Kaleckian vs. Marxian specifications of the investment function: Some empirical evidence for the US

Schoder, Christian

The New School for Social Research

2011

Kaleckian vs. Marxian Specifications of the Investment Function: Some Empirical Evidence for the US

Christian Schoder*
The New School for Social Research

March 13, 2011

Abstract

Following Lavoie et al. (2004), this paper empirically assesses four investment functions closing the Kaleckian baseline model in the long-run: (a) the *Naive-Kaleckian* specification without any long-run adjustment; (b) the *Intermediate-Kaleckian* specification with an endogenous adjustment of the normal utilization rate; (c) the *Hysteresis-Kaleckian* specification with an additional endogenous adjustment of autonomous investment; and (d) the *French-Marxian* specification with an exogenous normal utilization rate and endogenous autonomous investment. Confronting these specifications with data of the US manufacturing sector, we compare them with respect to the plausibility of the parameter estimates, the goodness of fit, the parameter stability, the out-of-sample performances and relative encompassing. We find the Intermediate-Kaleckian specification to be superior. For the Hysteresis-Kaleckian specification, we get implausible results which contradict Lavoie et al. (2004). Yet, their estimates seem to be biased due to endogeneity issues.

Keywords: Kaleckian growth model, Marxian growth model, investment functions, post-Keynesian economics
JEL Classification: E11, E12, E22

*Address: Department of Economics, The New School for Social Research, 6 East 16th Street, New York, NY 10003. Email: schoc152@newschool.edu.

1 Introduction

Various methodological, epistemological and theoretical discrepancies among heterodox schools of thought offer pluralism, but impede the emergence of a common research program (cf. Harvey and Garnett 2008). Hence, there have been several endeavors aimed at integrating, in particular, Marxian and post-Keynesian approaches trying to find principles shared and to overcome disparities identified.

Regarding short-run analysis, a broad consensus has been achieved. Both strands agree on the importance of effective demand for determining output and employment. Investment is perceived as an independent decision of the firms. Given the propensities to save of different income groups and given the distribution of income, variations in output – the rate of capacity utilization – adjust aggregate savings to aggregate investment in the goods market equilibrium.

Regarding the long-run behavior of the economy, major discrepancies between Kaleckians and Marxians still remain. The main disagreement centers around the question whether there exist long-run tendencies that are independent of short-run dynamics and push the economy towards a particular equilibrium position which is independent of aggregate demand. To be specific, while Marxians believe in pressures moving the short-run equilibrium rates of accumulation, profit and capacity utilization towards their respective 'normal' supply-side determined positions and the real wage towards a conventional level in the long run, post-Keynesians argue that "the long-term trend is but a slowly changing component of a chain of short-period situations" Kalecki (1971, p. 165). Hence, for them, there are essentially no mechanism driving the economy in the long run other than those operating in the short run. This discrepancy has vast consequences for their respective long-run analysis. While both strands agree on the importance of effective demand, independent investment and the paradox of thrift, thus rejecting 'Say's Law' in the short-run, Marxians object to the significance of effective demand and approve the validity of Say's Law in the long run. For them, investment is determined and constraint by available savings in the long run, a view post-Keynesians peremptorily reject.

This debate on the question of "being Keynesian in the short-run and classical in the long run" (Duménil and Lévy 1999) induced most Kaleckian inspired post-Keynesians to accept the view that the rate of capacity utilization, which is the variable equalizing aggregate demand and aggregate supply in the short-run, in some way has to be equal to a normal rate of capacity utilization in the steady state.[1] Two different mechanism of how this adjustment may work will be dealt with in this paper.

In the Marxian long-run closure, the short-run utilization rate is argued to adjust to an exogenously given normal rate by an alignment of autonomous investment in the long run. Distribution is seen to be exogenous with the real wage at the conventional level. Hence, the profit rate is also at its normal level. Aggregate demand does not play a role in the long run (cf. Duménil and Lévy 1999).

In the Kaleckian closure the normal rate is endogenous and adjusts to the average of short-run utilization rates. This view is justified by taking into account hysteresis-effects. Hence, aggregate demand is still important in the long run (cf. Lavoie 1996 and Dutt 1997, 2009).

Lavoie et al. (2004) assessed Marxian and post-Keynesian views on the long-run behavior of the economy on the grounds of different investment functions. Starting from a common short-run Kaleckian type of model, they close the long-run model in four different ways by assuming specific investment functions. The first investment function is simply the extension of the short run to the long run, not requiring any long-run adjustment of investment (*Naive-Kaleckian* closure). The second investment function considered by Lavoie et al. (2004) corresponds to the Kaleckian closure. Both, the expected growth rate of sales and the normal rate of capacity utilization adjust endogenously (*Hysteresis-Kaleckian* closure). The third and the second specifications of investment are consistent with the Marxian closure, since investment adjusts until the rate of utilization meets the normal rate (*French Marxian* and *American Marxian* closures). Using annual Canadian data on capital accumulation rates and capacity utilization from 1960 to 2000, the four investment functions are estimated for three different sectors and ranked according to information and encompassing tests. They conclude that the *Hysteresis-Kaleckian* specification outperforms all the other investment functions.

However, one can cast doubt on the validity of these conclusions, as the Hysteresis-Kaleckian specification used for estimation gives rise to serious endogeneity problems. Hence, the coefficients are likely to be biased.

This paper applies the basic procedure outlined by Lavoie et al. (2004)

[1] For a survey of the debate from a Kaleckian perspective, see Hein et al. (2011a,b) and Lavoie et al. (2004).

on the US manufacturing sector. We employ data on capital accumulation and capacity utilization for two time horizons: annually from 1949 to 2008 and quarterly from 1958:1 to 2008:4. Following Lavoie et al. (2004), we estimate the *French-Marxian* (FM), the *Naive-Kaleckian* (NK) and the *Hysteresis-Kaleckian* (HK) investment functions. Moreover, we introduce the *Intermediate-Kaleckian* (IK) specification of investment which features the endogenous adjustment of the normal rate of capacity utilization, but not of the expected growth rate of sales. By performing various statistical tests, in particular information and encompassing tests, and by assessing the out-of-sample forecasting performance the better specification shall be identified. The paper seeks to contribute to the ongoing debate by two innovations: First, we apply the estimations to the US. Second, apart from annual data we also use quarterly data which multiplies available observations.

