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ON THE INTEREST RATE SENSITIVITY OF AGGREGATE INVESTMENT IN THE EURO ZONE

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ABSTRACT

The purpose of this paper is to estimate the response of aggregate investment to interest rate changes in the Euro zone. Keynesian macroeconomic theory assumes that there is an inverse relationship between investment and interest rates, but empirical evidence is inconclusive. Interestingly, there are no studies relating macroeconomic investment to central bank rates in the Euro zone, despite the importance of this question for European monetary policy. To check whether the inverse interest rate – investment nexus holds for the Euro zone we conducted a comprehensive econometric study. In particular, we estimated a modified accelerator model that related aggregate investment in levels and the investment-to GDP (gross domestic product) ratio to income, interest rates and a set of control variables. The model was estimated by OLS (ordinary least squares) and simultaneous-equations methods such as TSLS (two-stage least squares) and GMM (generalized method of moments). The study was unable to uncover a significant interest rate effect on investment in the Euro zone. Thus, there is little support for the expansionary monetary policy of the European Central Bank.

Contribution/ Originality: The paper contributes to the literature on the macroeconomic interest rate elasticity of investment. It is the first paper that shows that the response of investment to interest rates is not significantly different from zero in the Euro zone. Thus, the expansionary monetary policy of the European Central Bank proved ineffective in fostering aggregate investment.

1. INTRODUCTION

Since the financial crisis in 2008, the European Central Bank (ECB) has conducted an expansionary monetary policy consisting of interest rate cuts and asset purchase programs resulting in increased base money supply. Interest rates have been lowered to historically unprecedented levels, becoming negative in 2014 (Deposit Facility). Short run (interbank rates) and long-term (bond) rates correspondingly became negative. This negative interest rate policy together with the asset purchase programs were justified by the promotion of growth and investment. Following official ECB statements, lower credit costs and other unconventional policy measures have supported investment, created two million new jobs and contributed to a GDP surplus of 2.5 to 3 percent (Schnabel, 2020).

It is the purpose of this paper to examine empirically whether the investment-promoting effect of declining interest rates receives empirical support. In particular, we will concentrate on the relationship between aggregate investment and (policy) interest rates in the Euro zone, although we are aware that investment is not the only growth-determining factor. Therefore, we first present a brief literature review on the interest-investment nexus. Next, we develop an expanded accelerator investment function and present empirical estimates of the interest rate sensitivity of aggregate investment. The analysis is supplemented by a discussion of endogeneity issues.

2. THEORY AND LITERATURE

From a theoretical perspective, there are good reasons to assume an inverse textbook relationship between investment and the interest rate, representing the negative slope of the IS (Keynesian investment-savings) curve. Although this relationship is highly policy-relevant, it is controversially discussed in the empirical literature. Hall, Sims, Modigliani, and Brainard (1977) calls it "disappointingly weak" and presents a set of possible explanations (time lags, putty-clay hypothesis, term structure of interest rates). Boivin, Kiley, and Mishkin (2010) discuss various transmission channels, particularly the user cost channel. They summarized the results of empirical studies and concluded that the elasticity of investment with respect to changes in capital user costs is controversial. Sensitivities vary across sectors and are generally low, with the exception of residential housing investment. Tadeu and Silva (2013) studied the determinants of private investment in Brazil using a comprehensive regression model including demand and capacity utilization factors, exchange and interest rates and public investment. They found a positive effect of interest rates on investment that was, however, not significant.

On the other hand, several studies provided some evidence for a significant inverse relationship at the firm level. Guiso, Kashyap, Panetta, and Terlizzese (2002) found rather high elasticities for Italian (predominantly small) firms, whereas (Cloyne, Ferreira, Froemel, & Surico, 2018) uncovered remarkable differences regarding firm age. Younger (US and UK) firms show a pronounced response of investment to interest rate changes, whereas older firms do not. A recent study by Durante, Ferrando, and Vermeulen (2020) confirmed this finding. Additionally, the authors' found the highest sensitivity was in the construction sector, whereas the service sector's response is much weaker. However, a noteworthy negative interest elasticity of investment at the firm level was rejected by Sharpe and Suarez (2021).

