Abstract
Several studies have shown a positive correlation between investment in machinery and equipment (M&E) and economic growth. For this reason, it is very important for policymakers to study the dynamics of investments and their expected evolution over time through forecast scenarios. The paper aims to present an error-correction model of investment in machinery and equipment at current price with a focus on the contribution of equipment leasing. The main empirical results of the model with equipment leasing as exogenous show that the variable explains 96% of the investment variability and, that as leasing grows by 1 percentage point, investment grows by 0.3%; the elasticity is reduced to 0.2 in the model with all the exogenous variables taken into account (the equipment leasing, the demand (sum of consumptions and exports), the long-term interest rate and the industrial production index).

JEL Classification: C1, C2, C51, E22, E31

Keywords: Equipment Leasing, Error-Correction Model, Investment in Machinery and Equipment, Unit Root and (co-)Integration Tests

1. Introduction and literature review
Starting from Smith and therefore at the very beginning of the industrial revolution, investment in physical capital has been regarded as fundamental to growth, being the savings the necessary condition for doing so.

Over the past years, economists as De Long and Summers (1991, 1992, 1993, 1994), De Long (1992), Iorwerth (2005) and Abdi (2008) have observed, in several countries, that there is a strong association between investment in machinery and equipment and economic growth. A different view is offered by Mankiw et al. (1992), according to whom economic growth can be well explained by the traditional Solow model, in which there is no particular role for investments in equipment, and no effect on long-run growth.

Levine and Renelt (1992) point out that the share of exports is positively correlated with the share of investment and, in turn, with cross-countries economic growth. On the other hand, Temple (1998) shows that investment in equipment has a weak correlation with the growth in OECD countries, but a stronger correlation in several developing countries. Madsen’s study (2001) on the causality relationship between investment and economic growth takes into account 18 OECD countries from 1950 to 1999 and brings as main result ‘that growth is predominantly caused by investment in machinery and equipment, whereas investment in non-residential buildings and structures is predominantly caused by economic growth, p.157’. In further studies on investment topic,
Madsen (2003) also shows that a high inflation level has a negative impact on investment activity. In fact, he points out that, historically, low inflation periods have been accompanied by more investment.

An important source of information for policy-makers is the biannual survey on investment in the manufacturing and mining sectors, which is carried out in Italy by ISAE. This survey involves a panel of firms, and finds that the current situation and expected evolution of demand are among the main factors that influence the decision on equipment investments. The study of Bontempi et al. (2007) on this topic show that, under uncertain demand conditions, there is a negative effect on firms’ investment plans. Hubbard (1998) as well as many other authors stress the fact that firms’ cash flow situation is another important factor that influences investment decisions. Moreover, results from the ISAE survey show that business investment generally aims to replace obsolete plants and enlarge production capacity.

The aim of this paper is to present an econometric model of investment in machinery and equipment with a focus on the role of coincident indicator and the added value in terms of explanatory power, in considering the equipment leasing as an exogenous variable. The article is organized as follows. Time series properties are discussed in the following section. Section 3 describes the proposed econometric models, while estimation results will be presented in Section 4. The findings are summarized in Section 5.

2. Time series properties: unit root and (co-)integration tests

The econometric models proposed in the next section are estimated using seasonally adjusted data. The time series are quarterly and take into consideration the period from the first quarter 1998 to the first quarter 2008. This amounts to a total of 41 quarterly observations. The country considered in this study is Italy. The data were obtained from Istat, Assilea and Eurostat-ECB and all computations are performed using E-views software and the R 2.7.1 environment together with the library ‘tseries’.

The variables considered are described below:

INV = Investment in Machinery and Equipment (excluded investment in transport) at current prices (€), source Istat;

D = Demand. It is defined as sum of exports of goods and services and national consumptions at current prices (€), source Istat;

IPI = Industrial Production Index, base (2000), source Istat;

LEAS = Equipment Leasing (machinery and equipment) at current prices (€), source Assilea;

IR = Long-Term Interest Rate - government bond yields, 10 years’ maturity (Italy), source Eurostat - European Central Bank;

Graphical analysis of time series on investment in machinery and equipment (Appendix, Figure A1) shows that during the last decade there has been a gradual decrease in the share of machinery and equipment on total fixed investment (from 42% in 1998 to 37% in the first quarter 2008). On the contrary, in the same period there has been
a gradual growth of equipment leasing share on total investment in machinery and equipment (from 7% to 10-11%; Appendix, Figure A1).

