $\ln R^*$ gives

$$\ln R^* = \gamma_S[\ln(1 - v^*) - \lambda_0] + \gamma_E \ln E + \gamma_S \ln S, \qquad (6)$$

where the parameters of the demand equation (the price and income elasticities) can be retrieved as $\lambda_R = 1/\gamma_S$ and $\lambda_E = -\gamma_E/\gamma_S$. Note that if the elasticity of demand with respect to employment is unity ($\gamma_S = -\gamma_E$ and $\lambda_E = 1$), then real rent is proportional to employment per unit of space.

Estimates of eq. (6) give predictions of equilibrium rent. If the underlying equilibrium vacancy rate is stable, then the first term in brackets in eq. (6) will be subsumed in an estimated constant term. In addition, the measurement of actual employment and the existing stock will track the effects of implied variation in the vacancy rate around its long-run equilibrium level. Allowing rents on new leases to adjust to the gap between the equilibrium and actual rent levels, lagged changes in the determinants of equilibrium rent, and other short-run influences implies:

$$\Delta \ln R_t = \beta_0 + \beta_1 EC_{t-1} + \sum \beta_{2i}\, \Delta \ln Rent_{t-i} + \sum \beta_{3i}\, \Delta \ln \mathrm{E}_{t-i} + \sum \beta_{4i}\, \Delta \ln \mathrm{S}_{t-i} + \beta_4\, X_{t-1} + \mu_t \qquad (7)$$

where $EC_{t-1} = \ln R_{t-1} - \ln R^*_{t-1}$, $\ln R^*$ is the equilibrium level of real rents, μ_t is an i.i.d. residual, and the X vector includes controls for unusual short-run shocks. Short-run changes in rent depend on lagged one-quarter changes in the long-run determinants and the extent to which real rents differ from their equilibrium level in the prior quarter. Because short-run changes are expected to help rents converge to their equilibrium levels, β_1 is expected to be negative. Cointegration techniques can be used to estimate the long-run equilibrium (eq. 6), which is embedded in the error-correction specification (eq. 7) of changes in real rents. In addition to formulating the rental quadrant of the DiPasquale-Wheaton model, eq. (6) is used to derive the gap between actual and equilibrium real rents for the Tobin's q model of construction. That model is also supplemented with information about the gap between current and equilibrium vacancy rates, for which we need further information from the space market.

Prior studies have found evidence supporting the notion of an equilibrium or natural commercial vacancy rate (see Rosen and Smith, 1983, and Shilling, Sirmans, and Corgel, 1987, *inter alia*). In this framework, the growth rate of real rents (ΔlnR) will tend to be zero when the vacancy rate (V) equals its equilibrium or natural level (V^*). Real rent growth tends to be positive (negative) when the vacancy rate is below (above) its natural or equilibrium rate:

$$\Delta lnR_t = \mu(V_t - V^*) + \varepsilon_t, \tag{8}$$

where $\mu > 0$ and ε_t, is an i.i.d. error. In practice, V^* is a latent variable that can be inferred from estimating a model of rent growth (ΔlnR_t) containing a constant and the actual vacancy rate and residuals can be correlated:

$$\Delta lnR_t = \sum \alpha_i \Delta lnR_{t-i} + \mu_0 + \mu_1 V_t + \delta_t, \tag{9}$$

where lags of ΔlnR_{t-i} are added to clean up the residuals (making the residual term δ_t, i.i.d.). The constraint $\sum \alpha_i = 1$ is imposed to ensure that inclusion of lags to avoid serially correlated errors does not violate the underlying assumptions of the natural rate framework. Because the data used span a sample period (1980:q1 to 2017:q2) when inflation is shifting, we specify the model in real terms to limit any bias or distortion in the estimates arising from changes in inflation trends. Our model yields similar results when re-estimated over a shorter, "Great Moderation" sample of 1983:q1-2017:q2 that omits the high inflation subsample of 1980-1982.

Equation (9) implies the natural or equilibrium vacancy rate (V^*) can be inferred from coefficient estimates to equal:

$$V^* = -\mu_0 / \mu_1 , \tag{10}$$

From eq. (10), we can derive the "vacancy gap" term ($V^* - V$) for our model of construction.

The Asset Market

If the expected rate of growth of a property's net operating income (*NOI)* is constant (g_t,) and the net selling price is expected to remain a constant multiple of *NOI*, then the equilibrium price P_t^e of an equity-financed investment, adjusted for the present value of tax depreciation *(taxdep)*, depends on the expected constant rate of growth in *NOI* and the property specific risk-adjusted discount rate (see Duca, Hendershott and Ling, 2017):

$$(1-taxdep)\,P_t^e = \frac{NOI_1}{r_t - g_t} \tag{11}$$

where *r* is the relevant discount rate. The equilibrium price is thus the first year *NOI* divided by the depreciation adjusted equilibrium cap rate,

$$CapRate_t^e = (r_t - g_t)(1-taxdep)\,. \tag{12}$$

Increases in *taxdep* are associated with lower equilibrium cap rates because increased tax benefits reduce the portion of the required pretax return that must be provided by the cash flow or dividend yield on the property.

Because rent relationships can be combined with cap rate relationships to derive an equilibrium price for property, our discussion of our empirical analysis will begin with the market for space followed by the asset market. From this base of empirical results for rents, vacancy rates, and prices, the text then presents our baseline empirical estimates for construction. Our last empirical section combines baseline empirical relationships from these key markets to build a small system of equations, which are jointly estimated and then used to analyze how the interest rate and employment implications of the 2017 tax legislation could affect the office market.

3. The Space Market: Rents and Vacancies

We first estimate an equilibrium real rent equation using an error-correction framework. This will yield an estimate of the real rent gap term *ECR*, which enters the Tobin's q model of construction. We then use rent and vacancy data to estimate a natural or equilibrium vacancy rate, from which we derive an estimate of the vacancy rate gap (*ECV*), which also enters the construction model.

Equilibrium Real Rent

An equation for equilibrium real rent was derived above as equation (6). We measure the real rent, employment and supply variables using a combination of data from CBRE and the National Income and Product (GDP) accounts. To track *S* (office space in millions of square feet) we splice post-1992 CBRE estimates with pre-1993 estimates we derive using data from CBRE and the U.S. Bureau of Economic Analysis (BEA).[5,6] R is measured by national average CBRE office rents (dollars per square foot) deflated by the implicit GDP price deflator excluding food and energy. Office employment (E) is tracked with CBRE estimates of office service workers using BLS for the metros in their national statistics. Rents are deflated by the GDP deflator excluding food and energy to avoid imparting large deviations in real rents owing to sudden swings in energy prices.

We estimate a version of eq. (7) that includes in the X vector two types of short-run controls for unusual factors, which if not addressed, yield serially correlated residuals. The first set includes the t-1 to t-3 lags of the first difference of the log of real energy prices changes. Because energy costs are included in some of the rental contracts from which the CBRE rent data are based, sharp rises in energy prices will impart near-term jumps in the pace of rent increases, followed by a sudden pullback. The second set are controls for unusual outlier events that suddenly reduce the demand for space relative to the more stable, short-run supply of space. These include a dummy equal to 1 in 2001:q3 to control for a sudden, uncertainty-related drop in the demand for space and the destruction of New York office space, which, reflecting above average rents in that metro, imparts a downward shock to rent growth based on CBRE national average office rents.[7] Another dummy, *2014Freeze*, equals 1 in 2014:q2 and -1 in the following quarter. This controls for a collapse of demand for space in the spring of 2014, when the Northeast and Midwest regions suffered a major prolonged freeze. Demand returned in the next quarter, when recorded rents returned to their earlier path of growth. With office supply essentially fixed in the very short run, this event imparted a large downward spike in rent growth in 2014q2, followed by an equally large upward spike in 2014:q3.

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[5] Concerned with unusually large quarterly spikes in implied additions to office space, we approached CBRE staff who told us that pre-1992 CBRE data on quarterly office space are unreliable, owing to the earlier lack of consistent controls for ensuring that industry clients accurately reported the quarterly timing of additions to office space. As discussed in Appendix A, using 1980:q1 and 1993:q1 data endpoints, we use BEA data (available from 1959:q1 to 2003:q1) to infer the quarterly pattern of the total amount of available office space. The resulting series yields a sensible looking quarterly pattern of the net rate of office construction. We used X-12 to seasonally the data.

[6] We also adjusted the office stock for the unusual effects of the September 2001 terrorist attack on New York City office space, which distorted space estimates but had little effect on rent estimates (which came from contracts) and on office employment—which CBRE derives from payroll data from the Bureau of Labor Statistics (BLS).

[7] CBRE weights New York City rents in 2001 by its then roughly 20 percent share of national office space.

Since the log-levels of real rents, the stock of office space, and office-related employment are nonstationary and have unit roots, we estimate the long-run relationship in equation (6) using cointegration techniques following the Johanssen (1995) method and using a vector error-correction framework that allows for the endogeneity of long-run variables. The cointegrating vector is estimated allowing for time trends in each long-run variable but not for a separate time trend in the cointegrating relationship. We jointly estimate equations (6) and (7) for the long-run equilibrium log-level of real rents and their short-run changes, respectively.

A lag length of nine quarters is used to jointly estimate eqs. (6) and (7). This length was selected to find a unique cointegrating vector, and yield well-behaved residuals. Unique, cointegrating (long-run) relationships can be estimated using shorter lag lengths based on the Akaike Information Criterion, which yielded similar long- and short-run coefficients. However, the residuals for the model of rent growth were serially correlated. If the short-run controls are omitted, estimated coefficients are similar and a unique cointegrating (long-run) relationship can be found with a nine-quarter lag length, but the short-run model of real rent growth has serially correlated errors. The sample period (1984:q1-2016:q1) covers a time when inflationary expectations are relatively stable and avoids distorting estimated coefficients by having the sample periods span periods under different inflationary regimes. The sample ends in 2016:q1, the longest common end date for which data are available to estimate each of the four-quandrant DiPasquale-Wheaton model relationships.[8]

Our estimate of the long-run relationship in equation (6) is:

$$\ln R_t = \underset{}{7.836} + \underset{(0.100)}{0.701 \ln E_t^{**}} - \underset{(0.133)}{0.727 \ln S_t^{**}} \tag{13}$$

where standard errors are in parentheses and ** denotes significance at the 99% confidence level. The absolute magnitudes of the significant coefficients on the supply and employment variables are not statistically different, implying that employees per unit space drive real rent. The price elasticity (unity divided by the ln*S* coefficient) is -1.37, which is more elastic than Hendershott et al.'s (2000) estimate for London (-0.24) and Englund et al.'s (2008) estimate for Stockholm. The larger U.S. coefficient seems plausible because the supply of land is likely more price elastic across

[8] A longer sample ending in 2017:q4 yielded qualitatively and quantitatively similar results.

major U.S. metros than for these two older European cities. The income elasticity for our U.S. sample is 0.96, close to both the 1.04 estimate for Stockholm and the 0.92 estimate for London. The narrower range of income elasticity estimates may reflect greater similarity in pressures on large firms to minimize costs and greater similarities in business office technologies across metros in advanced economies.