There are also studies revealing that the interest elasticity of investment seems to have declined significantly over time. Baldi and Lange (2019) found structural breaks in five countries under observation. Depending on the country, investment responds weaker to interest rate cuts since the 1980s or 1990s, and in Germany and the UK interest rate cuts even trigger declining aggregate investment (Baldi & Lange, 2019; Osler, 1994). Bachmann and Zorn (2019) found that investment was positively related to interest rates. All in all, the empirical evidence is inconclusive. Therefore, this paper makes a contribution to the aggregate investment sensitivity in the Euro zone and tests the hypothesis that interest rate cuts promote investment.

Many of the empirical studies were based on neoclassical investment functions that include interest rates (lending rates) as part of the user cost of capital. A few other studies compared alternative investment functions such as (simple and expanded) accelerator models, functions based on Tobin's q, cash flow models and pure time series models. On average, the accelerator model outperforms the other models in terms of statistical fit and predictive power (Barkbu, Berkmen, Lukyantsau, Saksonovs, & Schoelermann, 2015; Berndt, 1991). We will, therefore, present a modified and expanded accelerator model that can be easily used not only to evaluate the impact of interest rate changes on investment, but also on growth directly.

3. THE ACCELERATOR MODEL

The standard specification in levels of the accelerator model is as follows (Berndt, 1991):

$$I_t = \mu\lambda Y_t - (1-\delta)\mu\lambda Y_{t-1} + (1-\lambda)I_{t-1} \tag{1}$$

Current investment I_t depends on current production Y_t, and lagged investment, and production. The parameters are: $\mu = K/Y$, the capital-output ratio, δ the depreciation rate, and λ an adjustment coefficient. The

Koyck-type model is intrinsically an error-correction model that can be estimated by OLS (Greene, 2003). There is no constant term.

The level model can be transformed to solve for the investment share of GDP.

$$\frac{I_t}{Y_t} = \mu\lambda - (1-\delta)\mu\lambda\frac{Y_{t-1}}{Y_t} + (1-\lambda)\frac{I_{t-1}}{Y_t} \tag{2}$$

Since production growth is $g_t = \frac{Y_t - Y_{t-1}}{Y_t}$ we have $\frac{Y_{t-1}}{Y_t} = 1 - g_t$. Inserting in Equation 2 yields:

$$\frac{I_t}{Y_t} = \mu\lambda - (1-\delta)\mu\lambda(1-g_t) + (1-\lambda)\frac{I_{t-1}}{Y_t}. \tag{3}$$

The investment share thus depends on output growth and the ratio of lagged investment to current output. Equation 3 has a constant term. The regression equation equivalent is:

$$\frac{I_t}{Y_t} = \beta_0 + \beta_1 g_t + \beta_2\frac{I_{t-1}}{Y_t} + \varsigma_1 \tag{4}$$

It is well known that it is not only the investment ratio that depends on growth, but also growth depends on investment (Crowder & de Jong, 2011; Podrecca & Carmeci, 2001). Therefore, we can consider a similar functional form for growth:

$$g_t = \varepsilon_0 + \varepsilon_1\frac{I_t}{Y_t} + \varepsilon_2\frac{I_{t-1}}{Y_t} + \varsigma_2. \tag{5}$$

Equations 4 and 5 constitute a small simultaneous equation model with I_t / Y_t and g_t as endogenous variables. However, neither equation is identified because the predetermined variable I_{t-1} / Y_t enters both equations.

To complete the model, we first added the interest rate to Equations 4 and 5. This specification captures direct effects (e. g. exchange rate effects) as well as indirect effects via the investment-to-GDP ratio. Theoretically, lower interest rates should lead to higher growth rates as well as to increased investment. Second, we added the ratio of government spending to GDP to Equation 5 as a fiscal policy proxy. Finally, a set of dummy variables for years 2009 to 2014 was introduced in to capture the specific effects of the financial crisis (initial downturn, post-2009 recovery) to Equation 5. Finally, two indices of "investment freedom" (*INVFREE, a measure for freedom to invest in physical capital)* and "financial freedom" (*FINFREE, a measure for freedom of financial flows*) from the Heritage Index of Economic Freedom were added to Equation 4. The final regression model, which is fully identified is:

$$\frac{I_t}{Y_t} = \beta_0 + \beta_1 g_t + \beta_2\frac{I_{t-1}}{Y_t} + \beta_3 IR + \beta_4 INVFREE + \beta_5 FINFREE + \varsigma_1 \tag{6}$$

$$g_t = \varepsilon_0 + \varepsilon_1\frac{I_t}{Y_t} + \varepsilon_2\frac{I_{t-1}}{Y_t} + \varepsilon_3 IR + \varepsilon_4 GOVEX + \varepsilon_5 D09 + \varepsilon_6 D10 + \varepsilon_7 D11 + \varepsilon_8 D12 + \varepsilon_9 D13 + \varepsilon_{10} D14 + \varsigma_2 \tag{7}$$

