Subject to large and extensive fluctuations, construction investment is one of the most volatile components of GDP. Construction grows through cycles of expansions and contractions that vary widely in amplitude, but its fluctuations do not seem to follow a deterministic cyclical pattern with distinct phases of finite duration. Identifying the timing of peaks and troughs in construction investment cycles, and understanding the correlations with other macroeconomic series, allows practitioners to make more informed decisions.

**Keywords:** cointegration, co-movement, deviation cycle, Granger-causality

### 1. Introduction

To adopt a more strategic perspective, practitioners responsible for construction investment need a clear understanding of the working of the factors that drive the cycles of construction industry.

Unfortunately, there is no well-established model to account for some minimal set of basic stylized facts in the area of construction investment cycles.

Trying to overcome some of such limitations, this investigation attempts to provide an insight into the dynamic relationship between construction investment cycles - and its residential and non-residential components - and GDP cycle in Israel, through time series analysis of the record covering thirty six years.

### 2. Cycle Volatility

Literature generally connects cyclical fluctuation to volatility and long-run growth rate.

Construction cycle volatility is subject to a much larger relative variation than GDP (Figure 1, annual data).

![Figure 1: Cycle volatility of construction investment and GDP](image)

*Figure 1: Cycle volatility of construction investment and GDP*

There is sufficient evidence that there is a low positive linear relationship ($\beta = .36$) between cycle volatility and growth in construction investment; high volatility does not mean low values of growth.

### 3. Sinusoidal Oscillations

The phase spectrum - a measure of the extent to which cycles in one time series lead or lag behind cycles in the other time series - starts at zero and then decreases, indicating that construction investment tends to peak slightly before GDP at intermediate frequencies (Figure 2).

![Figure 2: Phase spectrum of GDP by construction investment](image)

*Figure 2: Phase spectrum of GDP by construction investment (dashed lines represent the estimated two standard error bands and the shaded area represents so-called “business cycle frequencies”, 8 to 32 quarters)*

The squared coherency - a measure of the degree to which two series are jointly influenced by cycles of a given frequency - is near 0.6 at low frequency, suggesting a significant correlation between construction investment and GDP in their long-run movements. High frequency oscillations in construction investment tend not to be strongly associated with the short-run movements of GDP.

### 4. Common Cycles

The length of the cycle - defined in this section in terms of “deviation cycle”, related to the turning points of deviations of data from an underlying trend - exhibits for public residential construction investment a distinct asymmetry, with a long expansion phase. This might be attributed to the Israeli government’s attempts to accommodate
mass migration waves, but the evidence on this point is not verified.

Construction investment and GDP do not seem to behave counter-cyclically throughout most of the analysis period (Figure 3, quarterly data).

![Figure 3: Cyclical component from Baxter-King filter for construction investment and GDP (shaded areas represent recessionary periods)](image)

The concordance index statistic .67 indicates, at 5% level of significance, that residential construction investment tends to co-move with GDP in its expansion and contraction phases.

5. Common Trends

The cointegration test statistic - which refers to the existence of a stationary linear combination of two non-stationary series - strongly supports the presence of one long-run cointegrating vector, and one common stochastic trend, for investment in private residential, and in all non-residential construction. In contrast with this finding, no significant evidence of a cointegrating relationship is observed between investment in public residential and in all non-residential construction.

6. Causality Test Results

The results for the Granger-causality test – applied to determine the impact of construction investment on the peaks and troughs of the business cycle - indicate a one-way causation process (Table 1).

<table>
<thead>
<tr>
<th>Causal series</th>
<th>GDP</th>
<th>Chi-Square</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Investment</td>
<td>8.69</td>
<td>.0032</td>
<td></td>
</tr>
<tr>
<td>Residential Construction</td>
<td>4.82</td>
<td>.0282</td>
<td></td>
</tr>
<tr>
<td>Non-Residential Investment</td>
<td>6.93</td>
<td>.0085</td>
<td></td>
</tr>
</tbody>
</table>

The null hypothesis of Granger-noncausality from the construction investment and its residential and non-residential components to GDP can be rejected. Past values of construction investment and GDP series may help to predict GDP, without necessarily causing GDP. No statistically significant evidence of reverse Granger-causality, from GDP to construction investment, is observed.