The paper is structured as follows: Section 2 sketches the basic short-run model and discusses different long-run closures. The respective investment functions will be derived. Section 3 discusses some issues related to the data used and presents some preliminary econometric considerations. Section 4 presents our estimation results. Section 5 concludes the paper.

2 A Kaleckian short-run model and some long-run closures

Basically, there is a consensus among post-Keynesian and Marxian economists on the behavior of the economy in the short run. Both agree on the principle of effective demand stating that investment demand which, *ex ante*, is independent of savings drives aggregate demand which determines output and employment. Since firms have spare capacities, short-run adjustment of savings takes place via variations in the rate of capacity utilization with income distribution being given. Say's Law is not valid, the economy is demand-determined. The paradox of thrift holds, meaning that an increase in the propensity to save reduces demand, income and, thus, savings.

The following model represents this view on the short-run dynamics. For simplicity we consider a closed economy without government activity and we assume that income distribution does not affect the investment behavior of firms. There is only one homogeneous good produced which is used for both consumption and investment. The economy comprises two classes: capitalists who own the means of production and hire labor-power and workers who sell their labor-power and receive a nominal wage which they use for consumption entirely. In the short-run, our economy is represented by the following set of equations:

$$g^i = \alpha + \beta(u - u_n) \tag{1}$$

$$g^s = sr \tag{2}$$

$$g^i = g^s \tag{3}$$

$$r = \frac{hu}{a_1} \tag{4}$$

$$h = \bar{h} \tag{5}$$

Equation (1) is the investment function.[2] The accumulation rate (g^i) is determined by the secular accumulation rate (α) which may be interpreted as the expected growth rate of sales and the difference between the rate of capacity utilization (u) and the normal rate of capacity utilization (u_n). (2) tells us that savings normalized by the capital stock (g^s) is equal to the capitalists propensity to save out of profits (s) and the profit rate (r). (3) is the equilibrium condition stating that aggregate demand equals aggregate supply. (4) illustrates a common decomposition of the profit rate into the profit share (h) times the rate of capacity utilization (u) over the capital-capacity ratio (a_1). (5) states that the profit share (h) is exogenous.

The short-run equilibrium position of u is

$$u^* = \frac{\alpha}{s\frac{h}{a_1} - \beta} \tag{6}$$

which is, in general, different from the normal rate of capacity utilization (u_n) in the short run as there has not been any adjustment yet. The short-run equilibrium of the accumulation rate is given by

$$g^* = s\frac{h}{a_1}\frac{\alpha}{s\frac{h}{a_1} - \beta}$$

[2] In the Kaleckian literature, other investment functions are also common which include either the profit share or the the profit rate. However, since we are not interested in the question of wage- vs. profit-led growth, we use a simple specification of investment, even if it implies a wage-led economy.

Keynesian stability requires that savings respond more sensitive to changes in utilization than investment, i.e. $s\frac{h}{a_1} > \beta$.

In the long run, the equilibrium rate of capacity utilization has to be equal to the normal rate, i.e.

$$u^* = u_n$$

At this normal rate, there is a unique normal rate of profit, given distribution and technology.

In the literature, there is considerable disagreement between Marxian and post-Keynesian economists on the question of how the actual utilization rate ends up to be equal to the normal utilization rate. Two types of long-run closures are common in the literature specifying how actual and normal utilization may align to each other. In the following, we want to discuss them and derive corresponding investment functions which our estimations will be based on.

2.1 The French-Marxian long-run closure

In this closure, the investment function is argued to adjust in order to align the actual utilization rate to the normal rate while distribution and the saving rate stay unchanged. In terms of our investment function in (1), this means that a deviation of utilization from the normal level puts pressure on the independent part of investment which is α.

$$\frac{d\alpha}{dt} = \lambda(u - u_n), \quad \lambda < 0 \tag{7}$$

As long as the short-run utilization rate is above (below) its normal level, firms will be induced to decrease (increase) investment. Behavioral stories justifying this long-run mechanism are provided by Duménil and Lévy (1995, 1999); Skott (2008); Skott and Ryoo (2008); Shaikh (2007). Substituting (7) into (1) and taking total derivatives yields the *French-Marxian* (FM) investment function for the long run,

$$\frac{dg}{dt} = \lambda(u - u_n) + \beta\frac{du}{dt} \tag{8}$$

2.2 The Kaleckian long-run closure

In this closure, the actual rate of capacity utilization influences the normal rate. Thus,

$$\frac{du_n}{dt} = \phi(u^* - u_n), \quad \phi > 0 \tag{9}$$

which gives rise to another long-run investment function. Differentiating (1) with respect to time and substituting (9) into (1) yields the *Intermediate-Kaleckian* (IK) specification of investment, i.e.

$$\frac{dg}{dt} = \beta\phi(u - u_n) + \beta\frac{du}{dt}. \tag{10}$$

Furthermore, one can argue that the expected secular growth rate of sales (α) could be influenced by the actual accumulation rate (g^*). Thus,

$$\frac{d\alpha}{dt} = \mu(g^* - \alpha), \quad \mu > 0 \tag{11}$$

Behavioral stories for this mechanism are told by Lavoie (1996); Dutt (1997). Taking total derivatives of (1) and substituting (9) and (11) into (1) yields the *Hysteresis-Kaleckian* (HK) investment function for the long run,

$$\frac{dg}{dt} = \mu(g - \alpha) + \beta\phi(u - u_n) + \beta\frac{du}{dt}. \tag{12}$$

For the sake of completeness, the long-run variant of the *Naive-Kaleckian* (NK) specification which does not require any long-run adjustment is given by

$$\frac{dg}{dt} = \beta\frac{du}{dt}. \tag{13}$$

3 Data

For estimating the NK, IK, HK and FM investment functions, we use US data on the manufacturing sector's accumulation and utilization rates for two different time frequencies: annual and quarterly.

The annual data cover the period from 1949 to 2008. Annual data on the rate of capacity utilization have been derived by taking annual averages of the quarterly time series of seasonally adjusted utilization rates provided by the FED in its release on 'Industrial Production and Capacity Utilization - G.17'. For the accumulation rate annual growth rates of the deflated nominal net stock of fixed capital were used which are provided by the US Bureau of Economic Analysis (BEA) in the 'Fixed Assets Accounts Tables'.