4. DATA AND ESTIMATION RESULTS

We used quarterly data for the Euro zone from I/1999 (the introduction of the Euro) to IV/2019 (the last quarter unaffected by the Covid-19 Pandemic). The variables included are:

I = gross fixed capital formation at market prices.

$Y =$ gross domestic product at market prices.
$g =$ real gross domestic product growth rate; quarterly growth rate over one year.

$IR =$ interest rate, 3 months EONIA interbank rate (euro overnight index average); monthly data converted to quarterly. The EONIA closely moves with the key policy rates of the ECB, but is more closely related to bank lending rates. Therefore, the EONIA can be considered the most appropriate proxy for the relevant interest rate.

$GOVEX =$ ratio of government spending to gross domestic product, annual converted to quarterly.
$D09 =$ financial crisis dummy variable (1, if a 2009 quarter, 0 otherwise).
$D10, \ldots D14 =$ annual recovery dummies 2010, 2010, 2011, 2012, 2013, 2014.
$INVFREE =$ freedom to invest index, Heritage Foundation, annual to quarterly.
$FINFREE =$ financial freedom index, Heritage Foundation, annual to quarterly.

First, we estimated Equation 1 (the standard accelerator model) with and without the interest rate variable to check whether the parameter values of μ, δ, and λ are reasonable. Then we estimated Equations 6 and 7 by OLS. Results from a 2SLS (two-stage least squares) and GMM (generalized method of moments) estimation are also presented to assess whether there is a simultaneity bias.

4.1. Investment Level Estimation

Estimating Equation 1 by OLS yields the following result (t-stats in brackets):

$$I_t = 0.4587Y_t - 0.4399Y_{t-1} + 0.9040I_{t-1} \qquad R^2 = 0.9735 \qquad \bar{R}^2 = 0.9729 \qquad DW = 2.94$$
$$(5.25) \qquad (5.01) \qquad (19.49)$$

From the estimated highly significant coefficients, the following parameters can be derived:

$$\mu = 4.778 \qquad \lambda = 0.096 \qquad \delta = 0.041$$

A depreciation rate of 4 percent and a capital-output ratio of 4.8 are reasonable values (Arnott, Bernstein, & Wu, 2015). The adjustment coefficient points to fast adjustment.

If Equation 1 is augmented with the interest rate variable, we get

$$I_t = 0.4438Y_t - 0.4156Y_{t-1} + 0.8572I_{t-1} + 879.6IR \qquad R^2 = 0.9737 \quad \bar{R}^2 = 0.9727 \quad DW = 2.83$$
$$(4.95) \qquad (4.46) \qquad (11.38) \qquad (0.79)$$

and the parameter estimates $\mu = 3.103 \qquad \lambda = 0.143 \qquad \delta = 0.064$.

The interest rate variable is not significant and has the wrong sign. We tried lagged values but failed to establish any significant inverse relationship. Thus, the basic accelerator model does not support a negative interest elasticity of investment if investment levels are considered.

However, this result could have been affected by the long period of negative interest rates since 2014. We, therefore, re-estimated the extended accelerator model for the sub-period 1999 to 2013, the "positive interest rate regime", as a robustness check:

$$I_t = 0.4375Y_t - 0.4115Y_{t-1} + 0.8641I_{t-1} + 1467.7IR \qquad R^2 = 0.9810 \quad \bar{R}^2 = 0.9806 \quad DW = 2.67$$
$$(6.94) \qquad (6.01) \qquad (11.80) \qquad (1.27)$$

The results only marginally deviate from the full period estimation results. Thus, it is unlikely that the long period of negative interest rates introduced a bias.