7. Discussion

Governments should consider that a policy of switching from a cyclical equilibrium to a corresponding acyclical one does not raise the long-run growth in construction investment.

Policy-makers should take into account that their policy of promoting public residential construction investment appears not sufficiently accompanied by similar efforts in all non-residential construction investment.

Construction firms should carefully consider the position of construction investment cycles in their analysis. In order to make better investment decisions and to forecast more accurately future returns, they should use cyclical rather than linear estimates. In recession periods, construction businesses need to reorganize their production and improve efficiency, to be ready to accelerate when the construction industry recovers.

8. Conclusions

The causality test results are partially consistent with those obtained by Green [4], who concludes that residential construction investment appears to Granger-cause GDP, but non-residential construction investment does not Granger-cause GDP. The results are not in accordance with those obtained by Tse & Ganesan [11], who find that GDP tends to lead construction flows.

This study contributes to theory by providing evidence on stylized facts, formulating additional stylized facts, and exhibiting a cyclical fluctuation process of construction investment that is not in accordance with most other models.

These conclusions provide a basis for future research, for the purpose of developing a transfer function model to study whether the Israeli GDP’s response to a residential construction investment shock is greater than that of the response to a non-residential construction investment shock.

References


Measuring Cyclical Fluctuations in Construction Investment

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Abstract
To adopt a more strategic perspective, practitioners responsible for construction investment need a clear understanding of the working of the factors that drive the cycles of construction industry. Unfortunately, the lack of uniformity in direction and magnitude of the cycles of construction investment has made difficult to create a uniform explanation, and there is no well-established model to account for some minimal set of basic stylized facts in this area.

Trying to overcome some of such limitations, this investigation attempts to provide an insight into the dynamic relationship between construction investment cycles - and its residential and non-residential components - and the general business cycle in Israel. The basic question arises whether construction investment leads or lags the expansion or contraction of the general business cycle. The assumptions are tested through time series analysis of the record covering thirty-six years.

The empirical results show that cycles in public residential construction investment have a longer duration than those of other construction sectors. A cointegrating relationship exists between private residential and non-residential construction investment. The null hypothesis of Granger-noncausality from the construction investment – as well from its residential and non-residential construction investment component - to GDP is rejected, suggesting that past values of construction investment may help to predict GDP.

For policymakers formulating the macroeconomic policy that affects output and influences construction activity, the benefits from the findings are very practical. For construction firms, understanding construction investment volatility and using “cycle thinking” approach in their business activities, facilitates them in making more informed decisions.

This study contributes to theory by exhibiting a cyclical fluctuation process of construction investment that is not in accordance with most other models.

Keywords: cointegration, co-movement, deviation cycle, Granger-causality

1 The views expressed in this paper are those of the author. No responsibility for them should be attributed to the Israeli Central Bureau of Statistics.
1. Introduction

Subject to large and extensive fluctuations, construction investment is one of the most volatile components of the GDP. Construction needs long development periods and a long response time for stocks to adjust to new market conditions. Substantial gaps between planning and completion phases cause construction to respond cyclically to exogenous shocks.

The proliferation of cycle research has become a priority for large institutional investors such as real estate investment trusts, insurance companies, pension plans and their sponsors. In order to make more informed decisions on construction investment, a clear understanding of the factors that drive the working of the cycles in the construction industry is necessary.