Figure 2 depicts the estimated equilibrium real rent (R^*) and the observed real rent on new leases (R). The implied long-run equilibrium real rent series leads trends in actual real rents, which adjust with a lag to shifts in long-run factors. Nevertheless, real rents exceeded their rent-based equilibrium levels during much of the 1980s. This partly reflected that the new tax depreciation benefits produced the Economic and Tax Recovery Act of 1981 (ERTA) directly lowered equilibrium rents by lowering the after-tax cost of providing existing rental space and indirectly lowered rents by encouraging much building and high vacancy rates. Real rents fell during the onset of the oil bust of 1985-86, particularly in the oil-patch, with the gap between actual and equilibrium rents remaining wide. As noted by Follain et al. (1992), a "lender frenzy"

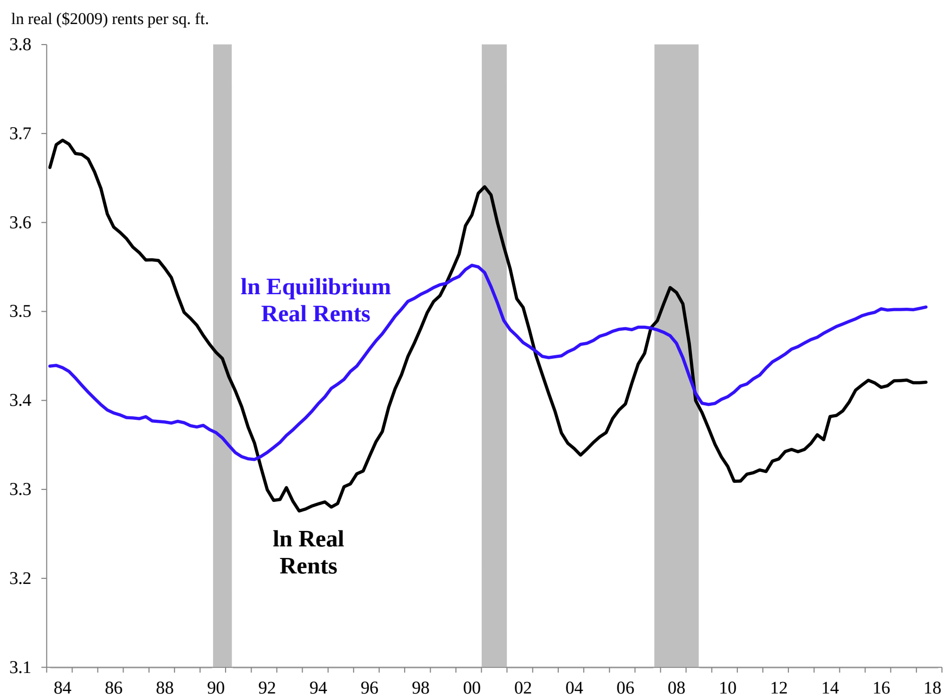


Figure 2: Actual and Equilibrium Log Levels of U.S. Real Office Rents
(Shaded areas denote recessions. Sources: CBRE, BEA, and authors' calculations.)

helped produce a glut of office space in most regions of the country. Moreover, this glut (excess) produced during the 1983-86 period lasted well into the 1990s, which put downward pressure on real rents long after the 1986 Tax Act removed the generous depreciation benefits put in place by ERTA. Since the late 1980s, the net present value of tax depreciation benefits for offices have been low and stable and real rents have generally stayed within 15 percent of equilibrium.

Vacancies

To estimate the natural vacancy rate, we estimate a vacancy rate model of real office rents based on equation (9) using the real rent series described earlier. The vacancy rate uses the national office series from CBRE. Using OLS, we estimated the following model over 1984:q1 to 2016:q1 to match the sample for our construction model:

$$\underset{}{\Delta lnR_t} = \underset{(0.0018)}{0.0036^{*}} - \underset{(0.00012)}{0.00025} \text{ x } Vac_{t-1}^{*} + \underset{(0.075)}{1.645} \, \Delta\ln R_{t-1}^{**} - \underset{(0.075)}{0.645} \, \Delta\ln R_{t-2}^{**} \tag{14}$$

where R^2 (corrected) = 0.991, LM (1) = 0.27, LM (2) = 0.86, $^{**(*)}$ denotes significance at the 99 (95) percent level. The estimates from eq. (14) imply a sensible equilibrium vacancy rate of 14.50 percent as shown in Figure 3. The estimated national level is near the range of MSA estimates reported in Parli and Miller (2014). To some extent our CBRE estimate is elevated because the CBRE vacancy rates reflect Class B and C properties (some of Parli and Millers' estimates were for Class A property). In general, real rent growth picks up when the actual vacancy rate falls below the estimated equilibrium level. In recent years, office vacancy rates have been slightly below the natural rate, consistent with the modest growth seen in real office rents.

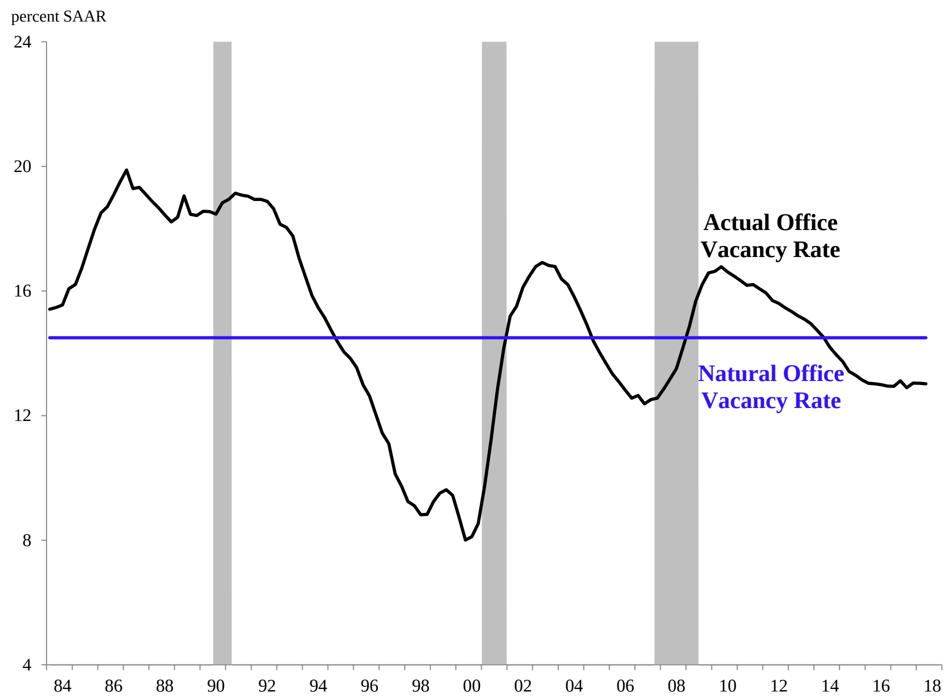


Figure 3: Actual and Estimated Equilibrium U.S. Office Vacancy Rate
(Shaded areas denote recessions. Sources: CBRE and authors' calculations.)

4. The Asset Market

We estimate an equilibrium cap rate model using an error-correction framework. In particular, we estimate a long-run relationship based on equation (12) for the asset market. We use survey data from the American Council of Life Insurers (ACLI) to measure the office cap rate. For the present value of tax depreciation, we use estimates from Duca, Hendershott, and Ling (2017). Because nominal rents tend to rise with inflation over the long-run, we proxy the expected long-run nominal growth in rents with a measure of long-run inflation expectations, namely the 10-year ahead expectation of PCE inflation from the Federal Reserve Board's quarterly model of the U.S. economy.

On the other hand, proxying a discount rate is complicated. Duca and Ling (forthcoming) estimate the determinants of CRE risks premium to add to the 10-year Treasury yield For the 1996-2015 period, they estimate the premium to be 1.92 plus 0.814 times the spread between Baa-rated corporate and 10-yr. Treasury yields) and the effective bank capital requirement on CRE (0.27 times the effective bank capital requirement). Higher capital requirements force banks to fund CRE mortgages with more equity—which is more costly than using deposits and less flexible to adjust in the short-run. In turn, banks pass the extra direct and indirect costs onto borrowers investing in property.

But there is evidence that the premium shifted down after the early 1980s (Blanchard, 1993; Campbell and Vuolteenaho, 2004). The fourth quarter of 1982 marked the end of money targeting by the Federal Reserve; enough progress had been made in reducing inflation that the Federal Reserve switched to using a federal funds interest rate target. Before 1983, asset prices were vulnerable to sharp interest rate cycles because the Federal Reserve had a poor track record of controlling inflation. Thus we add *InflatEra*, which equals 1 before 1982q4 and 0 since then, to r in equation (11) and resolving equation (12), we find that this term times (1-*taxdep*) is in it. Thus estimation of the equilibrium cap rate takes the form:

$$CapRate^{e}_{t} = \alpha_0 + \alpha_1 (r_t - g_t)(1 - taxdep_t) + \alpha_2\, InflatEra_t(1 - taxdep_t) \qquad (15)$$

As shown in Figure 4, the present value of tax depreciation benefits as a share of the purchase price (*taxdep*) rose with the Reagan tax cuts of the early 1980s, but then fell after the Tax Reform Act of 1986 (TRA86) and have generally remained low. Reflecting minor reductions in marginal personal income tax rates, *taxdep* edged lower following the 2017 tax cut.[9]

Since the cap rate and the two tax-depreciation adjusted terms in equation (15) are nonstationary and have unit roots, we estimate the long-run relationship in equation (15) using cointegration techniques following the Johanssen (1995) method. The cointegrating vector is estimated allowing for time trends in each long-run variable but not for a separate time trend in the cointegrating relationship. We jointly estimate the short-run change in the cap rate with an error-correction model of the standard form:

$$\Delta CapRate_t = \beta_0 + \beta_1 EC_{t-1} + \Sigma\beta_{2i}\Delta CapRate_{t-i} + \Sigma\beta_{3i}\Delta[(r_t - g_t)(1 - taxdep_{t-i})] +$$

$$\Sigma\beta_{4i}\Delta InflatEra_{t-i}(1 - taxdep_{t-i}) + Z_t + \varepsilon_t \qquad (16)$$

The coefficient on the *EC* term should be negative, implying that any excess of the actual over the equilibrium cap rate would tend to be followed by a decrease in cap rates, thereby pushing cap rate

[9] To reflect how expectations shifted with TRA86, the timing the fall in *taxdep* coincided with TRA86's passage. In future work, we will assess whether the 2017 Tax Cuts and Job Act's provision for tax exclusion associated with qualified business income is materially affecting the tax rate of the marginal CRE investor.