4.2. Investment Share, Growth, and Interest Rates

Next, the simultaneous equations model 6 and 7 was estimated. We used OLS in comparison to Two Stage Least Squares (TSLS) and the Generalized Method of Moments (GMM) to assess potential simultaneity bias as well as to obtain robust estimation results (heteroskedasticity, serial correlation). For the TSLS and GMM estimation lagged endogenous and exogenous variables up to lag of three were used as instruments. First, the growth equations were estimated with the full set of dummy variables. However, only the 2010 dummy was significant, the other dummies consistently being not significant. This points to a rather fast recovery process after the downturn in mid-2008. Therefore, the regression results with only the 2009 and 2010 dummies are displayed.

Table 1. Estimation of simultaneous equations model.

Dependent	(6) OLS I_t/Y_t	(7) OLS g_t	(6) TSLS I_t/Y_t	(7) TSLS g_t	(6) GMM I_t/Y_t	(7) GMM I_t/Y_t
I_t/Y_t		0.527* (1.88)		0.949 (1.33)		1.413** (2.51)
g_t	0.140*** (4.60)		0.135*** (4.24)		0.141*** (8.12)	
I_{t-1}/Y	0.793*** (9.94)	-0.978*** (3.64)	0.840*** (9.77)	-0.297 (0.60)	0.881*** (12.19)	-0.559 (1.66)
IR	0.040 (0.49)	0.211 (1.60)	0.001 (0.00)	-0.194 (0.89)	0.014 (0.22)	-0.228 (1.33)
FREEFIN	0.017 (0.84)		0.009 (0.44)		0.019 (1.66)	
FREEINV	-0.016 (0.80)		-0.019 (0.88)		-0.013 (1.11)	
GOVEXP		-0.711** (4.21)		-0.074 (0.19)		0.059 (0.19)
D09		-3.128*** (2.74)		-8.605*** (4.70)		-7.985*** (4.45)
D10		2.609*** (3.71)		2.486 (1.65)		2.361* (1.72)
constant		44.68*** (3.63)	4.038 (1.62)	10.31 (0.35)	2.105 (1.28)	-19.05 (0.82)
R-squared	0.864	0.710	0.863	0.552	0.59	0.492
DW	2.56	0.78	2.68	0.82	2.76	0.98

Note: t-statistics are given in parentheses; ***, **, * refer to the 1, 5, and 10% levels of significance.

The main findings are as follows:

1. The "core" accelerator model describes the movement of the investment-GDP ratio reasonably well, irrespective of the estimation method. Growth and lagged investment are consistently significant.

2. Regarding the growth equation, results are less convincing. The variables of the "core" accelerator model are significant only in the OLS equation, but not generally when simultaneous equations methods are applied. This is due to the inclusion of the 2010 dummy variable. Without the dummy, the investment-GDP ratio regains its significance if TSLS is applied. In the GMM estimate, the investment-to-GDP ratio is significant.

3. The interest rate variable proves insignificant throughout. We can thus conclude that on the basis of the modified accelerator model, interest rate cuts are highly unlikely to promote growth and investment.

Theoretically, the lack of a relationship between the investment-to-GDP ratio and the interest rate could be explained by a positive response of investment and GDP to interest rate cuts of the same magnitude. In this case, the ratio of investment to GDP would stay constant. However, the empirical evidence so far does not support this notion. As the accelerator level equations (section 4.1) indicate, there is no interest effect on aggregate investment. On the other hand, the growth equations do not show any significant negative relationship between growth and interest rates. It is, therefore, highly unlikely that there exists a long-term positive "level effect" of lower interest rates on GDP.

4. The "institutional" variables (freedom to invest, financial freedom) are not significant. It is beyond the scope of this paper to explore the reasons.

How could the missing inverse relationship between interest rates and investment be explained? One reason may be that a relatively large fraction of investment is not financed by bank loans, but is covered by internal funds due to an increased reluctance of becoming too dependent on bank loans. This argument gets some support at least for Germany when looking at the equity capital ratios of German small and medium sized firms (Mittelstand). From 2006 to 2018 the ratio increased from 24 percent to 32 percent (Statista, 2020). The corporate sector shows rising ratios since the late 1990s (Deutsches Aktieninstitut, 2013; KfW, 2018). A second argument may be incorporated in the shape of the theoretically downward sloped investment-interest demand curve. If we consider the standard textbook case of a linear relationship, the interest elasticity of investment approaches zero as the interest rate approaches zero. At already very low interest rates we may thus expect also a very low interest rate sensitivity of investment.