In recent decades, the empirical construction economics literature has focused on the cyclical behaviour of construction investment’s components, and their relationship with output and other economic series. It presents a wide range of often contrasting results. Grebler & Burns [3] show that in the U.S. the number of fluctuations in total construction investment and some of its main components exceed that of the output series. They find an increasing volatility of private construction and its residential sub-sector, as well as all construction. Green [4] analyzes the impact of residential versus non-residential construction investment on the GDP throughout the business cycle, using the Granger-causality test. His findings show that residential construction investment Granger-causes the GDP, but it is not caused by it; while non-residential construction investment does not Granger-cause the GDP, but is Granger-caused by the GDP. Coulson & Kim [2] test the dynamics of both residential and non-residential construction investment with respect to the GDP, and find that residential construction investment shocks are more important in the determination of the GDP than non-residential construction investment shocks. Using data from Hong Kong, Tse & Ganesan [11] point out that the GDP tends to lead the construction flow - not vice versa; and the construction flows are less volatile than the GDP. Kim [6] examines residential and non-residential construction investment in the Korean GDP fluctuations and finds that non-residential construction investment shocks are more important in fluctuations of the GDP than residential construction investment shocks. Sabatés [10] uses a vector autoregression (VAR) methodology to examine the dynamic effect between construction investment and GDP in the USA, including sub-components of residential and non-residential construction investment. The analysis of impulse-response functions suggests that the GDP growth is mainly induced by a shock in consumption, followed by a shock in investments in the construction of single-family housing and other residential structures.

The aim of this study is to examine the dynamic effect between construction investment cycles – and its residential and non-residential components - and the GDP cycle in Israel. The basic question arises whether construction investment leads or lags the expansion or contraction of GDP. Stylized facts suggest that residential construction investment tends to be counter-cyclical, while the non-residential construction investment tends to be co-incident with the macroeconomic cycle. To test these assumptions, time series methods are applied.
The organization of the remainder is as follows: a short description of the data is given, briefly describing the volatility of construction investment vs. the GDP, providing a rationale for cross-spectrum analysis of the relationship between these two main series. Next, the construction investment cycles are estimated, and the cyclical behaviour of construction investment and its main sub-components is discussed. The cointegration and Granger-causality test results are further examined in order to show the impact of construction investment on the peaks and troughs of the GDP growth cycle. Finally, the implications of the findings are discussed and the concluding remarks are presented.

2. Data Description and Statistical Transformations

In order to estimate the cycles in Israeli construction investment, quarterly data are used. To accomplish this task, seven series from the Israeli Central Bureau of Statistics are used (\(x_{i,t}\), where \(i=1, \ldots, 7\), and \(t=1, \ldots, 144\), denotes quarters, from the 1\(^{st}\) quarter of 1968 to the 4\(^{th}\) quarter of 2003): five series on the gross domestic capital formation in construction: construction investment (Construction I), residential construction investment (Residential CI), private residential construction investment (Private RCI), public residential construction investment (Public RCI) and non-residential construction investment (Non-RCI), which are supplemented by two “reference” series on: the GDP (GDP) and private consumption expenditure (C).

All series are deflated using their respective price index, are seasonally adjusted, and usually, are transformed into natural logarithms. In order to detrend the data, first differences and the Baxter-King band-bass filter are used.

The results of the Phillips-Perron unit root test indicate, that the null hypothesis of non-stationarity of the seven series in their level form is not rejected by using a 1\% statistic significance level (Table 1).

<table>
<thead>
<tr>
<th>Series</th>
<th>Level, (x_{i,t})</th>
<th>First difference, (\ln(x_{i,t}) - \ln(x_{i,t-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trend</td>
<td>No trend</td>
</tr>
<tr>
<td></td>
<td>2 lags</td>
<td>4 lags</td>
</tr>
<tr>
<td>Construction I</td>
<td>1.20</td>
<td>1.33</td>
</tr>
<tr>
<td>Residential CI</td>
<td>1.99</td>
<td>2.17</td>
</tr>
<tr>
<td>Private RCI</td>
<td>1.41</td>
<td>1.45</td>
</tr>
<tr>
<td>Public RCI</td>
<td>2.53</td>
<td>2.88</td>
</tr>
<tr>
<td>Non-RCI</td>
<td>.87</td>
<td>1.04</td>
</tr>
<tr>
<td>GDP</td>
<td>1.38</td>
<td>1.40</td>
</tr>
<tr>
<td>C</td>
<td>1.27</td>
<td>1.27</td>
</tr>
</tbody>
</table>

The critical values of the test are: 4.04 and 3.45 with trend, and 3.51 and 2.89 without trend, at 1\% and 5\% significance levels, respectively.