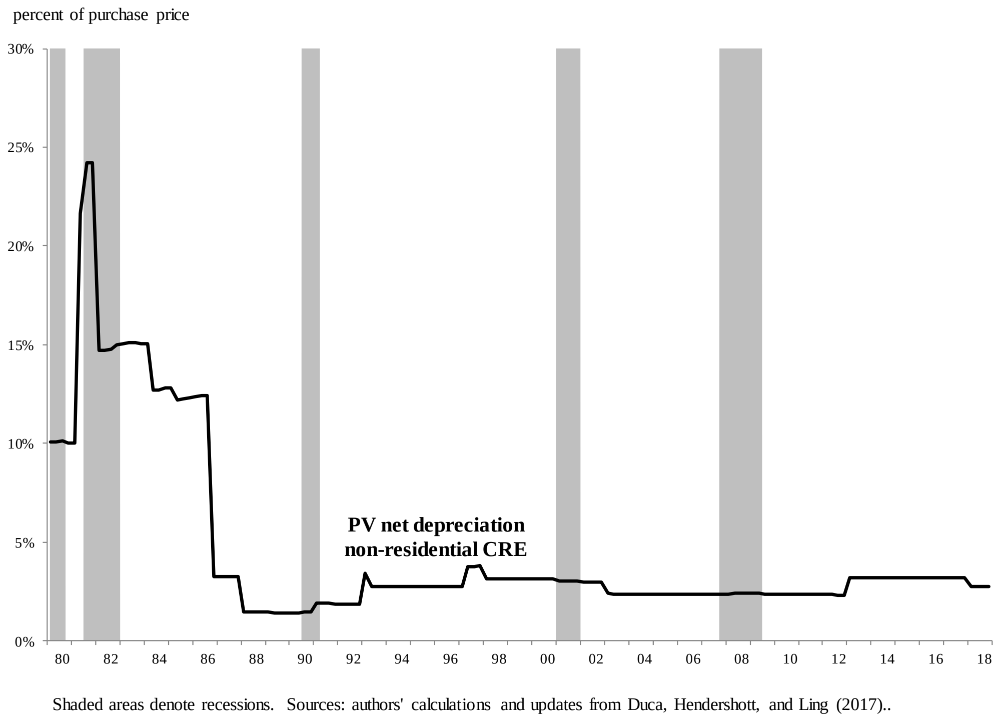


Figure 4: Present Value of Tax Depreciation Low Since the Tax Reform Act of 1986, Dips after 2017 Tax Act Lowered Marginal Tax Rates.
(Sources: authors' calculations and updates from Duca, Hendershott, and Ling (2017). Shaded areas denote recessions.)

levels toward their long-run equilibrium values. Because cap rates directly reflect the influence of several financial and nonfinancial driving variables, we estimate the model over a longer sample period than that used for the rent, vacancy, and construction models. This longer sample helps us better identify the lower frequency swings in cap rates and their long-run determinants, but it also necessitates that the vector Z control for a larger set of unusual short-run factors than in the set (X) used in the rent equation.

Z_t includes short-run variables to track large, temporary shifts in cap rates. For example, during pre-1983 upswings in interest rates, market interest rates sometimes rose above Regulation Q ("Reg Q") deposit interest rate ceilings, inducing deposit outflows and depositories to ration credit. By reducing credit availability and by making CRE funding more risky, the effective demand for CRE would fall during such episodes, lowering CRE prices,. In addition to including a measure of Reg Q effects, Z_t includes the short-run dummy *CredCont*, which equals 1 in 1980q1 and 1980q2, and 0 otherwise. *CredCont* tracks credit rationing induced by federal government controls on the growth rate of bank lending, which spurred banks to tighten credit standards (Aron, et al., 2012), thereby notably depressing asset prices and boosting cap rates. [10]

The estimation of long-run and short-run relationships is joint following Johansen (1995), and the vector error-correction framework allows for the endogeneity of long-run variables. The number of lags was chosen as the minimum lags required to obtain a unique significant cointegrating variable and, if possible, to also yield clean model residuals. Owing to the lag length selected for lagged first difference terms, our sample period is 1970:q3-2017:q2. As with the rent model, estimation assumptions allow for possible time trends in long-run variables without an independent time effect in the vector not attributable to measured factors.

Adding the empirically imported estimated effects of credit control and deposit regulations to the long-run equilibrium cap rate specified in equation (15) yields:

$$\begin{aligned} CapRate = 1.083 &+ \underset{(0.062)}{0.960}(r - g)(1 - taxdep)^{**} + \underset{(0.325)}{2.026}InflatEra(1 - taxdep)^{**} \\ &+ \underset{(0.049)}{0.260}RegQ_{t-1}^{**} + \underset{(0.251)}{1.127}CreditControl^{**} \end{aligned} \tag{17}$$

where standard errors are in parentheses, ** denotes significance at the 99% confidence level, and the definitions of *RegQ* and *CreditControl* are in the previous footnote. As shown in Figure 5, this credit-adjusted equilibrium long-run cap rate tracks most of the major trends in the observed office cap rate over nearly one-half century.[11]

[10] Reg Q induced credit rationing was large enough that ignoring it could entail omitted variable bias on estimates of long-run coefficients. To capture these unusual effects we include Duca and Wu's (2009) measure (*RegQ*) of the degree to which Reg Q was binding, using its *t-1* quarter value to reflect a slight lag for how funding shortfalls affect credit and CRE prices. There is also a dummy for the Nixon wage-price freeze of 1970:q3-q4, which, with a lag, notably depressed rents and cap rates over 1970:q4-1971:q2. *PriceControl* equals 1 in those quarters, and 0 otherwise. Also included is a dummy for the one-quarter delayed impact of the failure of Lehman Brothers (*Lehman* = 1 in 2009q1). The event arguably affected cap rates by reducing office employment. Also included is a dummy (*GovtShut*) equal to 1 in 2013:q2—just before the anticipated shutdown of the federal government in 2013:q3—and equal to -1 in 2013:q3 for its unwinding. This event plausibly increased uncertainty about office occupancy by affecting leased space federal employees, contractors, and suppliers.

[11] The major exception is the late 1980s, when equilibrium credit-adjusted cap rates exceeded actuals by one to two percentage points, implying an overvaluation on the order of approximately 25 percent. This over-valuation is consistent with the collapse of office prices in the early 1990s and the jump in actual cap rates toward their equilibrium level. Furthermore, the estimated tax depreciation effects are so large, that if they are removed from the overall equilibrium relationship, the implied equilibrium cap rate would greatly diverge from the actual before 1990, consistent with the importance of tax changes in other studies (e.g., Hendershott and Kane, 1992).

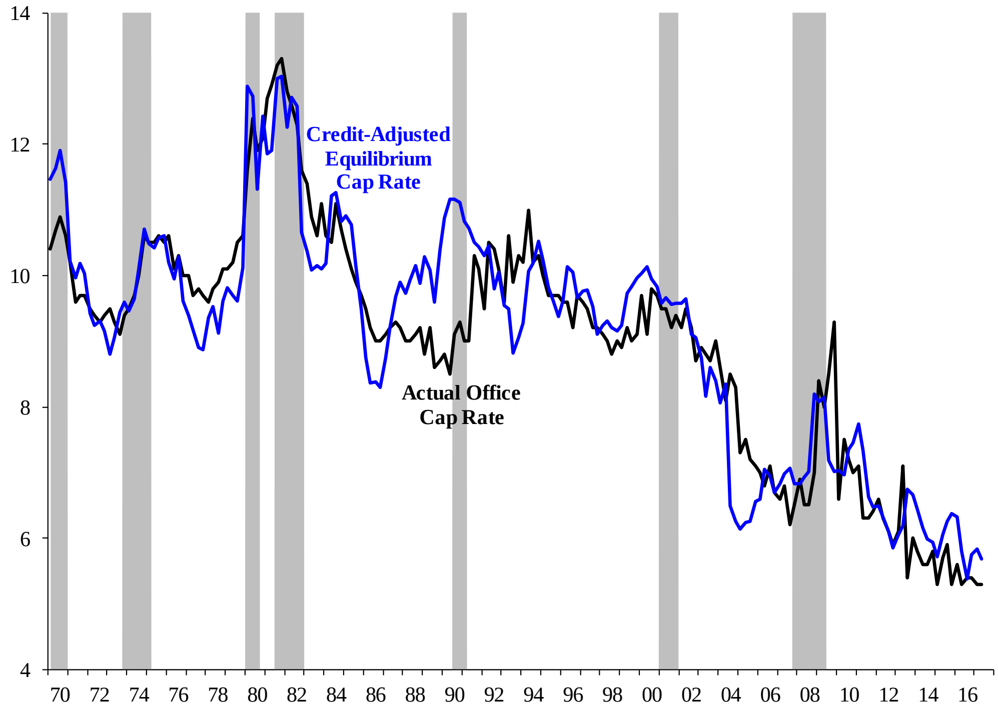


Figure 5: Credit-Adjusted Equilibrium and Actual Cap Rates over the Past Half Century
(Shaded areas denote recessions. Sources: ACLI and authors' calculations.)