Obtaining the quarterly data ranging from 1958:1 to 2008:4 was more challenging. While data on capacity utilization is provided by the FED on a quarterly basis, capital stock data for the manufacturing sector are available only on an annual basis. Hence, we employed the Chow and Lin (1971) procedure to compute the quarterly data on capital accumulation out of annual data. To be specific, we used quarterly data on nominal gross investment in structures of the manufacturing sector (provided by the BEA) to interpolate the missing values of the annual series on nominal gross fixed investment of the manufacturing sector which has been obtained by taking first differences from the corresponding series on the nominal gross capital stock of manufacturing (provided by the BEA). The resulting quarterly series on nominal gross fixed investment has been deflated using the quarterly price index for private fixed investment. Then, it has been used to construct the quarterly data on gross capital stock and, eventually, the quarterly data on the rate of real gross accumulation in the manufacturing sector.

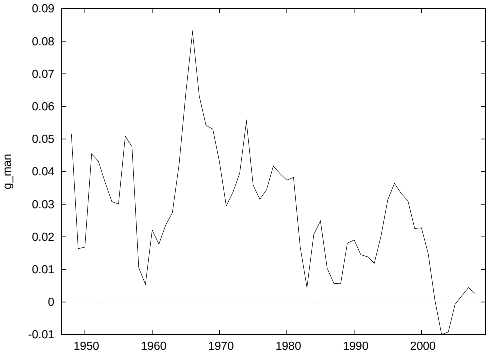
Figure 1 plots the data used in the regressions: (a) annual rates of real net capital accumulation, (b) annual rates of capacity utilization, (c) quarterly rates of real gross capital accumulation and (d) quarterly rates of capacity utilization.

4 Econometric Analysis

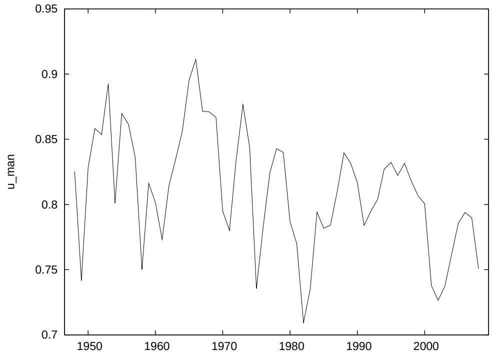
In order to make our theoretical investment functions estimable and in order to avoid endogeneity problems, a few transformations are in order.

First, regarding the lag structure, we lag the explanatory variables by one.[3] We do not include current values of the regressors in order to avoid endogeneity problems which might arise otherwise since there may be a feedback

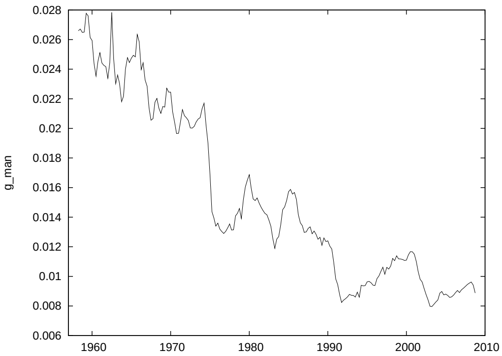
[3]Since investment expenditures can reasonably be expected to be lagged it would also make sense to include also higher order lags of the exogenous variables. Unfortunately, this would give rise to collinearity issues in the FM specification. Since we are interested in the comparison of the investment functions considered, we also abstain from including more lags in the other specifications.



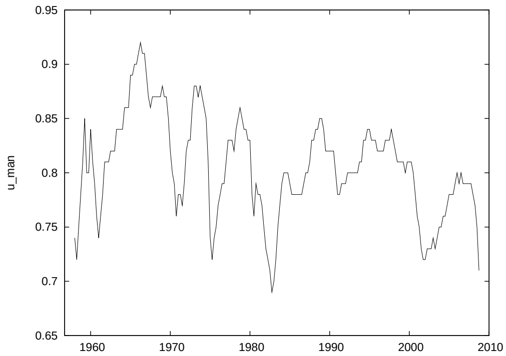
(a)



(b)



(c)



(d)

Figure 1: The annual rate of accumulation (a), the annual rate of capacity utilizations (b), the quarterly rate of accumulation (c) and the quarterly rate of capacity utilization (d)

from investment to capacity utilization. This implies for the French-Marxian specification that the adjustment of the secular accumulation rate is lagged, i.e.

$$\Delta\alpha_t = \lambda(u_{t-1} - u_n) \tag{14}$$

with $\Delta\alpha_t$ denoting the change of α from period $t-1$ to period t. Note that u_n is time invariant in this specification. Equivalently, we assume for the Intermediate-Marxian and Hysteresis-Kaleckian closures that the normal utilization rate depends only on the divergence between actual and normal utilization of the previous period. Thus,

$$\Delta u_{n,t} = \phi(u_{t-1} - u_{n,t-1}). \tag{15}$$

For the Hysteresis-Kaleckian specification we further assume that

$$\Delta\alpha_t = \mu(g_{t-1} - \alpha_{t-1}). \tag{16}$$

Second, as in the Marxian specification the normal rate of capacity utilization is exogenous, we define this variable as the sample average of the utilization rate in this specification. Since the normal utilization rate is endogenous in the Kaleckian specification, we apply an HP-filter proposed by Hodrick and Prescott (1980) to the utilization rate and define the normal rate as the trend component.[4] All of this is consistent with Lavoie et al. (2004).

Third, we include a constant to all regressions.

Applying this considerations to the econometric versions of (13), (10), (12) and (8) yields the econometric specifications of the Naive-Kaleckian, the Intermediate-Kaleckian, the Hysteresis-Kaleckian and the French-Marxian investment functions, respectively:

$$\Delta g_t = c + \beta\Delta u_{t-1} + \varepsilon_t \tag{17}$$

$$\Delta g_t = c + \beta\phi(u_{t-1} - u_{trend,t-1}) + \beta\Delta u_{t-1} + \varepsilon_t \tag{18}$$

$$\Delta g_t = c + \mu(g_{t-1} - g_{trend,t-1}) + \beta\phi(u_{t-1} - u_{trend,t-1}) + \beta\Delta u_{t-1} + \varepsilon_t \tag{19}$$

$$\Delta g_t = c + \lambda(u_{t-1} - \bar(u)) + \beta\Delta u_{t-1} + \varepsilon_t \tag{20}$$

These equations shall be estimated using the data on US manufacturing sector, as discussed above. As the Augmented Dickey Fuller tests have shown, none of the variables entering the regressions suffer under unit-roots. This comes to no surprise, as the time series considered are either used in first differences or as deviations from their trend.