With the application of first difference of the logarithm form, all the series that are investigated in this article become stationary.
3. Cycle Volatility

The cycle theory claims that cyclical fluctuations may be connected to volatility and long-term growth rates. The volatility of construction investment and the GDP is measured using the standard deviation of growth, in percentages. For each year, the standard deviation and the mean of the expression \( ((1+\ln (x_{i,t}/x_{i,t-1}))^4-1)*100 \) are computed. The volatility is plotted against each year (Figure 1) and against the average growth rate of each year (Figure 2).

Construction cycle volatility is subject to much larger relative variations than the GDP, with standard deviation reacting instantly to outliers of both series (Figure 1). The linear relationship between volatility and growth in construction investment has a positive low value (\( \rho = .3579 \), for \( df=34 \), and a non-directional probability of .0321 for the null hypothesis \( \rho=0 \)) (Figure 2). Miles & Scott [9] suggest that the business cycle volatility has a mixed effect of negative and positive implications on the long-run growth rate. On the one hand, construction cycle fluctuations can harm the construction industry: they generate volatility not just in its output but also in firm profits and cash flows, which may delay future investment; initiators of real estate development and construction will be reluctant to commit cash or borrow funds to finance investment if there is substantial risk of a serious contraction in the construction industry; unemployed construction workers lose certain skills and their productivity declines - this obstructs their efforts to regain employment when recovery occurs, and may permanently diminish construction output.

On the other hand, recessions in the construction industry may have some beneficial effects on the construction growth rate. When the construction industry enjoys expansion and production means are used intensively, so that overtime is high, it is costly for construction firms to stop activity and reorganize their production process to improve efficiency. If construction firms are already at full capacity when they receive additional orders, these new orders cannot be met, so firms start increasing prices to choke off demand. However, during recessions construction workers have spare time and equipment is idle; this is a time for firms to restructure and increase productivity. Intense competition during recessions also provides construction firms with incentives to reorganize and to improve efficiency, so that growth in the construction industry can accelerate when the industry recovers.
4. Sinusoidal Oscillations

Spectral analysis is a modelling procedure using sinusoidal components, whose purpose is to determine how important cycles of different frequencies account for the behaviour of a time-series variable. To compute the phase spectrum and the squared coherency (Figure 3 and Figure 4), differenced logs, $Ln(x_{i,t})-Ln(x_{i,t-1})$, are used. The dashed lines represent the estimated two standard error bands, and the shaded areas represent so-called “business cycle frequencies” (8 to 32 quarters).

The phase spectrum, as a measure of the extent to which cycles in one series lead or lag behind cycles in the other, suggests that long-term fluctuations (frequency near zero) and short-term fluctuations (frequency near 0.5) for construction investment and the GDP are nearly in phase (Figure 3). The phase spectrum starts at zero and then decreases, indicating that construction tends to peak slightly before the GDP at intermediate frequencies. This is reasonable, because controlling factors in the construction industry are the availability of money and credit in the mortgage markets. When the aggregate economy is prosperous and costs are rising, investors can find more lucrative investments than banks and real estate loans. This decreases the availability of money for construction investment and causes a slump in the construction industry. During tight money markets, construction loans carry higher interest rates; builders pass the high costs on to buyers or accept a lower profit. Conversely, interest rates decline during a depression, so saving institutions attract more money with which to finance construction.

The squared coherency, as a measure of the degree to which two series are jointly influenced by cycles of a given frequency, is near 0.6 at low frequency, indicating a significant correlation between construction investment and the GDP in their long-run movements (Figure 4). The squared coherency in the figure becomes smaller at higher frequencies. The estimated phase spectrum can vary at high frequencies, as a result of this low correlation between construction investment and the GDP at high frequencies. High-frequency oscillations in construction investment tend not to be closely associated with short-run movements of the GDP. It takes
considerable time to obtain local authorities’ building approval, secure financing, and complete actual construction, and this lag time accounts for many radical swings in supply and demand.