The leasing may be considered as a replacement or an addition to bank financing, and empirical studies have shown a positive association between the leasing adoption and the firm’s risk of bankruptcy (Krishnan and Moyer, 1994), and a greater use when firms are young and small (Sharpe and Nguyen, 1995). Drakos and Goulas (2008) in theirs article show that the country effect is a driving factor for leasing penetration and there are sector effects that exhibit differential propensities to lease capital.

In order to estimate the econometric model, a preliminary analysis has been carried out to test whether the time series are stationary or not, and to test the existence of (co-)integration relations. In economic literature several unit root tests have been proposed, and the most common one, that is the augmented Dickey-Fuller test (1979), will be used. A time series is integrated of order zero I(0) when it is stationary and rejects the null hypothesis of unit root; it is integrated of order one I(1) when becomes stationary in the first differences.

Table 1 Results of unit root and (co-)integration tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level</th>
<th>First Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With Constant and Trend</td>
<td>With Constant and Trend</td>
</tr>
<tr>
<td>INV</td>
<td>-1.134</td>
<td>-2.261</td>
</tr>
<tr>
<td>LEAS</td>
<td>-2.296</td>
<td>-3.385</td>
</tr>
<tr>
<td>IR</td>
<td>-1.663</td>
<td>-1.679</td>
</tr>
<tr>
<td>D</td>
<td>0.662</td>
<td>1.647</td>
</tr>
<tr>
<td>IPI</td>
<td>-2.022</td>
<td>-1.982</td>
</tr>
</tbody>
</table>

Notes: ADF is augmented Dickey-Fuller test (1979) estimated by OLS. The lag length in the models was chosen by the Schwarz (1978) Information Criterion. CADF represents the (co-)integration ADF (Engle and Granger, 1987) in the regression of the form \( \Delta \hat{\varepsilon} = \rho \Delta \hat{\varepsilon} + \xi \Delta \hat{\varepsilon} + v \), where \( \hat{\varepsilon} = y - \hat{\alpha} - \hat{\beta} x \). Critical value for the ADF test are given by MacKinnon (1996).

*, °, ^, indicate significance at the 1, 5, and 10% level.

Engle and Granger (1987) found that a linear combination of two or more non-stationary series may be stationary, and that a model in differences will be miss-specified if the variables involved are (co-)integrated. The results of the unit root tests are summarized in Table 1 (estimates in the different versions: with constant, with constant and trend) and show that the time series in levels are non-stationary, while they are stationary in the first difference.

The Engle and Granger (co-)integration test rejects the hypothesis of (co-)integration between investment and the long-term interest rate, and between investment and the industrial production index. On the contrary, the equipment leasing and the variable of demand are (co-)integrated with investment.
3. The econometric model

The existence of unit roots and of (co-)integration relations among the time series considered here, support the choice of an error-correction mechanism (ECM) approach to estimate the model of investment in machinery and equipment. The model is a combination of the long-run equilibrium and the short-run dynamics. Ordinary Least Squares (OLS) is the method used for estimation.

The (co-)integration relation with \( k \) variables is defined as:

\[
y_t = \beta' x_t + \xi_t
\]

where \( x_t \) is a matrix of dimension \( T \times k \) with \( k \) variables I(1) given by \( x_t = x_{t-1} + \varepsilon_t \) (processes random walk), \( \beta \) is the vector of (co-)integration coefficients and \( \xi_t \) is the error-term. The assumptions are:

1) \( \xi_t \approx N(0, \sigma^2) \);
2) the \( x_t \) must not be (co-)integrated among them;
3) \( \xi_t \) and \( \varepsilon_t \) are independent of each other;

The variables of relation (1) are (co-)integrated if the error-term is I(0). Otherwise, it is a spurious regression (Yule, 1926; Granger and Newbold, 1974; Phillips, 1986). To this end, residuals have to be tested and this can be achieved using the (co-)integration ADF test (Engle and Granger, 1987). In this paper, the equation (1) is specified as follows:

\[
\ln(INV_t) = \alpha + \beta_1 \ln(LEAS_t) + \beta_2 \ln(D_t) + \xi_t
\]

where \( \ln \) is the natural logarithm, \( \alpha \) is the intercept and \( \beta_1 \) and \( \beta_2 \) are the long-run parameters of equipment leasing and of demand, respectively. The error-term \( \xi_t \) can be estimated as:

\[
\hat{\xi}_t = \ln(INV_t) - (\hat{\alpha} + \hat{\beta}_1 \ln(LEAS_t) + \hat{\beta}_2 \ln(D_t))
\]

The assumptions of (co-)integration relation (1) and the results of unit roots test described in section 2 are much important to support the equation that will be defined in the next step.