5 Assessment

Following Lavoie et al. (2004), the assessment which specification is to be preferred econometrically consists of five steps. In a first step, we want to interpret the estimation results and draw conclusions on the question of the best specification from their respective meaningfulness. In a second step, we analyze the quality of estimation by performing standard diagnostic tests

[4] $\lambda = 100$ for annual data and $\lambda = 1600$ for quarterly data.

such as tests for autocorrelation, normality of residuals, misspecification, heteroscedasticity and instability of coefficients. In a third step, we rank the four specifications by comparing the residual sum of squares and applying different information criteria, such as the Akaike Information Criteria (AIC) and the Schwartz Information Criteria (SIC) and the Hannan-Quinn information criteria. In the fourth step, we assess the out-of-sample prediction performance of the models considered. As a fifth and last step, we want to apply some encompassing tests suggested by Davidson and MacKinnon (1981).

The analysis is presented in tables 1 to 5.[5] All in all, the difficulty of determining the investment behavior of firms is confirmed by our results. The overall performances of all specifications are inferior as indicated by the information criteria and the diagnostic tests. Most strikingly, the estimates based on annual data are more sensible than those derived from quarterly data. This may have two reasons: The interpolation based on the procedure developed by Chow and Lin (1971) required for computing quarterly capital stock data is too much a distortion. On the other hand, neglecting lags of higher order than one disregards important information contained in those lags.

Regarding the meaningfulness of the estimates of the model parameters, table 1 reports the point estimates for both the annual and the quarterly data. All the coefficients derived from annual data make sense and have the expected sign except from the Hysteresis-Kaleckian specification which, at first sight, is surprising as it contradicts the results obtained by Lavoie et al. (2004). Let us consider this striking result in more detail.

The coefficients of the HK function indicate an acceleration of accumulation if the short-run utilization rate is above its normal level. This contradicts the hypothesis that the normal rate of utilization increases with the gap between actual and normal utilization and reduces the rate of accumulation.

Moreover, the gap between accumulation and the expected rate of sales which is indicated by the trend element of the accumulation rate seems to have a negative impact on the rate of accumulation. This contradicts the hypothesis that the expected rate of sales increases as accumulation accelerates and further increases the rate of accumulation.

While this result is surprising from the perspective of economic theory, it is not surprising that Lavoie et al. (2004) obtain *reasonable* coefficients for the

[5]Details on the regression outputs of the four specifications estimated as well as econometric standard tests are reported in the appendix.

Table 1: Estimation results

	NK	IK	HK	FM
Annual data				
Observations	59	59	59	59
Dependent variable	Δg_t	Δg_t	Δg_t	Δg_t
c	-0.00 (-0.31)	-0.00 (-0.08)	-0.00 (-0.45)	-0.00 (-0.08)
$u_{t-1} - \bar{u}$	—	—	—	-0.04 (-1.29)
$u_{t-1} - u_{trend,t-1}$	—	-0.12 (-2.77)	0.13 (1.93)	—
$g_{t-1} - g_{trend,t-1}$	—	—	-0.77 (-4.70)	—
Δu_{t-1}	0.17 (5.38)	0.22 (6.00)	0.08 (1.96)	0.18 (5.17)
R^2	0.341	0.397	0.570	0.334
Adj. R^2	0.329	0.375	0.546	0.310
F-test	28.98	18.43	24.29	14.04
P-value(F)	0.00	0.00	0.00	0.00
Quarterly data				
Observations	202	202	202	202
Dependent variable	Δg_t	Δg_t	Δg_t	Δg_t
c	-0.00 (-1.16)	-0.00 (-1.22)	-0.00 (-1.36)	-0.00 (-1.21)
$u_{t-1} - \bar{u}$	—	—	—	0.00 (2.24)
$u_{t-1} - u_{trend,t-1}$	—	0.01 (3.15)	0.01 (5.91)	—
$g_{t-1} - g_{trend,t-1}$	—	—	-0.27 (-6.16)	—
Δu_{t-1}	0.02 (3.97)	0.01 (2.77)	0.00 (0.40)	0.01 (3.59)
R^2	0.073	0.107	0.251	0.096
Adj. R^2	0.069	0.098	0.239	0.087
F-test	15.79	11.98	22.10	10.56
P-value(F)	0.00	0.00	0.00	0.00

Notes: t-statistics in parenthesis.

HK specification. Their regression suffers under severe endogeneity problems which are quite likely the reason for the reversed signs. To be specific, they use the current value of the sales–expected sales gap, i.e. $g_t - g_{trend,t}$. Since the dependent variable is the change in the accumulation rate, the positive sign is not surprising. Indeed, using the current value of the sales–expected sales gap would also make the HK specification superior in our analysis.

The regressions based on quarterly data are, in general, worse than those based on annual data. The R^2 are lower, the coefficients less significant and have the wrong sign in more instances. Since the HK specification does not provide plausible results in neither of the time frequencies considered, it is an early drop-out from the race for the best investment specification. However, we report the information criteria and diagnostic tests for the sake of completeness.

Apart from the HK specification which features implausible estimates and is thus out of the game, the R^2 are highest for the IK function followed by the FM and the NK functions. According to the Akaike (AIC), Schwartz (SIC) and Hannan-Quinn (HQ) information criteria, which are reported in table 2,

Table 2: Information criteria

	NK	IK	HK	FM
Annual data				
AIC	-373.01	-383.75	-401.69	-377.89
SIC	-368.89	-377.52	-393.38	-371.66
HQ	-371.40	-381.32	-398.45	-375.45
Quarterly data				
AIC	-2285.26	-2290.88	-2324.24	-2288.29
SIC	-2278.64	-2280.95	-2311.01	-2278.36
HQ	-2282.58	-2286.86	-2318.89	-2284.27

the IK function is ranked first followed by the FM and the NK model.

