

An Alternative Perspective on Tobin's Q and Aggregate Investment Expenditure

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Abstract

This study provides new evidence on the relationship between Tobin's Q and private investment. Using a testing procedure advocated by Bierens applied to US data, both series are found to be stationary around a nonlinear deterministic trend and are co-trended insofar as they share a common nonlinear deterministic trend.

Key words: Tobin's Q ; investment; nonlinear trend; co-trend

JEL classification: E2; C2; C3

1. Introduction

In the decision to invest more in capital, Tobin's Q criterion is based on a comparison between the market value of a company's stock and the company's equity book value. In theory, high values of Q should encourage more investment. Building on Tobin (1969), links have been made between Q and the neoclassical investment model, while other studies have extended the theory to encompass various realistic features, including irreversibility and fixed costs. However, evidence in support of Q as a means of explaining aggregate business investment is weak. For example, Rapach and Wohar (2007) find that the Q investment model, compared with competing investment models, only produces the most accurate forecasts at a one-quarter horizon. Earlier work by Blanchard et al. (1993) finds that fundamentals work better than Q in explaining investment. Oliner et al. (1995) find that when Q is significant, it is wrongly signed. As argued by Price and Schleicher (2005), the lack of support for the role of Q is surprising in that one would expect user cost to be significant in the aggregate investment relationship.

This study reconsiders the relationship between Q and private investment. However, in sharp contrast to previous studies, an alternative assessment of the relationship is based on a testing procedure advocated by Bierens (1997a, 1997b, 2000), which considers whether nonlinear trend stationarity is present in the two

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series, and, if so, whether they are co-trended, sharing the same nonlinear deterministic trend. The rationale for paying closer attention to nonlinearities is based on the presence of information asymmetries and nonlinearities with respect to factors such as fixed costs, threshold effects, and irreversibility, which are entertained in the investment literature.

2. Methodology

For many long macroeconomic time series, it is implausible to argue that the parameters of the data generation process are unchanged over time. Perron (1997) and others have shown that when a time series has structural breaks in the mean, the unit root hypothesis is often accepted before structural breaks are taken into account. The Bierens (1997a, 1997b) nonlinear augmented Dickey-Fuller (NLADF) test allows the trend to be an almost arbitrary deterministic function of time. The test is based on an ADF-type auxiliary regression model that sees a nonlinear deterministic trend approximated by a linear function of Chebishev polynomials. These offer substantial advantages over regular time polynomials because they are orthogonal (with a closed form) and bounded and allow the researcher to distinguish stationarity around a linear trend from stationarity around a nonlinear deterministic trend under the alternative hypothesis.

Suppose a given series is modelled as $\mu_t = \omega + \phi\mu_{t-1} + v_t$, where ω is a constant drift parameter and v_t is a stationary autoregressive process. The usual test for linear adjustment towards the mean is based on assessing the unit root properties of μ_t through OLS estimation of ADF regressions such as:

$$\Delta\mu_t = \omega + \zeta\mu_{t-1} + \sum_{i=1}^k \psi_i \Delta\mu_{t-i} + v_t, \quad (1)$$

where $-2 < \zeta < 0$ indicates stationarity of μ_t . The test of the null hypothesis $\phi = 1$ proposed by Bierens is against the alternative of nonlinear trend stationarity:

$$\mu_t = g(t) + v_t, \quad (2)$$

where $g(t)$ is a possibly nonlinear trend function. The NLADF regression is written as:

$$\Delta\mu_t = \omega + \zeta\mu_{t-1} + \sum_{i=1}^p \psi_i \Delta\mu_{t-i} + \theta^T P_{t,n}^{(m)} + v_t, \quad (3)$$

where $P_{t,n}^{(m)} = (P_{0,n}^*(t), P_{1,n}^*(t), \dots, P_{m,n}^*(t))^T$ is a vector of orthogonal Chebishev polynomials such that $P_{0,n}^*(t) = 1$, $P_{1,n}^*(t)$ is equivalent to a linear trend, and $P_{2,n}^*(t)$ through to $P_{m,n}^*(t)$ are cosine functions. Under the null hypothesis of a unit root, $\zeta = 0$ and $\theta^T = 0$. The unit root hypothesis is tested on the basis of the t -statistic on ζ and the test statistic $Am = (n - p - 1)\rho \left| 1 - \sum_{i=1}^k \psi_i \right|$. These are two-tailed tests so if the non-stationary null is rejected, the proper alternative hypothesis will depend on

the whether there is left- or right-side rejection. A left-side rejection favors the alternative of mean stationarity, linear trend stationarity, or nonlinear trend stationarity; whereas a right-side rejection favors the alternative of nonlinear trend stationarity alone.