5. Construction (Supply)

We estimate symmetric and asymmetric versions of the Tobin's q model of construction outlined in equations (1) and (2). To measure Tobin's q, we track movements in current office prices (*P*) with the NCREIF Property Index (NPI), which tracks property-level quarterly returns on a large pool of properties acquired in the private market for investment purposes only.[12]

Replacement costs (*RCost*) are estimated to be a weighted average of land prices and the cost of building structures, where the weights, 0.2 and 0.8, are from a survey of California construction firms (Fannie Mae, 2015). This approach is similar to Glaeser and Gyourko's (2018) estimates of replacement costs for residential construction. For land costs, we use the residential land price index (Case-Shiller version) from the Lincoln Land Institute, which is based on the

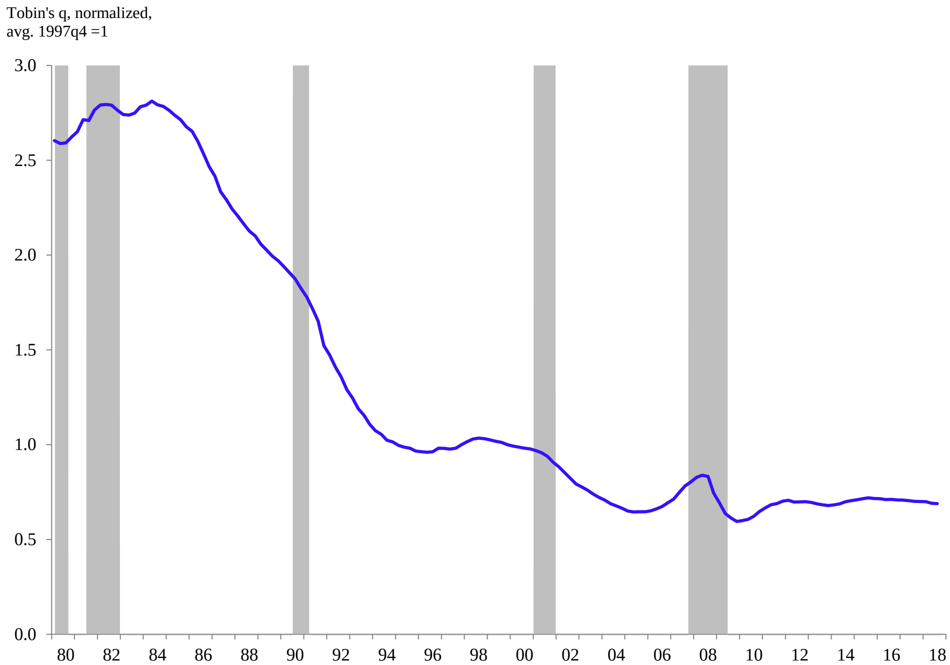
[12] Established in 1982, the National Council of Real Estate Investment Fiduciaries (NCREIF) is a not-for-profit institutional real estate industry association that collects, processes, validates, and disseminates information on the risk/return characteristics of commercial real estate assets owned by institutional (primarily pension and endowment fund) investors. The property composition of the NPI changes quarterly as data contributing NCREIF members buy and sell properties. However, all historical property-level data remain in the database and index.

analysis of Davis and Heathcote (2007). For the cost of building structures, we use quarterly prices for nonresidential structures from the National Income and Product Accounts.

Because the price appreciation and cost series are indexes, rather than values for a representative property, their ratio will not vary around the unity equilibrium. To convert our series to one where q (plus expected change) > 1 encourages investment, we divide our ratio by its level (0.42) in 1997q4, when vacancy rates are near their estimated natural rate and after the early 1990s bust in construction and prior to the commercial price bust of the late 2000s (Figure 6) .[13] As a practical matter, market valuations of property incorporate tax consideration, whereas replacement cost estimates from the source data do not. Following Hayashi (1982), in our construction models, we divide our estimate of q by 1 minus the present value of tax depreciation as a share of property value.

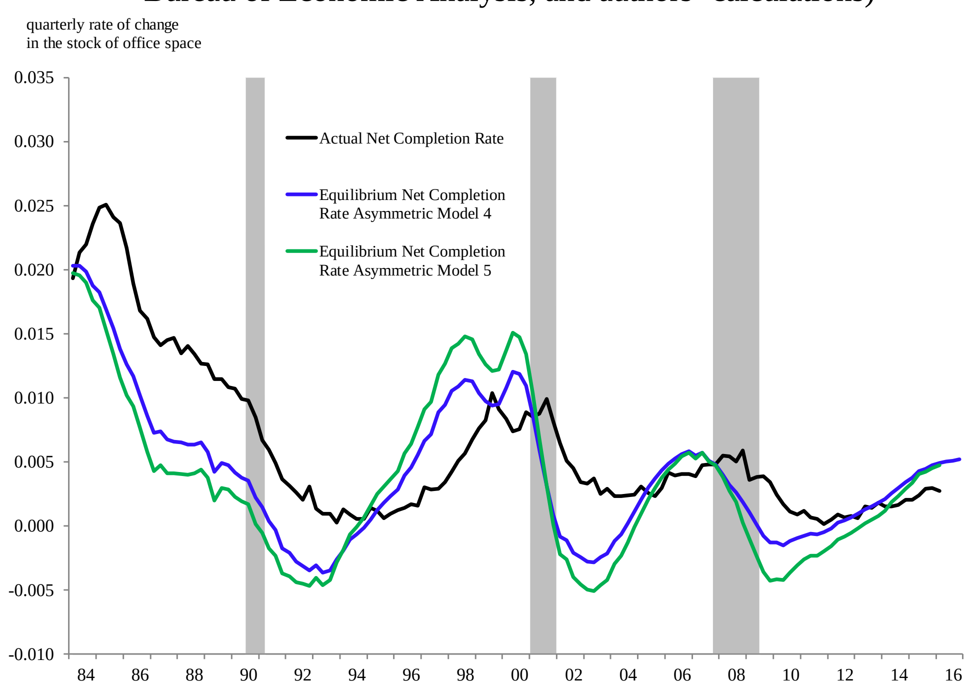
Our estimation is for the office market, and net investment is defined as the percent net change in national office space that is occupied or available for rent (adjusted CBRE data in square feet), seasonally adjusted with X-12. In published estimated models of investment based on Tobin's q, investment is often scaled by the prior stock of capital (e.g., Hayashi, 1982). Examples for construction include Madsen (2011) and Oulton (1981). This scaled series of net office investment is shown in Figure 7 along with equilibrium estimates from two models (discussed later). As the figure shows and as discussed in more detail in the appendix, the pre-1991 adjustment to the pace of office space additions in square feet are much more consistent with estimates of real office construction from the Bureau of Economic Analysis (BEA). We append this adjusted series to post-1993 data from CBRE. By adopting this strategy, we are able to analyze the construction boom-bust of the 1980s by effectively splicing sensible post-1990 estimates with an office space series that is adjusted to be more consistent with BEA construction estimates. As shown in Figure 8, this series has similar trends as the dollar volume of real office construction scaled by potential real GDP (CBO estimates). Given the large role of stock adjustment in real estate cycles, we estimate the series for net additions scaled by the stock of office space.

[13] Of course we do not know exactly when q equaled unity. To test the sensitivity to our choice, we construct alternative q series by dividing our ratio by 0.42 and 0.45 (these correspond to q roughly equaling unity in 2002q2 and 1993q2, respectively), and we will estimate with each of the three resulting q series that are graphed in Figure 7.



Sources: CBRE, BEA, NCREIF, and authors' calculations. Notes: Office completions are scaled by numbers of workers. Recessions denoted by shaded areas.

Figure 6: Time Series Proxy for Tobin's q for U.S. Office Space
(Shaded areas denote recessions. Sources: Lincoln Land Institute, Bureau of Economic Analysis, and authors' calculations)



Sources: CBRE, BEA, NCREIF, and authors' calculations. Notes: Office completions are scaled by prior period stock of office space. Recessions denoted by shaded areas.

Figure 7: Percent Change in the Stock of Office Space
(Shaded areas denote recessions. Sources: CBRE data and authors' calculations.)

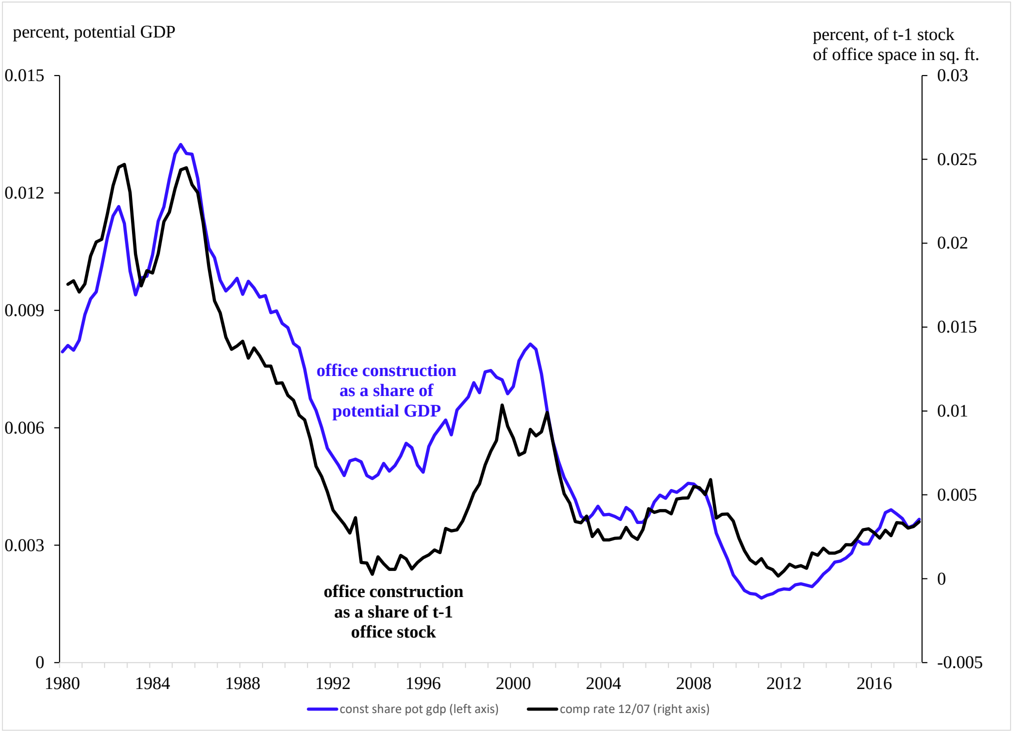


Figure 8: Office Construction Cycles Have Become More Muted
(Shaded areas denote recessions. Sources: CBRE, BEA, and authors' calculations)

Using the adjusted (cleaned) office space series, we estimate:

$$I^* = \gamma_0 + \gamma_1 qa + \gamma_1 qb \tag{18}$$

$$\Delta I = \beta_0 + \beta_1 EC_{t-1} + \sum \beta_{2i}\, \Delta I_{t-I} + \sum \beta_{3i} \Delta qa_{t-i} + \sum \beta_{3i} \Delta qb_{t-i}$$
$$+ \beta_4\, RentGap_{\,t-1} + \beta_5\, VacGap_{\,t-1} + \beta_5 Crisis_t + \beta_6 Sept11_t \tag{19}$$

where $EC_{t-1} = I - I^*$ and *Crisis* is a dummy (= 1 in 2008:q4, and -1 in 2009q1) to control for the unusual effects of the onset of the real estate and financial crisis that started in late 2008. *Sept11* is a dummy (= 1 in 2001:q3, and -1 in 2001q4) to control for a temporary pause, followed by a jump, in construction following the September 2011 terrorist attacks. Because of persistence in construction, and because error-correction models use prior quarter data on Tobin's q, there is a large positive outlier in 2008:q4 followed by an equally sized negative outlier in 2009:q1. The inclusion of this dummy does not noticeably affect key coefficient estimates, while avoiding serial correlation in model residuals.