5. Common Cycles

Cyclical dynamics are usually modelled as part of a time series model. In this section, the integrated time series are Baxter-King band-bass filtered [1], and the turning points of the deviation cycles are formally located using a Phase Average Trend (PAT) program [12]. The Baxter-King method is a finite moving-average approximation of an ideal band-pass filter, designed to pass through components of time series with fluctuations of between 6 and 32 quarters while removing higher and lower frequencies as “non-cyclical”. PAT is a multi-step, successive-approximation approach dictated by the objective of deriving estimates that reflect in a reasonable way the interplay of longer (trend) and shorter (cyclical) movements. The $x_{i,t}$ time series is decomposed additively into a nonstationary (trend) component $T_{i,t}$ and a stationary (cyclical) component $C_{i,t}$ in order to generate the underlying model $x_{i,t} = T_{i,t} + C_{i,t}$. The number of cycles is listed in Table 2, along with the duration of the corresponding above-trend and below-trend phases.

<table>
<thead>
<tr>
<th>Series</th>
<th>Number of cycles</th>
<th>Cycle</th>
<th>Expansion</th>
<th>Contraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
<td>Mean</td>
</tr>
<tr>
<td>Construction I</td>
<td>6</td>
<td>16.8</td>
<td>4.3</td>
<td>8.0</td>
</tr>
<tr>
<td>Residential CI</td>
<td>6</td>
<td>15.8</td>
<td>3.1</td>
<td>7.8</td>
</tr>
<tr>
<td>Private RCI</td>
<td>7</td>
<td>15.7</td>
<td>3.6</td>
<td>7.7</td>
</tr>
<tr>
<td>Public RCI</td>
<td>4</td>
<td>23.3</td>
<td>10.0</td>
<td>16.8</td>
</tr>
<tr>
<td>Non-RCI</td>
<td>8</td>
<td>16.5</td>
<td>3.4</td>
<td>8.4</td>
</tr>
<tr>
<td>GDP</td>
<td>8</td>
<td>15.6</td>
<td>3.8</td>
<td>8.8</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>17.7</td>
<td>2.8</td>
<td>8.3</td>
</tr>
</tbody>
</table>

The duration of construction cycles shows moderate differences, excluding public residential construction investments. The asymmetric cycle of public residential construction investment exhibits a long expansion period that might be attributed to government attempts to accommodate mass migration waves, but the evidence on this point is not verified. The contraction period, however, is much shorter, with a small standard deviation. The presence of such $sui generis$ cycles indicates that this specific construction sector can fluctuate without parallel movements in other construction sectors, or in the general output.

When distinguishing between cycle phases and erratic changes, the question arises whether the cyclical movements of various construction investments are synchronous, or out of phase, with the GDP, and with each other. The co-movement differs from one pair of series to another (Figure 5 and Figure 6). Shaded areas represent recessionary periods reported by Marom et al. [7]. Construction investment and the GDP do not seem to behave counter-cyclically throughout most of the analysis period (Figure 5), as opposed to the residential and non-residential.
construction investments, which do not seem to operate pro-cyclically during most of the analysis period with respect to each other (Figure 6). An expansion of residential construction investment may be accompanied by augmented retail and consumer service facilities and utility extensions, which appear in non-residential construction investment. Some of these investments may be simultaneous and others sequential. The often contrary cyclical fluctuations of the investment in different construction sub-sectors may neutralize each other, with the result that total construction investment moves relatively close to a trend line.

To elucidate the relationship between cycles, and determine whether two series co-move, we can associate them with binary random series that take the value one when the series are in expansion, and zero when they are in contraction. The concordance index $C_{xy}$ of the cycles of two-time series $x_t$ and $y_t$ is mathematically defined by Harding & Pagan [5] as the fraction of time when they are in the same state $S$ (phase):

$$C_{xy} = n^{-1} \left[ \sum_{t=1}^{n} \mathbb{1}(x_t = 1, y_t = 1) \right] + n^{-1} \left[ \sum_{t=1}^{n} \mathbb{1}(x_t = 0, y_t = 0) \right]$$

The concordance index statistic presented in (4.1) is bounded by construction to the range [0,1] and has the technical advantage that it is entirely non-parametric. If the series $x_t$ and $y_t$ were pro-cyclical, then the index $C_{xy}$ would be one, while a value of zero marks it down as being counter-cyclical.