The diagnostic tests are reported in table 3. As indicated by the White and the Breusch-Pagan tests, heteroscedasticity is not a problem in general, neither for annual nor quarterly data. Serial correlation seems to be present in all specifications when using quarterly data. This may be due to the fact that only one lag for the independent variables has been used and no lagged dependent variables show up as regressors. In the case of annual data, autocorrelation is indicated only in the HK model. Non-normality of the residuals is a problem for all specifications for both data frequencies. The IK specification beats the FM specification also on grounds of parameter stability. Both seem to suffer from miss-specification, but the former less then the latter. Ironically, the model with implausible coefficients performs best in terms of the accuracy of the specification.

The out-of-sample performance is assessed by comparing the root mean square errors (RMSE) and the mean absolute errors (MAE) of the forecasts. To generate the out-of-sample forecasts, we split the annual sample in 1990 and the quarterly sample in 1994:4. From each of the first subsample of the sample the parameter estimates were obtained and used for static forecasting into the second subsample. The resulting RMSE's and MAE's are illustrated in table 4. Within the set of plausible specifications, the NK model performs best with annual data. The IK outperforms the others with quarterly data. With annual data, the Marxian specification performs worst out of sample.

Encompassing tests have been undertaken only for the IK and FM specifications, since the IK model encompasses the NK model by definition and the HK model does not yield plausible results. Since the F-test and the J-test developed by Davidson and MacKinnon (1981) lead to the same test statistic in our case, we only report the latter in table 5. With quarterly data both the FM and IK specifications encompass the other. However, with annual

Table 3: Diagnostic tests

	NK	IK	HK	FM
Annual data				
RESET	6.219 (0.004)	2.949 (0.061)	0.446 (0.643)	5.839 (0.005)
White	0.902 (0.637)	1.753 (0.882)	9.209 (0.418)	4.163 (0.526)
Breusch-Pagan	1.001 (0.317)	1.686 (0.430)	10.110 (0.018)	3.894 (0.143)
Normality	6.139 (0.046)	4.886 (0.087)	7.019 (0.030)	4.846 (0.089)
Durbin-Watson	2.216	2.055	1.741	2.026
AR(1-2)	1.530 (0.226)	0.692 (0.505)	2.708 (0.076)	0.702 (0.500)
CUSUM	-0.094 (0.925)	-0.673 (0.504)	-0.789 (0.434)	-1.502 (0.139)
Quarterly data				
RESET	7.685 (0.001)	4.746 (0.010)	6.425 (0.002)	7.281 (0.001)
White	4.534 (0.104)	5.501 (0.358)	15.065 (0.090)	8.727 (0.120)
Breusch-Pagan	2.039 (0.153)	1.853 (0.396)	3.304 (0.347)	9.401 (0.009)
Normality	39.317 (0.000)	42.458 (0.000)	36.323 (0.000)	41.143 (0.000)
Durbin-Watson	1.621	1.703	1.527	1.669
AR(1-4)	3.157 (0.015)	2.551 (0.040)	7.627 (0.000)	2.737 (0.030)
CUSUM	0.082 (0.934)	-0.134 (0.893)	-0.289 (0.773)	0.873 (0.384)

Notes: p-values in parenthesis.

Table 4: Out-of-sample forecasting performances

	NK	IK	HK	FM
Annual data				
RMSE	0.0047	0.0055	0.0049	0.0058
MAE	0.0040	0.0043	0.0039	0.0047
Quarterly data				
RMSE	0.00039	0.00035	0.00030	0.00039
MAE	0.00031	0.00027	0.00024	0.00031

Table 5: Encompassing tests for the annual models

		annual data	quarterly data
FM encompasses IK	J-test	7.58 (0.008)	1.29 (0.257)
HK encompasses M	J-test	1.66 (0.203)	0.19 (0.667)

Notes: p-values in parenthesis.

data we can reject the null hypothesis that the FM model encompasses the IK model while the reverse does not hold.

After all, the Intermediate-Kaleckian specification turned out to outperform all the others considered. Apart from the Hysteresis-Kaleckian which does not yield plausible parameter estimates, it has the highest R^2 and the lowest information criteria. It performs best out of sample with quarterly data and encompasses the French-Marxian model regardless of whether annual or quarterly data are used.

6 Conclusions

In this paper, we considered four long-run closures of the short-run Kaleckian model. Wile in the short run the rate of capacity utilization is adjusting endogenously in order to equalize aggregate supply and demand, it has been argued by Marxians and Kaleckians alike that the rate of capacity utilization cannot be different from its normal level in the long run. However, while the Marxians perceive the normal rate of utilization as exogenous, Kaleckians argue in favor of an endogenous adjustment of the normal rate to the actual rate. Hence, we developed four investment functions representing these views following Lavoie et al. (2004): The *Naive-Kaleckian* specification does not require any adjustment in the long run other than in the short run. The *Intermediate-Kaleckian* specification takes into account the endogenous adjustment of the normal rate of utilization whenever the actual rate deviates from it. The *Hysteresis-Kaleckian* additionally allows for an endogenous adjustment of the autonomous part of accumulation which is thought of increasing whenever the rate of accumulation exceeds the expected rate. In contrast to that, the *French-Marxian* specification takes the normal utilization rate as exogenous and allows autonomous accumulation to decrease (increase) whenever the actual rate is higher (lower) than the normal rate of accumulation.

We confronted the specifications with annual and quarterly US manufacturing data ranging from 1949 to 2008 and 1958:1 to 2008:4, respectively. We used data on capacity utilization and the stock of fixed assets. While the annual data was available in a ready-to-use form, we applied the Chow and Lin (1971) procedure to interpolate the investment series by a related series.

We then engaged in a five step procedure of assessing the different investment specifications. First, we interpreted the estimation results and came to the conclusion that the Hysteresis-Kaleckian specification yields implausible coefficients. In a second step, we compared the explanatory power and the goodness of fit of the plausible specifications. Here, the Intermediate-Kaleckian specification seems to fit best. The third step of analysis was a comparison of diagnostic tests which did not offer many insights on the relative performances. Rather, we can conclude from this analysis that all models seem to be misspecified. In a fourth step, the out-of-sample performance has been analyzed. The Naive-Kaleckian and the Intermediate-Kaleckian models are the winner of this round. Finally, we ran encompassing tests between the French-Marxian and the Intermediate-Kaleckian specifications which leads us to the conclusion that the latter is superior.