We proxy $\Delta^{exp}q$ by stationary t-1 lagged error-correction terms for real rents (*RentGap*) and the vacancy rate (*VacGap*) estimated in earlier sections. These error-correction terms are stationary by construction, in contrast to the nonstationary I and q. As a practical matter we address this issue by including stationary lags of the *RentGap* and *VacGap* variables in the short-run equation. Short-run changes in construction [equation (19)], in turn, are a function of the extent to which net investment differs from its desired pace in the previous quarter, lagged changes in construction, lagged changes in q, and lagged rent and vacancy errors. The coefficient on the EC term should be negative, as changes in the pace of construction should move its level back in line with long-run fundamentals.

The error-correction approach is used for two reasons. First, the investment and the q variables are nonstationary and I(1) over the sample. Second, there are some costs and frictions associated with constructing previously planned new office space, so some delays in adjusting the pace of space adjustments to the desired pace implied by q could occur.[14] More specifically, we find that selection criteria (discussed below) yield a lag length of six quarters for each model. Recall that the economic choices underlying construction lags reflect two decisions: to construct new buildings and to renovate and maintain existing properties. Lag lengths can also be plausibly shortened by builders acting off expectations.

We jointly estimate four linear variants of equations (18) and (19). Model 1 uses the symmetrically constructed Tobin's q variable and the crisis dummy, but omits the lagged deviations of vacancy rates and real rents from their equilibrium levels. Model 2 adds those

[14] Note that a relatively high estimated speed of adjustment of the percent change in office space to its desired pace in eq. (17) is not inconsistent with a shift in the path of q having drawn out effects on the level of the capital stock.

disequilibria terms to Model 1. Models 3 and 4 test for asymmetric effects of Tobin's q, and respectively omit and include the lagged vacancy rate and real rent disquilibria. The estimation of long-run and short-run relationships is joint following Johansen (1995), and the vector error-correction framework. The lag length minimizes the number of lags needed to obtain a unique significant cointegrating variable and, if possible, to also yield clean model residuals. Owing to the lag lengths used to estimate real rents and the resulting real rent gap term, the longest common sample period for the models using our measure of *q* and construction starts in 1984:q1. Consistent with the rent and cap rate models, the estimation assumptions allow for possible time trends in long-run variables, but not for an independent time effect in the vector that would pick up, in an ad hoc way, influences outside of those tracked by factors measured in our models. Model 5 only includes the asymmetric measure of Tobin's q that equals the max of Tobin's q and 1.

In addition to these models, three alterative specifications, Models 6-8 rerun Models 2, 4, and 5, respectively, through 2018:q2. This was done using data on land price expectations from annual surveys from the National Association of Realtors to extrapolate the land price series from the Lincoln Land Institute through 2018q3, which allowed us to extend the Tobin's q proxy through that quarter.

In Table 1, among the models using non-extrapolated Tobin's q readings (Models 1-5), a unique and statistically significant long-run (cointegrating) relationship was not found for the symmetric Tobin's q model (Model 1) that did not account for real rent and vacancy disequilbria. However, a unique cointegrating vector is identified for the asymmetric q model lacking those two disequilibria variables. In addition, a significant, unique long-run relationship is found in models 2, 4, and 5, which include the highly significant vacancy and real rent disequilibria that have the anticipated negative signs. This is consistent with construction reacting to vacancy rate information not fully tracked by our q variable. It also suggests that the relevant version of q is forward-looking and accounts for expectations of future real rents that are not fully reflected in measures of q based on current costs and prices.[15]

Specifically, for Models 2-5 the trace statistic for 0 vectors rejects the null hypothesis of no significant cointegrating vectors, while the null hypothesis that there are not more than one significant cointegrating vectors is not rejected. Regarding the economics, net changes in office space are strongly positively related to the proxy for Tobin's q in these better-specified models.

Of the models that include the vacancy and real rate gap controls, the model allowing for asymmetric q effects (Model 4) has the stronger evidence of cointegration (higher significance level) than the model imposing symmetric q effects. Of the linear models, Model 4 also has the best fit (lowest standard error and highest corrected R^2) for tracking changes in the construction rate. In Model 4, Tobin's q is insignificant when it has a value under 1.0, but has a large and significant positive coefficient when it exceeds one. This model's error correction term is highly significant and negative, indicating that the pace of construction close s about 17 percent of the prior quarter' gap between actual and equilibrium construction. The superior performance of Model 4 implies that Tobin's q models should account for the asymmetric response of construction to Tobin's q and for anticipated changes in *q* during the construction process. While Model 5 does not fit quite as well as Model 4, it does not include the asymmetric negative Tobin's q statistic that has a counter-intuitive sign.

Models 6-8 are estimated through 2018q2 using the survey-extrapolated series for Tobin's q, with real rent gaps estimated using a longer rent sample through that quarter. The lag lengths needed to obtain clean residuals were a little longer, but the models yielded estimates that were

[15] Because it is costly and often takes time to buy and sell properties, CRE price adjustment is usually sluggish.

very similar to those for the corresponding shorter sample Models 2, 4, and 5. For the simulations, we will use the data in Models 6-8 to provide a more up-to-date basis for forecasting the indirect impact of the 2017 tax reform on office prices and construction.

6. Forecasting TCJA Effects on Office Prices and Construction in a Multi-Equation System

Having established sensible specifications for the three key CRE markets, this section simulates the effects of TCJA on commercial office prices and net investment by building a multi-equation system that tries to incorporate the main qualitative elements of the DiPasquale-Wheaton four-quadrant textbook model. To do this, we use Pesaran et al.'s (2001) insight that many cointegration models—particularly linear ones like the models we developed, have simpler, auto-regressive analogues that are more amenable to joining in a multi-equation system. We simulate our small system since 1984 to limit the risk of miss-specifying individual equations across major regime shifts—particularly the shift in inflation risk following the Volcker disinflation of the early 1980s and the diminishment of credit rationing associated with the deregulation of deposit interest rates in the early 1980s.

To simulate the effects of TCJA on commercial office prices and construction, we estimated our simplified system of equations with OLS from 1984:q1 to 2017:q4, which required extending the data through 2017:q4. This was straight forward with one modification. In the construction of Tobin's q, the replacement cost variable put a 20 percent weight on land prices, but the latter series ends in 2016. To extend it, we used average responses to 2016 and 2017 surveys conducted by the National Association of Realtors about the actual year-over-year change in land prices for 2016 and the expected change for 2017 (3 and 4 percent annual rates of change) and cumulatively applied the implied quarterly rates of change to our last land price reading. We extended the land price series into 2018 by applying the expected 2017 rate of change to 2018. As discussed below, because the symmetric Tobin's q variable is sufficiently under 1 in value in 2018:q4, we can set the asymmetric positive version of Tobin's q equal to 1 (*TobinsQPos* =Q if >1, 1 otherwise) throughout the simulation period and not need to model land prices in 2019 and 2020 if we used an ARDL specification of construction similar to model 5 in Table 1, which includes *TobinsQPos* but not its negative, asymmetric counterpart.

Reflecting the shorter sample period and some streamlining of lagged first difference terms, we used a simpler, ARDL specification for the cap rate in which time t-1 long-run terms replace the t-1 error-correction term in the model of changes with a t-1 lag:

$$\Delta\, CapRate_t = \beta_0 + \beta_1\, CapRate_{t-1} + \beta_2\, (r_{t-1}-g_{t-1})(1-taxdep_{t-1})]$$
$$+\, \Sigma^4_{i=1}\, \beta_{3i}\Delta CapRate_{t-i} + \Sigma^4_{i=1}\, [(r_{t-i}-g_{t-i})(1-taxdep_{t-i})]\ . \qquad (20)$$

The implied long-run effect of $(r_t-g_t)(1-taxdep_{t-i})$ on the cap rate of 0.91 is close to the 0.96 from the longer-sample error-correction model, and the implied speed of adjustment of the cap rate to its long-run equilibrium is about 20 percent in both models.

Similarly, we simplified the rent model by replacing the time t-1 error-correction term with the t-1 lags of the long-run relationship in the first difference equation:

$$\Delta\, \ln R_t\ = \beta_0 + \beta_1 R_{t-1} + \beta_2 \ln E_{t-1} + \beta 3 \ln St_{-1} + \sum^4_{i=1} \beta_{4i}\, \Delta \ln Rent_{t-i} + \sum^4_{i=1} \beta_{5i}\, \Delta ln E_{t-i}$$
$$+ \sum^4_{i=1} \beta_{6i}\, \Delta\ln\, S_{t-i} + \beta_4\, X_{t-1}\ + \mu_t\ . \qquad (21)$$

As before, the X vector of additional short-run exogenous controls includes three lags of log changes in real energy prices and the dummy for the September 2001 terrorist attacks. The implied long-run employment elasticity (the ratio of the long-run coefficient on log employment to that on the log of the stock of office space) on the cap rate of 0.91 is close to the 0.96 from the longer-sample error-correction model. The implied speed of adjustment of real rents to long-run equilibrium is roughly similar (about 8 – ½ percent) in the ARDL and the cointegration model (about 10 percent).