The model of investment in machinery and equipment with error-correction mechanism can be specified in the following way:

\[
\Delta \ln(INV_t) = \gamma \Delta \ln(LEAS_t) + \omega \Delta(IPI_t) + \zeta \Delta \ln(D_{t-1}) + \pi \Delta(IR_{t-1}) + \rho \hat{\xi}_{t-1} + \upsilon_t
\]

where \( \Delta \) denotes the first difference operator (i.e., \( \Delta x_t = x_t - x_{t-1} \)), \( \ln \) is the natural logarithm, \( \gamma, \omega, \zeta, \pi \) are the short-run parameters of equipment leasing, industrial production index, demand and long-term interest rate respectively, \( \rho \) is the parameter of error-correction term, and the \( \upsilon_t \) are assumed to be i.i.d. \((0, \Sigma)\). The expectations about the signs of the estimated parameters are \( \gamma, \omega, \zeta > 0; \pi \) and \( \rho < 0 \). The error-correction
model has two main features: the properties of long-run are included in the error-term \( \xi_{t-1} \), while the properties of short-run are partially captured by the parameter of error-correction \( \rho \).

Model (4) proposes a way to analyze the impact of some economic variables on the investment in machinery and equipment. However, the present article aims as well to investigate the contribution made by the variable of equipment leasing in explaining the dynamics of investment in machinery and equipment.

A new error-correction model is estimated:

\[
\Delta \ln(INV_t) = \gamma \Delta \ln(LEAS_t) + \rho \hat{\xi}_{t-1} + \nu_t
\]

where \( \gamma \) is the short-run parameter of equipment leasing, \( \rho \) is the parameter of error-correction and \( \hat{\xi} \) the error-term of the long-run model estimated and defined as:

\[
\hat{\xi}_t = \ln(INV_t) - (\hat{\alpha} + \hat{\beta} \ln(LEAS_t))
\]

The limitation when considering the equipment leasing is that this time series is available only at current prices. The inflation is analysed and measured by deflator of investment in machinery and equipment and it is estimated by an ARMA (2,2) model.

4. Empirical results

Empirical results from model (4) are shown in Table 2. Tests on individual OLS residuals suggest that the model is well specified and do not indicate the presence of heteroskedasticity and autocorrelation. The Chow test does not show significant differences in the estimates of equations before and after the most important negative corrections observed in history on investment growth.

The elasticity analysis of the model (4) shows that as equipment leasing increase by 1 percentage point, investment in machinery and equipment increases by 0.2%. The parameter is positive and statistically significant. The index of industrial production whose variable describes the change in the physical volume of industry production, has a positive and significant impact on growth in investment in machinery and equipment. Several studies suggested that the industrial confidence index is a good leading indicator of the dynamics of industrial production (Bodo and Signorini, 1987; Bianchi et al., 2007). Therefore, it can be assumed that an increase of the industry confidence indicator, allows us to expect a higher level of production and, consequently, higher investment.
Table 2 Summary of estimation results of error-correction model (4)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t-statistics</th>
<th>Pr &gt;</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma \Delta(\ln \text{LEAS}_t) )</td>
<td>0.217423</td>
<td>0.0516</td>
<td>4.22</td>
<td>0.0002</td>
<td></td>
</tr>
<tr>
<td>( \omega \Delta(\text{IPI}_t) )</td>
<td>0.00824</td>
<td>0.00221</td>
<td>3.73</td>
<td>0.0007</td>
<td></td>
</tr>
<tr>
<td>( \zeta \Delta(\ln \text{D}_{t-1}) )</td>
<td>0.540781</td>
<td>0.1629</td>
<td>3.32</td>
<td>0.0023</td>
<td></td>
</tr>
<tr>
<td>( \pi \Delta(\text{IR}_{t-1}) )</td>
<td>-0.0155</td>
<td>0.00823</td>
<td>-1.88</td>
<td>0.0688</td>
<td></td>
</tr>
<tr>
<td>( \rho (\hat{\zeta}_{t-1}) )</td>
<td>-0.61427</td>
<td>0.1296</td>
<td>-4.74</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

R² | 0.98 |
Root MSE | 0.01 |
DW | 2.09 |
MAPE (%) | 0.93 |

Heteroscedasticity Test

<table>
<thead>
<tr>
<th>Test</th>
<th>Statistic</th>
<th>DF</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>White’s Test</td>
<td>26.16</td>
<td>20</td>
<td>0.1607</td>
</tr>
</tbody>
</table>