Unfortunately, there was no feasible possibility to equally improve the specification of each model while keeping them comparable. This has various reasons: First, there is no sectoral data available for unit labor costs, interest costs, debt ratios and asset prices which may all be important control variables affecting investment. Second, extending the lag structure was not an option, as this gave rise to multicollinearity problems for some specifications.

The winner of the competition is the Intermediate-Kaleckian specification. For economic theory, this implies that the normal rate of capacity utilization might be better perceived as endogenous, as opposed to the Marxian view. The French-Marxian specification which includes an adjustment of the actual rate to the normal rate is inferior to the Intermediate-Kaleckian model in which adjustment runs the other way round. So far, the results obtained by Lavoie et al. (2004) can be confirmed.

However, the autonomous part of investment seems not to be sensitive to past realizations as expected by Kaleckians, at least not with a positive sign. Thus, the data does not confirm the view that accumulation increases the faster, the higher accumulation was in the past.

References

Chow, G. C., Lin, A. (1971): Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Time Series by Related Series, *The Review of Economics and Statistics*, 53(4), pp. 372–5.

Davidson, R., MacKinnon, J. G. (1981): Several tests for model specification in the presence of alternative hypothesis, *Econometrica*, 49(3), pp. 781–93.

Duménil, G., Lévy, D. (1995): A post-Keynesian long-term equilibrium with equalized profit rates? A rejoinder to Amitava Dutt's synthesis, *Review of Radical Political Economics*, 27(2), pp. 135–41.

Duménil, G., Lévy, D. (1999): Being Keynesian in the short term and classical in the long term: The traverse to classical long-term equilibrium, *The Manchester School*, 67(6), pp. 684–716.

Dutt, A. K. (1997): Equilibrium, path dependence and hysteresis in post-Keynesian models, in: Arestis, P., Palma, G., Sawyer, M., eds., *Markets, Unemployment and Economic Policy: Essays in Honour of Geoff Harcourt*, Routledge, London, vol. 2, pp. 238–53.

Dutt, A. K. (2009): Path dependence, equilibrium and economic growth, in: Arestis, P., Sawyer, M., eds., *Path Dependency in Macroeconomics. International Papers in Political Economy*, Macmillan Palgrave, Houndmills, New York, pp. 119–61.

Harvey, J. T., Garnett, R. F. (2008): *Future Directions for Heterodox Economics*, University of Michigan Press, Michigan.

Hein, E., Lavoie, M., van Treeck, T. (2011a): Harrodian instability and the 'normal rate' of capacity utilisation in Kaleckian models of distribution and growth - a survey, *Metroeconomica*, forthcoming.

Hein, E., Lavoie, M., van Treeck, T. (2011b): Some instability puzzles in Kaleckian models of growth and distribution: A critical survey, *Cambridge Journal of Economics*, forthcoming.

Hodrick, R., Prescott, E. C. (1980): Post-war U.S. business cycles: an empirical investigation, Discussion Paper 451, Carnegie-Mellon University.

Kalecki, M. (1971): *Selected Essays on the Dynamics of the Capitalist Economy*, Cambridge University Press, Cambridge.

Lavoie, M. (1996): Traverse, hysteresis, and normal rates of capacity utilization in Kaleckian models of grwoth and distribution, *Review of Radical Political Economics*, 28(4), pp. 113–47.

Lavoie, M., Rodríguez, G., Seccareccia, M. (2004): Similitudes and Discrepancies in Post-Keynesian and Marxist Theories of Investment: A Theoretical and Empirical Investigation, *International Review of Applied Economics*, 18(2), pp. 127–49.

Shaikh, A. (2007): Economic Policy in a Growth Context: A classical Synthesis of Keynes and Harrod, Working paper, The New School for Social Research.

Skott, P. (2008): Growth, Instability and Cycles: Harrodian and Kaleckian Models of Accumulation and Income Distribution, Working Paper 2008-12, University of Massachusetts.

Skott, P., Ryoo, S. (2008): Macroeconomic implications of financialisation, *Cambridge Journal of Economics*, 32(6), pp. 827–862.

A Estimation output

OLS, using observations 1951–2008 ($T = 58$)
Dependent variable: d_g_man

	Coefficient	Std. Error	t-ratio	p-value
const	−0.000387871	0.00125395	−0.3093	0.7582
d_u_man_1	0.170984	0.0317627	5.3832	0.0000

Mean dependent var	−0.000246	S.D. dependent var	0.011658
Sum squared resid	0.005105	S.E. of regression	0.009548
R^2	0.341011	Adjusted R^2	0.329243
$F(1, 56)$	28.97859	P-value(F)	1.50e–06
Log-likelihood	188.5038	Akaike criterion	−373.0075
Schwarz criterion	−368.8866	Hannan–Quinn	−371.4023
$\hat{\rho}$	−0.127981	Durbin–Watson	2.216176

RESET test for specification –
Null hypothesis: specification is adequate
Test statistic: $F(2, 54) = 6.21868$
with p-value $= P(F(2, 54) > 6.21868) = 0.00371104$

White's test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 0.902331
with p-value $= P(\chi^2(2) > 0.902331) = 0.636885$

Breusch-Pagan test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 1.00115
with p-value $= P(\chi^2(1) > 1.00115) = 0.317032$

Test for normality of residual –
Null hypothesis: error is normally distributed
Test statistic: $\chi^2(2) = 6.13937$
with p-value = 0.0464357

LM test for autocorrelation up to order 2 –
Null hypothesis: no autocorrelation
Test statistic: LMF = 1.52978
with p-value $= P(F(2, 54) > 1.52978) = 0.22582$

CUSUM test for parameter stability –
Null hypothesis: no change in parameters
Test statistic: Harvey–Collier $t(55)$ = -0.0944334
with p-value $= P(t_{55} > -0.0944334) = 0.925108$

OLS, using observations 1950–2008 ($T = 59$)
Dependent variable: d_g_man

	Coefficient	Std. Error	t-ratio	p-value
const	−0.000100896	0.00118927	−0.0848	0.9327
d_u_man_1	0.217465	0.0362584	5.9977	0.0000
a_man_k_1	−0.123014	0.0443377	−2.7745	0.0075