In Israel, residential construction investment moves together with the GDP in its expansion and contraction phases ($C_{xy} = .67$, at 5% significance level) (Table 3). This evidence does not confirm the stylized fact of counter-cyclical behavior of residential construction investment.
Table 3: Concordance index statistics

<table>
<thead>
<tr>
<th>Series</th>
<th>Construction I</th>
<th>Residential CI</th>
<th>Private RCI</th>
<th>Public RCI</th>
<th>Non-RCI</th>
<th>GDP</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction I</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential CI</td>
<td>.83</td>
<td>.00</td>
<td>.69</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private RCI</td>
<td>.71</td>
<td>a</td>
<td>.69</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public RCI</td>
<td>.66</td>
<td>b</td>
<td>.72</td>
<td>.48</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-RCI</td>
<td>.66</td>
<td>b</td>
<td>.49</td>
<td>.55</td>
<td>.44</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>.64</td>
<td>c</td>
<td>.67</td>
<td>.65</td>
<td>.63</td>
<td>.56</td>
<td>1.00</td>
</tr>
<tr>
<td>C</td>
<td>.59</td>
<td></td>
<td>.54</td>
<td>.63</td>
<td>.44</td>
<td>.54</td>
<td>.72</td>
</tr>
</tbody>
</table>

Figures marked a, b and c are statistically significant at 1%, 5% and 10% significance levels, respectively. The critical values are computed for the test proposed by McDermott & Scott [5].

6. Common Trends

Two or more series may have trends and cycles in common. The difference between the two concepts is that common cycles are a short-run phenomenon concerned with co-movement between stationary series, while common trends (and cointegration) are concerned with long-run relationships between sets of non-stationary series. Cointegration refers to the existence of a stationary linear combination of two (or more) non-stationary series that share a stochastic trend.

Potential cointegration among different construction investment categories (in their natural logarithm form) is estimated using the Johansen rank (r) test (Table 4).

The null hypothesis of non-cointegration is rejected when the trace statistic is greater than the test’s critical value. The critical values of the Johansen test are for a non-restricted trace, at 1% and 5% significance levels, 19.69 and 15.34 respectively for \( r=0 \), and 6.64 and 3.84 respectively for \( r=1 \). The critical values for the restricted trace test, at 1% and 5% significance levels, are 24.74 and 19.99 respectively for \( r=0 \), and 12.73 and 9.13 respectively for \( r=1 \). Figures marked a and b are statistically significant at 1% and 5% levels of significance, respectively.

Table 4: Results of Johansen rank test for cointegration

<table>
<thead>
<tr>
<th>Series Ln( (x_{i,t}) )</th>
<th>Trace statistic</th>
<th>Intercept restriction test for ( r=1 )</th>
<th>Errors correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No restriction</td>
<td>Under restriction</td>
<td>Chi-square</td>
</tr>
<tr>
<td></td>
<td>( r=0 )</td>
<td>( r=1 )</td>
<td>( r=0 )</td>
</tr>
<tr>
<td>Residential I, Non-RCI</td>
<td>20.78</td>
<td>1.09</td>
<td>23.23</td>
</tr>
<tr>
<td>Private RCI, Non-RCI</td>
<td>25.46</td>
<td>.52</td>
<td>28.27</td>
</tr>
<tr>
<td>Public RCI, Non-RCI</td>
<td>14.73</td>
<td>1.05</td>
<td>16.93</td>
</tr>
<tr>
<td>Private RCI, Public RCI</td>
<td>22.48</td>
<td>10.79</td>
<td>24.79</td>
</tr>
</tbody>
</table>
While no cointegration relationship is observed between public and non-residential construction investment, the test statistics strongly support the presence of one cointegrational vector for private residential and non-residential construction investment. Whether or not the intercept restriction is imposed, the hypothesis of \( r=0 \) cointegrating vectors between private residential and non-residential construction investment is rejected. Johansen’s test indicates a single \( (r=1) \) cointegrating vector, and hence a single common trend. The null hypothesis, which the intercept restriction holds, is not rejected, using the chi-square test 1.65 with 1 degree of freedom.