Although some macroeconomic time series are not unit root processes, they might still behave as if they are cointegrated. This could be accounted for by the presence of a common nonlinear deterministic time trend. Bierens (2000) proposes a nonparametric test for nonlinear co-trending based on the eigenvalues of matrices constructed from the partial sums of the variables.¹ The test is nonparametric in the sense that the nonlinear trends and any serial correlation process do not have to be specified. The generalized eigenvalues of the matrices M_1 and M_2 are:

$$\begin{aligned}\hat{M}_1 &= \frac{1}{n} \left[F(1/n)F(1/n)' + \dots + F(1)F(1)' \right], \\ \hat{M}_2 &= \frac{1}{n} \left[dF(m/n)dF(m/n)' + \dots + dF(1)dF(1)' \right],\end{aligned}\quad (4)$$

with $F(t/n) = (1/n)[x_1 + \dots + x_t]$ and $dF(t/n) = [F(t/n) - F((t/n) - (m/n))]/(m/n)$, where x_t is the de-trended or de-meaned μ_t and $m = n^\alpha$ with n equal to the number of usable observations. Solving $|\hat{M}_1 - \lambda \hat{M}_2| = 0$ for λ , the test statistics are calculated as $n^{1-\alpha} \hat{\lambda}_r$, where r is the number of co-trending vectors under the null. The existence of r co-trending vectors among $r+1$ series indicates the presence of r linear combinations that are stationary around a linear trend where these series share a single $(r+1) - r$ common nonlinear deterministic time trend. This is indicative of a strong degree of co-movement across the $r+1$ series.

3. Data and Results

Investment expenditure data for the US are obtained from the *Bureau of Economic Analysis*, where gross private domestic investment is divided by the price deflator for fixed investment to provide real investment (*inv*). Tobin's Q is measured as the market value of equities divided by net worth (market value). The relevant Q data are obtained from the *Flow of Funds Accounts of the United States* provided by the *Federal Reserve*.² The *inv* and Q series are transformed into natural logarithms and are quarterly for the study period 1960Q1-2009Q2. Figure 1 indicates that Q and *inv* have moved together over time. However, there are also episodes of sharp variations in the relationship, making it very likely that structural breaks exist. Table 1A reports ADF and Elliot et al. (1996) DF-GLS unit root tests, which are unable to reject non-stationarity at the 5% significance level throughout. Table 1B reports results based on the Perron (1997) unit root tests that allow for a single (unknown) structural break. At the 5% significance level, the non-stationary null is accepted throughout.

Figure 1. Real Investment Expenditure and Tobin's Q, 1960Q1-2009Q2

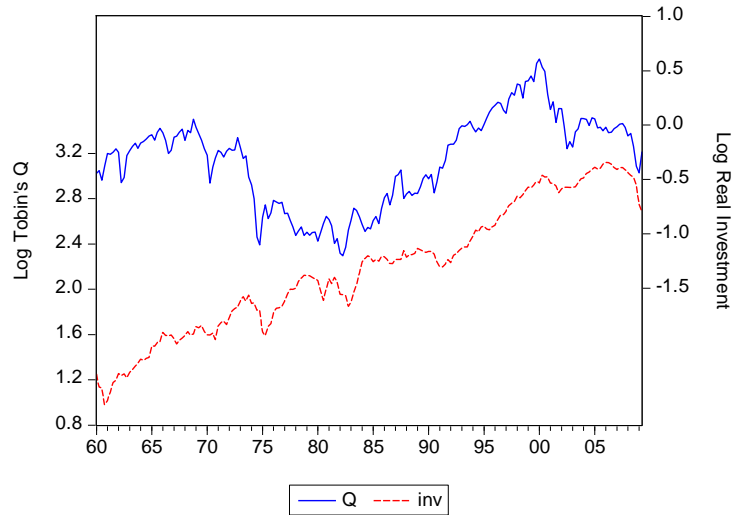


Table 1A. Unit Root Tests

| | ADF (no trend) | ADF (trend) | DF-GLS (no trend) | DF-GLS (trend) |
|------------|----------------|-------------|-------------------|---------------------|
| <i>inv</i> | -1.756 | -2.378 | -0.428 | -2.691 ^c |
| <i>Q</i> | -1.545 | -1.630 | -1.478 | -1.624 |

Notes: In all cases, the lag length is selected according to the Schwarz Information Criterion (SIC). The 10% critical values are -2.575, -3.140, -1.616, and -2.644 for the ADF (no trend), ADF (trend), DF-GLS (no trend), and DF-GLS (trend) models respectively. In the latter model, the superscript *c* denotes rejection of the null hypothesis at the 10% significance level.