Mean dependent var	−0.000234	S.D. dependent var	0.011557
Sum squared resid	0.004671	S.E. of regression	0.009133
R^2	0.397005	Adjusted R^2	0.375470
$F(2, 56)$	18.43490	P-value(F)	7.06e–07
Log-likelihood	194.8759	Akaike criterion	−383.7518
Schwarz criterion	−377.5191	Hannan–Quinn	−381.3188
$\hat{\rho}$	−0.037706	Durbin–Watson	2.055369

RESET test for specification –
Null hypothesis: specification is adequate
Test statistic: $F(2, 54) = 2.94903$
with p-value $= P(F(2, 54) > 2.94903) = 0.0608816$

White's test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 1.75274
with p-value $= P(\chi^2(5) > 1.75274) = 0.88219$

Breusch-Pagan test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 1.68606
with p-value $= P(\chi^2(2) > 1.68606) = 0.430405$

Test for normality of residual –
Null hypothesis: error is normally distributed
Test statistic: $\chi^2(2) = 4.8862$
with p-value = 0.0868911

LM test for autocorrelation up to order 2 –
Null hypothesis: no autocorrelation
Test statistic: LMF = 0.692009
with p-value $= P(F(2, 54) > 0.692009) = 0.504953$

CUSUM test for parameter stability –
Null hypothesis: no change in parameters
Test statistic: Harvey–Collier $t(55)$ = -0.672591
with p-value $= P(t_{55} >$ -0.672591$) = 0.504024$

OLS, using observations 1950–2008 (T = 59)
Dependent variable: d_g_man

	Coefficient	Std. Error	t-ratio	p-value
const	−0.000457944	0.00101632	−0.4506	0.6541
d_u_man_1	0.0824479	0.0421803	1.9547	0.0557
a_man_k_1	0.125097	0.0648972	1.9276	0.0591
x_man_a_1	−0.765427	0.162777	−4.7023	0.0000

Mean dependent var	−0.000234	S.D. dependent var	0.011557
Sum squared resid	0.003332	S.E. of regression	0.007783
R^2	0.569913	Adjusted R^2	0.546454
$F(3,55)$	24.29369	P-value(F)	3.84e–10
Log-likelihood	204.8445	Akaike criterion	−401.6891
Schwarz criterion	−393.3789	Hannan–Quinn	−398.4451
$\hat{\rho}$	0.127842	Durbin–Watson	1.741399

RESET test for specification –
Null hypothesis: specification is adequate
Test statistic: $F(2,53) = 0.445668$
with p-value = $P(F(2,53) > 0.445668) = 0.642774$

White's test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 9.20873
with p-value = $P(\chi^2(9) > 9.20873) = 0.418234$

Breusch-Pagan test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 10.1102
with p-value = $P(\chi^2(3) > 10.1102) = 0.0176519$

LM test for autocorrelation up to order 2 –
Null hypothesis: no autocorrelation
Test statistic: LMF = 2.70843
with p-value = $P(F(2,53) > 2.70843) = 0.0758665$

CUSUM test for parameter stability –
Null hypothesis: no change in parameters
Test statistic: Harvey–Collier $t(54)$ = -0.789015
with p-value = $P(t_{54} >$ -0.789015) = 0.433554

OLS, using observations 1950–2008 ($T = 59$)
Dependent variable: d_g_man

	Coefficient	Std. Error	t-ratio	p-value
const	−9.63252e–05	0.00125022	−0.0770	0.9389
a_man_m_1	−0.0402727	0.0311537	−1.2927	0.2014
d_u_man_1	0.178295	0.0345029	5.1675	0.0000

Mean dependent var	−0.000234	S.D. dependent var	0.011557
Sum squared resid	0.005160	S.E. of regression	0.009599
R^2	0.333992	Adjusted R^2	0.310206
$F(2,56)$	14.04156	P-value(F)	0.000011
Log-likelihood	191.9438	Akaike criterion	−377.8876
Schwarz criterion	−371.6550	Hannan–Quinn	−375.4546
$\hat{\rho}$	−0.028676	Durbin–Watson	2.025539

RESET test for specification –
Null hypothesis: specification is adequate
Test statistic: $F(2,54) = 5.8394$
with p-value = $P(F(2,54) > 5.8394) = 0.00506002$

White's test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 4.1627
with p-value = $P(\chi^2(5) > 4.1627) = 0.526237$

Breusch-Pagan test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 3.89417
with p-value = $P(\chi^2(2) > 3.89417) = 0.142689$

Test for normality of residual –
Null hypothesis: error is normally distributed
Test statistic: $\chi^2(2) = 4.84596$
with p-value = 0.0886571

LM test for autocorrelation up to order 2 –
Null hypothesis: no autocorrelation
Test statistic: LMF = 0.701977
with p-value = $P(F(2,54) > 0.701977) = 0.50007$

CUSUM test for parameter stability –
Null hypothesis: no change in parameters
Test statistic: Harvey–Collier $t(55)$ = -1.50218
with p-value = $P(t_{55} > \text{-1.50218}) = 0.138772$

OLS, using observations 1958:3–2008:4 ($T = 202$)
Dependent variable: d_ld_k_gross_q

	Coefficient	Std. Error	t-ratio	p-value
const	−6.86058e–05	5.92006e–05	−1.1589	0.2479
d_u_man_1	0.0152756	0.00384445	3.9734	0.0001

Mean dependent var	−0.000068	S.D. dependent var	0.000872
Sum squared resid	0.000142	S.E. of regression	0.000841
R^2	0.073165	Adjusted R^2	0.068531
$F(1, 200)$	15.78810	P-value(F)	0.000099
Log-likelihood	1144.630	Akaike criterion	−2285.260
Schwarz criterion	−2278.644	Hannan–Quinn	−2282.583
$\hat{\rho}$	0.188212	Durbin–Watson	1.620880

RESET test for specification –
Null hypothesis: specification is adequate
Test statistic: $F(2, 198) = 7.68459$
with p-value $= P(F(2, 198) > 7.68459) = 0.000610686$

White's test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 4.53394
with p-value $= P(\chi^2(2) > 4.53394) = 0.103626$

Breusch-Pagan test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 2.03916
with p-value $= P(\chi^2(1) > 2.03916) = 0.153294$