If we normalize on non-residential construction investment series, the estimated cointegrating vector is \((1, -2.0207)\). The structural interpretation of the cointegration equation implies that the long-run relationship between the two series is:

\[
\text{Non-RCI}_t = 9.1592 + 2.0207 \cdot \text{Private RCI}_t + e_t.
\]

Thus, the coefficient on private residential construction investment indicates, as expected, a positive relationship between private residential and total non-residential construction investment over a long period of time; i.e., support for the hypothesis that private residential construction investment crowds in non-residential construction investment.

We can consider the non-residential construction investment as a deviation from the long-run equilibrium equation. To model the adjustment of present non-residential construction investment towards this long-run equilibrium with private residential construction investment, we can incorporate an error correction model \((ECM)\), which links short-run instability to long-run stability:

\[
\begin{pmatrix}
\Delta \text{Non-RCI}_t \\
\Delta \text{Private RCI}_t
\end{pmatrix} =
\begin{pmatrix}
0.101 \\
0.637
\end{pmatrix}
+ \begin{pmatrix}
0.013 & -0.25 \\
0.070 & -1.42
\end{pmatrix}
\begin{pmatrix}
\text{Non-RCI}_{t-1} \\
\text{Private RCI}_{t-1}
\end{pmatrix} + \begin{pmatrix}
-0.157 \\
0.192
\end{pmatrix}
\begin{pmatrix}
\text{Non-RCI}_{t-1} \\
\text{Private RCI}_{t-1}
\end{pmatrix} + \begin{pmatrix}
0.020 \\
0.025
\end{pmatrix}
\begin{pmatrix}
\Delta \text{Non-RCI}_{t-1} \\
\Delta \text{Private RCI}_{t-1}
\end{pmatrix}
\]

\[
+ \begin{pmatrix}
0.081 \\
-1.11
\end{pmatrix}
\begin{pmatrix}
\Delta \text{Non-RCI}_{t-2} \\
\Delta \text{Private RCI}_{t-2}
\end{pmatrix} + \begin{pmatrix}
\varepsilon_{\text{Non-RCI}_t} \\
\varepsilon_{\text{Private RCI}_t}
\end{pmatrix}. \tag{5.1}
\]

where \( \Delta \) is the difference operator \( (\Delta x_{t} = x_{t} - x_{t-1}) \) and the asymptotic standard errors are presented in parentheses under the estimated coefficients. The error correction model explains how quickly the series respond to deviation from the long-run relationship. We deduce from Equation (5.1) that the current changes in non-residential investment are explained by the intercept, the adjustment towards the long-run relation with private residential investment, and the past changes in non-residential investment and in private residential investment. The error variance matrix is:

\[
\Sigma = \frac{1}{1000} \begin{pmatrix}
4.19 & 2.12 \\
2.12 & 3.95
\end{pmatrix}
\]

indicating a correlation .5211 between the errors.
6.1 Causality Test Results

In order to formulate a policy of economic stability it might be interesting to determine, using the Granger-causality test, the impact of construction investment on the peaks and troughs of the business cycle. Granger-causality is an econometric representation of the timing of causation. A series \( x_{1,t} \) is said to be “Granger-causing” a series \( x_{2,t} \) when a prediction of \( x_{2,t} \) on the basis of its past history can be improved by further taking into account the previous period’s \( x_{1,t} \).

The results for the Granger-causality test of first differences of the natural logarithms of the series, \( \ln(x_{i,t}) – \ln(x_{i,t-1}) \), indicate a one-way causation process (Table 5).

<table>
<thead>
<tr>
<th>Causal series</th>
<th>GDP</th>
<th>Caused series</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Chi-Square</td>
<td></td>
</tr>
<tr>
<td>Construction I</td>
<td>8.69</td>
<td>.0032</td>
<td>Construction I</td>
</tr>
<tr>
<td>Residential CI</td>
<td>4.82</td>
<td>.0282</td>
<td>Residential CI</td>
</tr>
<tr>
<td>Non-RCI</td>
<td>6.93</td>
<td>.0085</td>
<td>Non-RCI</td>
</tr>
</tbody>
</table>

The two directions of causality are shown in this table: firstly where construction investment Granger-causes GDP (left-hand-side), and secondly where GDP Granger-causes construction investment (right-hand-side). The regression is run for the natural logarithm of the series by setting the order of lags=6, with 1 degree of freedom. From the \( p \)-values, we can reject the null hypothesis of Granger-noncausality from the construction investment to the GDP, using a 5% significance level. This result formalizes the stylized fact that construction investment cycles lead GDP cycles. On the other hand, from the \( p \)-values we fail to reject the null hypothesis of Granger-noncausality from the GDP to construction investment, using a 5% significance level.