The construction equation was simplified in a few ways. First, to convert eqs. (18) and (19) into an ARDL specification, we replaced the error-correction term in eq. (19) with the t-1 lags of the long-run terms into the first difference equation. Second, we adopted the asymmetric model 5, which uses the asymmetric positive variant (*qa*) of Tobin's q, which equals the maximum of 1 and the reading on the symmetrically defined Tobin's q variable. This seems reasonable because only the asymmetric positive version of Tobin's q has a sensible sign in the cointegration model that includes both (model 4) and the fits of models 4 and 5 are similar (see Table 1). In addition, because the symmetric Tobin's q variable is sufficiently under 1 in value, we can set asymmetric positive version of Tobin's q equal to 1 throughout the simulation period and not worry about modeling land prices in 2019 and 2020. A third modification of the cointegration model equations (eqs. (18) and (19)) is that we dropped the rent disequilibrium term (which had a marginal and counterintuitive positive sign in the ARDL version) and, as discussed below, modified the vacancy rate disequilibrium term (*VGap*):

$$\Delta I = \beta_0 + \beta_1\, I_{\mathrm{t\text{-}i}} + \beta_2\, qa + \sum \beta_{3\mathrm{i}}\, \Delta I_{\mathrm{t\text{-}i}} + \sum \beta_{4\mathrm{i}} \Delta qa_{t-i} + \beta_{4\mathrm{i}}\, VGap_{\,t-i} + \beta_5 Crisis_t + \beta_6 Sept11_t \quad (22)$$

So far, we have three equations in our system—eqs. (20)-(22). To close the model, we need to model vacancies and define *VacGap* in ways that capture how employment construction feeds back into future vacancy rates. *VacGap* equals the gap between the actual vacancy rate and the equilibrium level of vacancies implied by estimating eq. (14), which is 14.50. We estimate the vacancy rate as a function of office employment (*E*) relative the stock of office space (*S*) from the following specification:

$$V_t = \beta_0 + \beta_1\, E_{t-1}/S_{t-1} + \sum\nolimits^{3}_{\mathrm{i}=1} \beta_{2\mathrm{i}}\, \Delta V_{t-i} + \beta_3\, \Delta lnE_{t-i} + \beta_4\, X_t + \mu_t \;. \quad (23)$$

where $\beta_1 < 0$ and the vector includes dummies to control for odd readings in CBRE vacancy rates for 1987:q3 (dummy = 1 in that quarter, 0 otherwise) and for 1989:q2 and 1989:q3 (= 1 in 1989:q2, -1 in 1989:q3, and 0 otherwise). The latter outliers reflected data quality issues with pre-1990 CBRE data that are addressed with our use of NIPA data on office construction for the stock of office space. From the coefficients one can forecast vacancies to construct the vacancy rate gap (*VacGap*) which enters the construction equation.

In the system of equations (20)-(23) there are four endogenous variables (cap rates, real rents, construction, and vacancy rates) and several exogenous variables (aside from dummy variables for shocks) including employment, Treasury and Baa bond yields, the present value of tax depreciation, and capital requirements. In principle, there should be five equations in order to model replacement costs (structure and land costs). However, because the symmetric measure of Tobin's q that underlies our measure of the positive asymmetric Tobin's q variable (q^a) is far enough below 1, we can get by with a four-equation system for simulating office construction.[16] The vacancy, real rent, and construction equations are inter-related because they all include the stock of office space. While the cap rate equation may seem to stand alone, it has a role in helping us simulate office prices, which have implications for CRE loan quality.

We estimate the system in-sample from 1984:q1 to 2017:q4 as the first step to simulating the effects of TCJA on commercial prices and construction (key coefficients are listed in Table 2). For the simulations, we freeze the effective capital requirement for CRE and use updates of Duca, Hendershott, and Ling's (2017) estimates of the present value of tax depreciation. As mentioned earlier, TCJA has had a minor effect on the present value of tax depreciation. Its main impact on CRE is likely to be more indirect through its effects on office employment and Treasury and Baa bond yields. For office employment, we use CBRE's 2017:q3 (proprietary) forecast of office employment as a baseline, non-TCJA path. For the TCJA path of employment, we use CBO's (2018) estimate of the effect of the TCJA on the level of total nonfarm employment (+0.2, +0.5, and +0.6 percent in 2018, 2019, and 2020, respectively) to project office employment off CBRE's 2017:q3 projected path. In doing this, we equally apportioned the forecasted annual change across the quarters of each year. According to CBO, the TCJA raises the growth rate of GDP by about 0.3 percent in both 2018 and 2019, whereas the Tax Policy Center projected larger near-term effect that is much more front-loaded equal to 0.8 percent in 2018 (see Barro and Furman, 2018), but a near zero effect in the long-run in contrast to CBO (2018).[17]

We use the November 2017 Blue Chip Financial Forecast Survey to project the spread of the Baa corporate bond yield over the 10-year Treasury rate for 2018 and 2019, and set the spread for 2020:q1 and q2 equal to its expected level for 2019q4. This spread affects the required rate of

[16] In the future, we plan to model replacement costs and further expand our system of CRE equations so that the cap rate and rent equations drive prices and hence Tobin's q and by implication construction and office space.

[17] In future versions, we plan to apply Okun's Law to alternative GDP forecasts to back-out different implied effects on office employment and will explore longer forecast horizons.

return on CRE projects which affects the cap rate), Note that subsequent Blue Chip Financial Forecast surveys have similar implied spreads for 2020:q1 and 2020:q2. We use this path for the spread, which is relatively stable over time, in all of our simulations.

For the impact of the TJCA on the 10-year Treasury yield, we use two alternative paths. The "TCJA path" is CBO's April 2018 forecast of the 10-year Treasury rate, which is inclusive of CBO's estimated effect of TCJA. The "non-TCJA" path for this interest rate equals the April 2018 forecast minus CBO's April 2018 estimate of the impact of the TCJA on the long-term yield. In doing this, we equally apportioned CBO's forecasted annual change across each quarter in a year.

The construction paths for the non-TCJA and TCJA scenarios are plotted in Figure 9. As can be seen, there is a small-sized positive effect of the TCJA on construction. This partly reflects that the impact of TCJA on construction only occurs via its employment effects on the vacancy rate because Tobin's q is below unity, which shuts down a price channel through which the TCJA could otherwise affect construction. Had Tobin's q been sufficiently high, the TCJA's negative effect on prices would have muted or possibly more than offset the positive employment effects. This qualification reflects the nonlinear nature of construction and how the impact of tax changes on commercial construction can be state-dependent.

To derive the implied impact of the TCJA on office prices we combined the cap rate and real rent forecasts as follows. The real rate forecast, combined with an assumed 2 percent underlying pace of inflation, implies a path for nominal office rents. Because the cap rate (annualized net operating income divided by price) is a proxy for rents divided by prices, one can derive a price path However, implied absolute price levels are not directly comparable to other sources because the nominal rent and cap rate series come from two different sources and because rents likely overstate net operating income which is adjusted for operating expenses. However, can we index the implied price levels to 100 in 2017:q4 and then compare the two forecast paths to infer the net impact of TCJA on commercial office prices.

We should note that conditions have changed greatly since the CBO made its April 2018 forecast. That earlier forecast foresaw notable increases in the 10-year Treasury yield to around 4.1 percent in 2020. Early December 2018 forecasts by market participants were much lower, and likely fell more during the remainder of December 2018 because long-term Treasury yields fell by around 40 basis points. To abstract from changes in conditions and expectations, it is more appropriate to focus on the net impact of TCJA. Accordingly, we track the difference between the

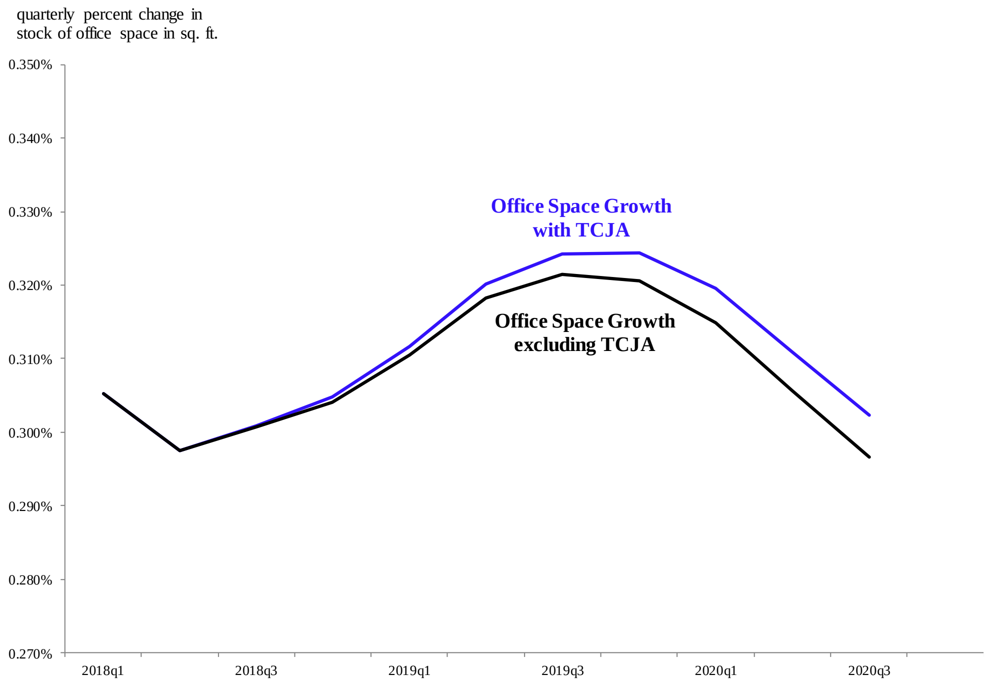


Figure 9: Forecasted Impact of TCJA on Commercial Office Construction Using April 2018 Forecasts of TCJA Net Effects on Interest Rates and Employment
(Sources: Blue Chip Financial Forecasts, CBRE, CBO, and author's calculations)