Test for normality of residual –
Null hypothesis: error is normally distributed
Test statistic: $\chi^2(2) = 39.3166$
with p-value = 2.9007e-09

LM test for autocorrelation up to order 4 –
Null hypothesis: no autocorrelation
Test statistic: LMF = 3.15697
with p-value $= P(F(4, 196) > 3.15697) = 0.0152564$

CUSUM test for parameter stability –
Null hypothesis: no change in parameters
Test statistic: Harvey–Collier $t(199) = 0.0823328$
with p-value $= P(t_{199} > 0.0823328) = 0.934465$

OLS, using observations 1958:3–2008:4 ($T = 202$)
Dependent variable: d_ld_k_gross_q

	Coefficient	Std. Error	t-ratio	p-value
const	−7.09156e–05	5.82470e–05	−1.2175	0.2249
d_u_man_1	0.0123774	0.00392469	3.1537	0.0019
a_man_k_1	0.00612315	0.00221455	2.7650	0.0062

Mean dependent var	−0.000068	S.D. dependent var	0.000872
Sum squared resid	0.000136	S.E. of regression	0.000828
R^2	0.107454	Adjusted R^2	0.098484
$F(2, 199)$	11.97884	P-value(F)	0.000012
Log-likelihood	1148.438	Akaike criterion	−2290.875
Schwarz criterion	−2280.950	Hannan–Quinn	−2286.860
$\hat{\rho}$	0.146304	Durbin–Watson	1.702856

RESET test for specification –
Null hypothesis: specification is adequate
Test statistic: $F(2, 197) = 4.74637$
with p-value $= P(F(2, 197) > 4.74637) = 0.00970064$

White's test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 5.50107
with p-value $= P(\chi^2(5) > 5.50107) = 0.357828$

Breusch-Pagan test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 1.85304
with p-value $= P(\chi^2(2) > 1.85304) = 0.395929$

Test for normality of residual –
Null hypothesis: error is normally distributed
Test statistic: $\chi^2(2) = 42.4585$
with p-value = 6.02909e-10

LM test for autocorrelation up to order 4 –
Null hypothesis: no autocorrelation
Test statistic: LMF = 2.55153
with p-value $= P(F(4, 195) > 2.55153) = 0.0404502$

CUSUM test for parameter stability –
Null hypothesis: no change in parameters
Test statistic: Harvey–Collier $t(198)$ = -0.134144
with p-value $= P(t_{198} > -0.134144) = 0.893425$

OLS, using observations 1958:3–2008:4 ($T = 202$)
Dependent variable: d_ld_k_gross_q

	Coefficient	Std. Error	t-ratio	p-value
const	−7.25954e–05	5.35000e–05	−1.3569	0.1764
d_u_man_1	0.00161827	0.00400624	0.4039	0.6867
a_man_k_1	0.0144132	0.00243952	5.9082	0.0000
x_man_q_1	−0.276552	0.0449294	−6.1552	0.0000

Mean dependent var	−0.000068	S.D. dependent var	0.000872
Sum squared resid	0.000114	S.E. of regression	0.000760
R^2	0.250810	Adjusted R^2	0.239459
$F(3, 198)$	22.09518	P-value(F)	2.20e–12
Log-likelihood	1166.121	Akaike criterion	−2324.243
Schwarz criterion	−2311.010	Hannan–Quinn	−2318.889
$\hat{\rho}$	0.233632	Durbin–Watson	1.526929

RESET test for specification –
Null hypothesis: specification is adequate
Test statistic: $F(2, 196) = 6.42453$
with p-value $= P(F(2, 196) > 6.42453) = 0.00198384$

White's test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 15.065
with p-value $= P(\chi^2(9) > 15.065) = 0.0891667$

Breusch-Pagan test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 3.30419
with p-value $= P(\chi^2(3) > 3.30419) = 0.34706$

Test for normality of residual –
Null hypothesis: error is normally distributed
Test statistic: $\chi^2(2) = 36.3228$
with p-value = 1.29599e-08

LM test for autocorrelation up to order 4 –
Null hypothesis: no autocorrelation
Test statistic: LMF = 7.62651
with p-value $= P(F(4, 194) > 7.62651) = 9.98476\text{e-}06$

CUSUM test for parameter stability –
Null hypothesis: no change in parameters
Test statistic: Harvey–Collier $t(197) = -0.288625$
with p-value $= P(t_{197} > -0.288625) = 0.773172$

OLS, using observations 1958:3–2008:4 ($T = 202$)
Dependent variable: d_ld_k_gross_q

	Coefficient	Std. Error	t-ratio	p-value
const	−7.09015e–05	5.86243e–05	−1.2094	0.2279
d_u_man_1	0.0138420	0.00385991	3.5861	0.0004
a_man_m_1	0.00294302	0.00131429	2.2392	0.0262

Mean dependent var	−0.000068	S.D. dependent var	0.000872
Sum squared resid	0.000138	S.E. of regression	0.000833
R^2	0.095944	Adjusted R^2	0.086858
$F(2, 199)$	10.55959	P-value(F)	0.000044
Log-likelihood	1147.144	Akaike criterion	−2288.287
Schwarz criterion	−2278.362	Hannan–Quinn	−2284.271
$\hat{\rho}$	0.163476	Durbin–Watson	1.668625

RESET test for specification –
Null hypothesis: specification is adequate
Test statistic: $F(2, 197) = 7.28111$
with p-value $= P(F(2, 197) > 7.28111) = 0.00088975$

White's test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 8.72665
with p-value $= P(\chi^2(5) > 8.72665) = 0.120476$

Breusch-Pagan test for heteroskedasticity –
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 9.40145
with p-value $= P(\chi^2(2) > 9.40145) = 0.00908868$

Test for normality of residual –
Null hypothesis: error is normally distributed
Test statistic: $\chi^2(2) = 41.143$
with p-value = 1.16388e-09

LM test for autocorrelation up to order 4 –
Null hypothesis: no autocorrelation
Test statistic: LMF = 2.73713
with p-value $= P(F(4, 195) > 2.73713) = 0.030069$

CUSUM test for parameter stability –
Null hypothesis: no change in parameters
Test statistic: Harvey–Collier $t(198) = 0.873005$
with p-value $= P(t_{198} > 0.873005) = 0.383718$