Residential construction is the major component of the Israeli construction industry. Thus, it is not surprising that we can reject the null hypothesis that residential construction investment, like total construction investment, does not Granger-cause the GDP; and at the same time, we cannot reject the null hypothesis that the GDP does not Granger-cause residential construction investment. Finally, non-residential construction investment appears to Granger-cause the GDP, but the GDP does not seem to Granger-cause non-residential construction investment.

In conclusion, the series of construction investment and its residential and non-residential components seem to individually Granger-cause the GDP, but the GDP does not appear to Granger-cause them; this is a significant stylized fact. The statistical implications of this model structure is that future values of total, residential and non-residential construction investments, are influenced only by their own past, and not by the past of the GDP; whereas future values of the GDP are influenced by the past of both the GDP and construction investment and its components. These results are striking; but unfortunately, Granger-causality can never prove
causality with certainty, because there are several other factors that could affect the test results. The construction investment series may predict the GDP without necessarily causing the GDP.

7. Discussion

Evidence shows that the linear relationship between volatility and growth in construction investment is low, suggesting that high volatility does not essentially reduce the growth rate of construction investment. The implication of this finding to governments is that switching from the cyclical equilibrium to a corresponding acyclical one does not raise the long-run growth in construction investment. For construction businesses, this means that they need to reorganize their production and improve efficiency in recession periods, in order to be ready to accelerate when the construction industry recovers.

Interestingly, the public residential construction investment cycle appears very dissimilar compared to other construction investment cycles, in terms of long duration and lack of symmetry. Cyclical asymmetry is usually connected to high volatility, asymmetric shocks and asymmetric shock-transmition mechanisms. For construction firms focusing on public residential projects, this means that they should carefully consider the position of construction investment cycles in their analysis. In order to make better investment decisions and to forecast more accurately future returns, they should use cyclical rather than linear estimates.

The results also suggest that no cointegration relationship is observed between public residential and non-residential construction investment. For governments, this means that their policy of promoting residential construction investment may be not sufficiently accompanied by similar efforts in the domain of non-residential construction investment. For businesses focused on public residential construction, this means that although they develop the residential space itself, as well the immediate residential environment, this is not the case with regards to the infrastructure of the immediate neighborhood.

8. Conclusions

The cyclical fluctuations of construction investment in the Israeli economy are examined, using different time series methods. The empirical results show that construction grows through cycles of expansions and contractions that vary widely in amplitude and duration, but its fluctuations do not seem to follow a deterministic cyclical pattern with distinct phases of finite duration. High values of cycle volatility seem to represent a dominant feature of construction investment. The co-movement of construction investment and GDP cycles exhibits significant coherency at low frequencies. The concordance index shows that residential investment characteristically moves together with the GDP in its phases of expansion and contraction. The non-stationary series of private residential and non-residential construction investment are cointegrated, sharing a common stochastic trend. The results show that construction investment, as well as each of its components - residential and non-residential - seems to Granger-cause the GDP, but the GDP
does not appear to Granger-cause any of them. These findings are partially compatible with the results obtained by Green [4], who concludes in his experiment that residential construction investment appears to Granger-cause the GDP, but non-residential construction investment does not Granger-cause the GDP. However, the results are not in accordance with those obtained by Tse & Ganesan [11], who find that the GDP tends to lead construction flows.

This study contributes to theory by providing evidence on stylized facts, formulating additional stylized facts and exhibiting a cyclical fluctuation process of construction investment that is not in accordance with most other models. Furthermore, it contributes to a better understanding of the correlations of construction investment with other macroeconomic series.

These conclusions provide a basis for future work. The one-way Granger-causality found between construction investment and the GDP needs further research, for the purpose of developing a transfer function model on Israeli data to study whether the GDP’s response to a residential construction investment shock is greater than that of the response to a non-residential construction investment shock.

References