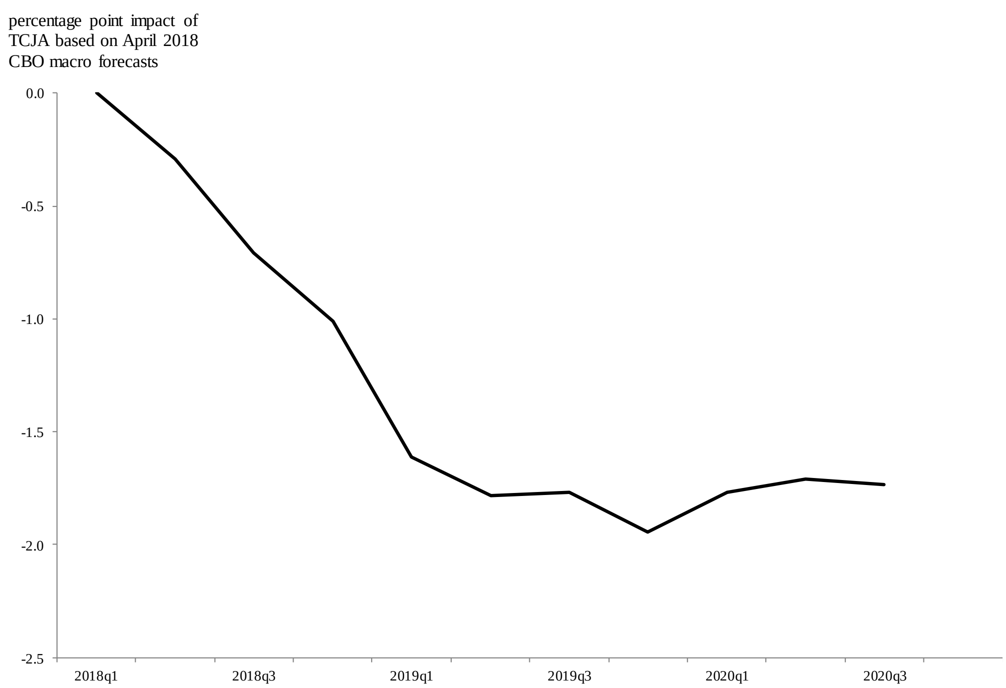


Figure 10: Forecasted Net Impact of TCJA on Commercial Office Prices Using April 2018 Forecasts of TCJA Net Effects on Interest Rates and Employment
(Sources: Blue Chip Financial Forecasts, CBRE, CBO, and author's calculations)

forecasts of nominal commercial office prices that were based on our interpolations of the annual employment and interest rate CBO paths with and without TCJA. As shown in Figure 10, the difference in the forecasts imply that the TCJA has reduced commercial office prices by about 1 – ¾ percent after about five quarters. This small effect largely reflects the modest net effect of the TCJA on long-term interest rates according to CBO.[18] However, if the TCJA's impact on employment unwinds and if its interest rate effects are larger, its negative impact on CRE prices could become larger. [19]

7. Conclusion

This study develops a preliminary multi-equation approach that can be used to assess the impact of changes in general financial and macroeconomic conditions, as well as changes in taxation and some regulations on commercial office prices and construction. Applying an early-stage version of this framework, the forecasted effects of the TCJA on commercial construction are slightly positive despite a mild negative effect on office prices of 1 – ¾ percent in the near-term. This price reduction reflects a tug of war between the positive effects of stronger near-term employment which are somewhat dominated by the negative effects of slightly higher long-term interest rates from the tax cut. For construction, owing to the asymmetric low response of office construction to changes in real estate prices when Tobin's q is low, the forecasted price effects of higher interest rates are dominated by the forecasted employment effects. In future versions of our study, we plan to expand our multi-equation system to endogenize construction costs and to broaden our set of scenarios for assessing the potential effects of the TCJA and also of other factors on commercial office and construction prices.

[18] CBO's projected TCJA effects on the long Treasury rate reflect the impact of both higher short-term rates from a monetary policy reaction function and of higher budget deficit-to-GDP ratios. In this regard, CBO's projected impact of the TCJA on the deficit-to-GDP ratio of around 0.6 percentage points would push up the 10-year Treasury yield by 15-22 basis points applying coefficient estimates from Gale and Orszag (2004) and Laubach (2009).

[19] Because long-term interest rates are low, the duration of CRE assets is so high that one percentage point higher long-term interest rates could push up cap rates to induce a 15 percentage point drop in real CRE prices, ceteris paribus.

Table 1: Estimation of the Percent Change (*I*) in Net Commercial Office Stock
Sample Periods: 1984:q1-2016:q1 and 1984:q1-2018:q2, Spliced BEA and CBRE Construction Data

Equilibrium $I_t = \beta_0 + \beta_1 Q_t + \varepsilon_t$

	Sample: 1984:q1-2016:q1					Sample: 1984:q1-2018:q2		
Model No.	1	2	3	4	5	6	7	8
Constant x100	-3.700	-7.514	-3.937	-6.129	-1.154	-0.627	-0.804	-1.033
Q x100	3.393**	1.086**				0.999**		
	(0.583)	(0.187)				(0.135)		
Q>1 x100			2.044**	1.251**	1.267**		1.327**	1.119**
(=Q if >1, 1 else)			(0.332)	(0.117)	(0.127)		(0.119)	(0.099)
Q<1 x100			1.887	-0.575*			-0.475	
(=Q if <1, 1 else)			(1.412)	(0.249)			(0.274)	
unique coin.vec.[1]	No	Yes**	Yes**	Yes**	Yes**	Yes**	Yes**	Yes**
# lags in vector	6	6	6	8	9	6	8	9
trace, no vector	27.13**	21.96**	43.58**	69.78**	51.70**	24.04**	72.04**	54.38**
trace, 1 vector	5.58**	0.09	14.42	11.85	0.56	0.02	13.44	1.41

Short-Run: $\Delta I = \beta_0 + \beta_1 EC_{t-1} + \Sigma\beta_{2i}\,\Delta I_{t-i} + \Sigma\beta_{3i}\,\Delta Q_{-i} + \Sigma\beta_{4i}\,(R\text{-}R^*)_i + \Sigma\beta_{5i}\,(V\text{-}V^*)_i + X_t + \varepsilon_t$

	1	2	3	4	5	6	7	8
EC_{t-1},	-0.002	-0.083**	-0.002	-0.167**	-0.147**	-0.087**	-0.140**	-0.155**
'adjust..speed'	(0.003)	(0.022)	(0.007)	(0.029)	(0.025)	(0.023)	(0.024)	(0.026)
Constant x 100	0.038	0.036	0.025	0.010	0.036	0.038	0.001	0.028
	(0.050)	(0.071)	(0.074)	(0.063)	(0.066)	(0.056)	(0.001)	(0.045)
ΔI_{t-1}	0.279**	0.192*	0.329**	0.158	0.109	0.188*	0.138	0.112
	(0.087)	(0.083)	(0.092)	(0.082)	(0.081)	(0.080)	(0.080)	(0.078)
ΔQ_{t-1}	0.005*	0.004*	0.002	-0.002	0.002	0.038*	-0.001	0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.018)	(0.003)	(0.002)
$Crisis_t$ x 100	0.147**	0.141**	0.115*	0.132**	0.157**	0.141**	0.131**	0.157**
	(0.048)	(0.044)	(0.053)	(0.044)	(0.040)	(0.044)	(0.043)	(0.040)

Sept11 x 100	0.140**	0.123*	0.145**	0.157**	0.156**	0.124*	0.163**	0.158**
	(0.049)	(0.044)	(0.048)	(0.041)	(0.040)	(0.044)	(0.040)	(0.043)
$VacGap_{t-1}$ x100		-0.013**		-0.031**	-0.027**	0.013**	-0.029**	-0.027**
		(0.003)		(0.004)	(0.004)	(0.003)	(0.004)	(0.004)
$RentGap_{t-1}$		-0.011		-0.009*	-0.015**	-0.083	-0.014**	-0.011*
		(0.005)		(0.005)	(0.005)	(0.055)	(0.005)	(0.005)
Adj. R^2	0.379	0.476	0.363	0.604	0.562	0.469	0.595	0.557
S.E. x 100	0.665	0.610	0.657	0.530	0.558	0.600	0.524	0.055
LRE (1)	6.52	5.96	17.73*	13.35	1.81	6.42	15.23	1.78
LRE (2)	2.22	1.83	9.63	10.12	1.08	1.86	10.06	0.95
LRE (3)	3.54	4.65	7.50	8.05	6.91	5.07	8.88	6.88
LRE (4)	5.84	6.37	7.58	9.81	7.86	7.33	8.88	8.21

1. Significant according to trace statistic, accounting for the size of the vector. Notes: (i) Absolute standard errors in parentheses. ** (*) denotes significant at the 99% (95%) confidence level. (ii) Lag lengths chosen to obtain unique significant vectors with sensible coefficients and clean residuals. (iii) First difference terms of elements in the cointegrating vector lagged more than one quarter are omitted to conserve space. (iv) Maximum likelihood estimates of the equilibrium relationship using a two-equation system with (at most) one cointegrating vector. (v) *I* is the net percent change in U.S. office space (CBRE). *Q* measures the market price of existing properties (NCREIF) relative to replacement costs. (*RRentGap*) is the gap between actual and equilibrium rents. (*VacGap*) is the gap between actual and equilibrium vacancy rates. *Crisis* equals 1 in 2008:q4 and -1 in 2009:q1 to control for temporary disruptions from the real estate and financial crisis of 2008-09. LRE is the Edgeworth expansion corrected ratio test statistic for serial correlation from lags 1 to the lag length indicated. The significance reflects the size of the cointegrating vector and the length of the lags on residuals.