Table 1B. Perron (1997) Unit Root Tests

| Model | IO1 | | IO2 | | AO | |
|------------|--------|--------------------|--------|--------------------|--------|--------------------|
| | T_b | $t_{\hat{\alpha}}$ | T_b | $t_{\hat{\alpha}}$ | T_b | $t_{\hat{\alpha}}$ |
| <i>inv</i> | 2008Q3 | -3.770 | 2008Q1 | -3.732 | 2009Q1 | -4.071 |
| <i>Q</i> | 1990Q2 | -3.568 | 1972Q3 | -3.386 | 1978Q2 | -2.535 |

Notes: the models are the Innovational Outlier (IO1) model which incorporates a change in the intercept, the Innovational Outlier (IO2) model which incorporates a change in the intercept and the slope, and the Additive Outlier (AO) model which incorporates a change in the slope only, but both segments of the trend function are joined at the time break. T_b denotes the time of the break and $t_{\hat{\alpha}}$ denotes the test statistic for a unit root. With respect to the null of non-stationarity, the 10% critical values are -4.58, -4.82, and -4.38 for the IO1, IO2, and AO models respectively.

Table 2 presents NLADF test results based on the auxiliary regression in (3).³ The lag length p is chosen using the Schwarz Information Criterion, and the Chebishev time polynomial is set from $m = 20$.⁴ This test can potentially present substantial size distortion, so relevant critical values are simulated using a wild bootstrap based on 10,000 replications of a Gaussian $AR(m)$ process for $\Delta\mu_t$ with

parameters and error variance equal to the estimated $AR(m)$ null model. According to the t -statistic and Am tests, there is a right-side rejection of the unit root hypothesis in favor of nonlinear trend stationarity at the 10% significance level or better in both cases. The estimated values for ζ , -0.168 and -0.366 , provide approximated half-lives associated with a deviation from the long-run nonlinear deterministic trend value of 3.77 and 1.52 quarters for inv and Q respectively.⁵ While studies such as Price and Schleicher (2005) employ conventional ADF unit root testing and express unease at finding a non-stationary Q , the NLADF results here suggest that Q is in fact stationary, but with respect to a nonlinear as opposed to a linear trend.

Table 2. NLADF Tests

| | inv | Q |
|----------------|--------------------|--------------------|
| $\hat{\zeta}$ | -0.168 | -0.366 |
| t -statistic | -3.848 (0.970) | 6.221 (0.904) |
| Am | -42.861 (0.943) | -72.086 (0.919) |

Notes: Simulated p -values based on 10,000 replications are given in parentheses.

So far, the results indicate that both inv and Q are nonlinear trend stationary. The co-trending test results presented in Table 3 point to the existence of one co-trending vector ($r = 1$). Whereas the existing literature has struggled to find a long-run equilibrium relationship between inv and Q , the evidence here of a single linear combination of the inv and Q that is stationary around a nonlinear trend suggests that the two series share a common nonlinear deterministic time trend, where common trending behavior would appear to be a reasonable statistical characterization. While this should not necessarily be interpreted as causality, the co-trending vector can be written in terms of Q , where a positive coefficient of 0.023 points to the sensitivity of the inv nonlinear trend in response to the Q nonlinear trend.

Table 3. Nonlinear Co-Trending Analysis

| Null | Alternative | Test statistic | 10% critical value | 5% critical value | Outcome |
|---------|-------------|----------------|--------------------|-------------------|---------|
| $r = 1$ | $r = 0$ | 0.082 | 0.120 | 0.151 | Accept |
| $r = 2$ | $r = 1$ | 0.264 | 0.169 | 0.203 | Reject |

Nonlinear trend in $inv = 0.023 \times$ nonlinear trend in Q

Note: r denotes the number of co-trending vectors.

4. Conclusion

This study provides an alternative perspective on the perceived failure of Tobin's Q to explain aggregate investment. Both series are found to be stationary around a nonlinear trend, and they can be regarded as related insofar as they share a common nonlinear deterministic time trend.

Notes

1. Bierens (2000) considers nonlinear co-trending in the context of inflation and interest rates in the US. Further applications include Camarero and Ordonez (2006) who consider European unemployment rates.
2. Table B.102 "Balance Sheet of Nonfarm Nonfinancial Corporate Business" where line 35 "Market value of equities outstanding" is divided by line 32 "Net worth (market value)."
3. Estimation is conducted using the EasyReg International software made available by Herman Bierens.
4. Bierens (1997a) argues there is no definitive method for choosing m . If m is too low, it may be insufficient to approximate the nonlinearity under the alternative. If m is too high, it may cause the test to lack power.
5. Approximated as $(\ln 0.5)/\ln(1 + \hat{\zeta})$.

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