Structural Change Test

<table>
<thead>
<tr>
<th>Test</th>
<th>Break Point</th>
<th>Num DF</th>
<th>Den DF</th>
<th>Value F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chow</td>
<td>2001Q4</td>
<td>5</td>
<td>27</td>
<td>0.57</td>
<td>0.7255</td>
</tr>
<tr>
<td>Chow</td>
<td>2003Q1</td>
<td>5</td>
<td>27</td>
<td>1.05</td>
<td>0.4083</td>
</tr>
</tbody>
</table>

Notes: White’s Test (White, 1980); Chow Test is used to test for break point or structural changes in a model (Davidson and MacKinnon, 1993); Model estimated by OLS method.

The coefficient that represent the sum of consumptions and exports (\( \hat{\zeta}_{t-1} \)) shows that this variable plays an important role in explaining the expected growth of the investment in machinery and equipment. It has a positive sign and an elasticity equal to about 0.5. Instead, a growth of long-term interest rate has a negative impact on investment in machinery and equipment as it means a higher cost for firms in the request for funding (see also the articles of Gehrels and Wiggins, 1957; Krainer, 1966). The coefficient of the error-correction term \( \rho \) can be interpreted as an indicator of the adjustment speed in the disequilibrium and it is equal to -0.6.

Results for model (5) are presented in Table 3. According to this analysis, the variable of equipment leasing alone explains 96% of the investment variability in machinery and equipment. The elasticity of the parameter \( \hat{\gamma} \) indicates that as equipment leasing increase by 1 percentage point, investment grows by 0.3%. On the contrary, we expect a negative growth of investment in machinery and equipment. The result leads to the belief that equipment leasing growth over time is very important in order to support investment in machinery and equipment. This aspect is relevant because, as noticed in previous studies, a growth in investment in machinery and equipment has a positive impact on economic growth.
Table 3  Summary of estimation results of error-correction model (5)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t-statistics</th>
<th>Pr &gt;</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma \Delta(\ln \text{LEAS}_t)$</td>
<td>0.272741</td>
<td>0.0555</td>
<td>4.92</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>$\rho (\hat{\xi}_{t-1})$</td>
<td>-0.19885</td>
<td>0.0914</td>
<td>-2.18</td>
<td>0.0361</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root MSE</td>
<td></td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DW</td>
<td></td>
<td>1.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAPE (%)</td>
<td></td>
<td>2.11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: model estimated by OLS method.

Further tests on the parameter of equipment leasing in models (4) and (5) found that the variable is not significant at one or more $k$ lags (where $k = 1,...,4$).

Based on the results obtained for the estimated models, it can be suggested that this variable can be considered a good coincident indicator of the dynamics of investment in machinery and equipment.

Compared to the delay in the official data publication of the main quarterly macroeconomic variables in Italy, usually between 50 and 70 days, the information about equipment leasing of Assilea source is available after 15-20 days from any monthly closing. This may allow us to make a first flash estimate of investment in machinery and equipment, and hence to come up with some preliminary considerations regarding the just-ended quarter, before the publication of national account data.

5. Conclusions

This article shows that equipment leasing and demand (sum of consumptions and exports) are (co-)integrated with investment in machinery and equipment. The classic Engle and Granger (1987) test was employed.

An error-correction model has been proposed for estimating investment in machinery and equipment, which takes into account new economic relations with respect to traditional models on this topic. In particular, results from model (5) show the significant contribution of equipment leasing in explaining the dynamics of investment. This variable can be considered a good coincident indicator of investment in machinery and equipment, and hence may provide flash estimates on the just-ended quarter, some months in advance compared to the publication of the official data.
References


Appendix

**Figure A1** Trend of the investment in machinery and equipment

![Graph showing the trend of investment in machinery and equipment](image)

Notes: Sources Istat and Assilea. Time series at current prices and seasonally adjusted.

**Table A1** Summary of estimation results of long-run model (2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t-statistics</th>
<th>Pr &gt;</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.925779</td>
<td>0.5296</td>
<td>9.30</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>$\beta_1 (\ln LEAS_t)$</td>
<td>0.19762</td>
<td>0.0312</td>
<td>6.33</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>$\beta_2 (\ln D_t)$</td>
<td>0.470345</td>
<td>0.0456</td>
<td>10.31</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.9708</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DW</td>
<td>1.0873</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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