Table 2: Main OLS Estimates of Simple System for Commercial Office Markets

Variable	Cap Rate ΔCapRate Model 1	Construction ΔI Model 2	Vacancy V_t Model 3	Real Rent R_t Model 4
Constant	0.211	0.00134**	48.551**	0.970**
	(0.20)	(0.00024)	(1.27)	(0.31)
$CapRate_{t-1}$ (Model 1)	-0.195**	0.059**		
I_{t-1} (Model 2)	(0.63)	(0.29)		
Δ $CapRate_{t-1}$ (Model 1)	-0.431**	0.225*		
Δ I_{t-1} (Model 2)	(0.93)	(0.083)		
$(r_{t-1}-g_{t-1})(1-taxdep_{t-1})$ (Mod. 1)	0.177**	0.057*		
*TobinsQa/(1-taxdep)*x100 M 2)	(0.06)	(0.026)		
$\Delta(r_{t-1}-g_{t-1})(1-taxdep_{t-1})$ (Mod. 1)	0.041	0.225*		
Δ *TobinsQa/(1-taxdep)*x100, M.2	(0.10)	(0.83)		
R_{t-1} (Model 4)				-0.084*
				(0.034)
ΔV_{t-1} (Model 3)			0.459	-0.084*
ΔR_{t-1} (Model 4)			(0.41)	(0.034)
E_{t-1}/S_{t-1} (Model 3)			-10000.74**	0.093**
E_{t-1} (Model 4)			(381.27)	(0.025)
S_{t-1} (Model 4)				-0.103*
				(0.030)
Adjusted R^2	.307	.501	.869	0.730
S.E. x100 (Mod. 1, 2, 4)	0.411	0.577	1.088	0.830

Other coefficients omitted to conserve space.

Key Implied Long-Run Relationships:

<u>Construction: Coefficient on asymmetric Tobin's q (bounded by 1 from below)</u>
1.267 *TobinsQa/(1-taxdep)* from error-correction Model 5, Table 1
1.057 *TobinsQa/(1-taxdep)* from Model 2, Table 2 (Tobin's qa coefficient/ I_{t-1} coefficient)

<u>Real Rent: Elasticity of real rents with respect to employment (coefficient on *E*/coefficient on *S*):</u>
Employment elasticity: 0.964 (error-correction model)
Employment elasticity: 0.895 (Model 4, Table 2)

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Appendix A: Adjusting the Timing of Pre-1991 Net Additions to Office Space to be More Consistent with BEA Estimates of Real Office Construction

Office stock estimates are based on underlying data collected by CBRE (and earlier with former CBRE business partners) from office investors. This poses two types of challenges with tracking net additions to office space. First, owners sometimes—based on financing or tax considerations—shift the timing of when they report a building is available for lease or is occupied.[20] Indeed, in some quarters before 1990, there are unusually large spikes in the change in office space in one direction, followed by roughly an equal sized spike in the other direction. These occurred in the following pairs of quarters: 1981:q3-1981:q4, 1982:q2-1982:q3, 1982:q4-1983:q1, 1984:q4-1985:q1, 1985:q2-1985q3, 1989:q3-1989q4, and 1990:q4-1991q1. In every case, these temporary see-saw spikes are at odds with BEA estimates of real office construction.

A second source of distortions occurred during the 1987-89 adjustment of investors to large tax changes from the 1986 tax reform (e.g., ending of passive tax write-offs) and the resolution of the savings and loan (thrift) crisis. As a result of those disruptive events, reporting by owners was inconsistent as properties shifted hands and new tax considerations may have altered the timing of when offices were reported to be available. Partly in reaction, CBRE staff started instituting changes in 1987:q4 to more consistently track the stock of office space. As a result, there is a large upward shift in the pace of net additions to the office stock in 1987:q4 that likely reflects under-reporting in earlier quarters that year. Nevertheless, until other changes to consistently track office space were instituted by CBRE in the early 1990s, earlier estimates were distorted and are at odds with BEA estimates of real office.

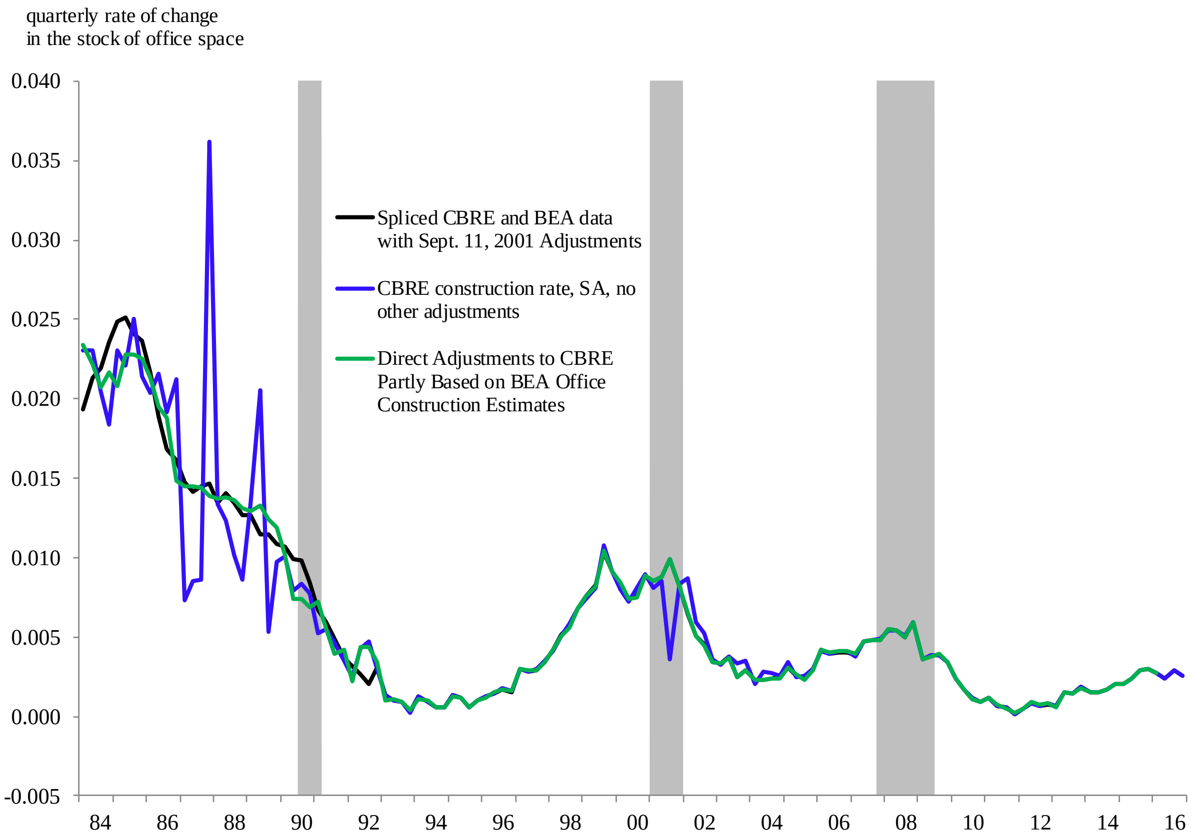
[20]For example, if a new building is not sufficiently occupied to meet the underwriting criteria for a regular commercial mortgage to replace a construction loan, the owner may delay reporting the building is available until they obtain enough new lessors to qualify for a long-term commercial mortgage for an occupied structure.

To mitigate these two problems, we adjusted the data following two alternative strategies. The first is to use BEA estimates of real office construction (in real dollars) which cover 1959:q1-2018:q1 to create a quarterly time pattern for the expansion in national office space. We first seasonally adjusting the raw CBRE office stock estimates, and then used the CBRE endpoints of 1980:q1 and 1993:q1 to pin down the start and end periods for interpolating office space over the period of questionable data quality. Then we address the issue of converting construction spending in 1996 dollars (mainly structures plus land improvement) into square feet of space. Some construction spending reflects depreciation of the prior period capital stock either through renovations or new construction to replace demolished property. We first set the period *t* stock of space equal to the prior period minus the quarterly depreciation rate of nonresidential structures from the Federal Reserve Board's quarterly model of the U.S. economy. We then added an amount equal to 0.1575 times the seasonally adjusted quarterly real dollar amount of construction. (This is roughly \$6.35 a sq. ft. or is 0.630 times the SAAR pace of constructions). This produced a reading for 1993:q1 that slightly exceeded the CBRE data point for that quarter by less than 0.06 percent of the 1993:q1 CBRE reading. We then applied a multiplicative break adjustment by multiplying the 1980:q1 – 1992:q4 BEA-based interpolations by 0.9994 before splicing that series to seasonally adjusted post-1992 readings from CBRE. We refer to this as the BEA-based interpolated series.

The second strategy was to produce a "directly adjusted" office space series by making two types of adjustments to reported data. First, we adjusted the see-saw spikes in net additions of space in the following pairs of quarters: 1981:q3-1981:q4, 1982:q2-1982:q3, 1982:q4-1983:q1, 1984:q4-1985:q1, 1985:q2-1985q3, 1989:q3-1989q4, 1990:q4-1991q1, and 1993q4-1994q1. We corrected these spikes by averaging net additions to space using surrounding quarters, making the adjusted pre-1991 series much more consistent with BEA data around those quarters. Then to address the second source of poor data quality, we followed the broad contours in BEA data on new office construction spending by interpolating the additions to office space to be a smooth pace from 1986:q4 to 1989:q1. As a result of both adjustments, the resulting series on the pace of net additions to office space are much more in line with BEA estimates of the pace of new office construction in real dollars. The only visually notable divergence between the two series, plotted in the Appendix Figure, occurs in 1992, just before the interpolated portion of the BEA-spliced series ends.

Finally, both of the adjusted series were modified to abstract from how the terrorist attacks of September 2001 caused a large outsized plunge in the national rate of office space expansion, followed by a temporary surge in 2002 as earlier space was repaired or whole buildings were replaced. The attacks resulted in a 21.4 million square foot decline in the amount of office space available in the New York metropolitan area (NYC), enough to notably distort the pace of net national additions to office space. By 2005:q3 (about 4 years later), the NYC stock of office space had returned to 2001:q2 levels. To control for these distortions, we added back to the reported stock of space, the gap between the 2001:q2 level of NYC space minus the quarterly level reading between 2001:q3 and 2005:q3. The adjustments remove the plunge and the temporary surge seen in the unadjusted data shown in Appendix Figure 1.

The two adjusted office stock series yielded similar findings for estimating a Tobin's q model of construction. However, since the adjustments based on interpolating BEA estimates are more systematic and perhaps more convincing to the outside reader, the main body of the paper discusses and presents results using the BEA-based interpolated data.



Sources: CBRE, BEA, NCREIF, and authors' calculations. Notes: Office completions are scaled by prior period stock of office space. Recessions denoted by shaded areas.

Appendix Figure A1: Adjusting Less Reliable Pre-1993 CBRE Office Space Estimates
(Sources: CBRE, BEA, and authors' calculations)