5. IS THE POLICY INTEREST RATE EXOGENOUS?

The above analysis takes the policy interest rate as an exogenous variable that is independently fixed by the central bank to promote growth, to smooth the business cycle and to pursue an inflation target. The supposed exogeneity can be questioned for two reasons. Firstly, central bank rates may follow a policy rule of a Taylor type. In this case, high growth rates will correspond to high policy interest rates thus creating a positive correlation between both variables. Alternatively, from a neoclassical growth theory viewpoint, the real interest rate is determined by productivity growth, time preference and presumably a risk parameter (Bundesbank, 2001; Klump & Reichel, 1994; Le Page, 2011). Policy rates then may follow real determinants. Theoretically, all three variables may be endogenous and rendering the expanded accelerator model a special (and maybe an incomplete) case. To test for potential endogeneity with special focus on the interest rate, we checked if there was a potential co-integrating relationship between the investment rate, the growth rate and the interest rate.

In a first step, the order of integration of each series was determined. We conducted four different unit root tests (Augmented Dickey-Fuller, Dickey-Fuller-GLS, KPSS, and Ng-Perron) and additionally tested for fractional integration. With respect to the interest rate, all unit tests uniformly showed that the series was integrated of order one (I(1)). Regarding the investment – GDP ratio, ADF and DF-GLS (Dickey-Fuller generalized least squares) indicate I(1), whereas KPSS (Kwiatkowski-Phillips-Schmidt-Shin) points to I(0), and NP to I(2). The real growth rate is consistently an I(0) series, i.e. stationary without differencing. Results in tabular form are presented in the appendix. Additional testing for fractional integration yields the following orders of integration: The estimated order for the interest rate is about 1.2, for the investment rate it is around 1.40 (Whittle estimator) and 1.53 (GPH test). Finally, we obtained test statistics of 0.61 (Whittle) and 0.67 (GPH, Geweke and Porter-Hudak) for real GDP growth. We can conclude that the interest rate and the investment rate are I(1), whereas real growth is likely to be I(0).

Specification of a vector error correction model according to Johansen/Juselius may now be recommended with the interest rate and the investment rate as endogenous variables and the real growth rate treated as exogenous in the short-run VAR (vector auto-regression) section. Philipps-Ouliaris as well as Johansen co-integration tests, however, reveal that there is no co-integrating relationship between interest rates and investment rates. All test statistics failed to exceed the corresponding critical values by far, thus rejecting cointegration (see Appendix 1, 2, 3). We, therefore, specified a VAR model with three lags, based on the SIC minimum (Karlsson, Behrenz, & Shukur, 2019) with the real growth rate and the first differences of the interest (D_IR) and the investment (D_(I/Y)) rate as endogenous variables. Block exogeneity Wald tests were then applied to find out whether the different variable coefficient groups exerted an influence on each of the dependent variables. Table 2 presents the results for the three dependent variables.

Table 2. VAR block exogeneity tests (F-values).

Dependent Variables →	D_IR	D_(I/Y)	g
Sum of D_IR lags	6.849***	0.313	4.408***
Sum of D_(I/Y) lags	5.267***	10.849***	2.325*
Sum of g lags	1.868	1.426	50.042***

Note: *, *** denotes rejection of Null of no joint impact at 10%, 1% levels of sig.

Regarding the endogeneity of the interest rate, it can be concluded that interest rates are not determined by growth rates as suggested by theory (Borio, Disyatat, Juselius, & Rungcharoenkitkul, 2017). There is, however, an impact on the investment-GDP ratio. As growth rates are positively related to the investment-GDP ratio and the investment ratio may be interpreted as a proxy for the state of an economy, it is likely that monetary policy authorities respond to decreasing investment ratios by lowering interest rates.

Turning to the main research question of this paper, the interest elasticity of investment, our results revealed no significant impact of interest rates on investment. The corresponding impulse responses confirm the test result above, irrespective of the Cholesky variable ordering.

The (positive) interest rate effect on growth rates which has been not significant in the simultaneous equations framework is now apparent and calls for an explanation. The cause is rooted in the different specifications of the VAR and the simultaneous equations model (SEM). The VAR introduces different restrictions to the simultaneous model and does not include variables that proved significant, such as the annual dummies and the (current and lagged) investment-GDP ratios. On the other hand, the SEM does not include all the lags of the VAR's endogenous variables. Re-estimation of an expanded VAR including the exogenous variables of the SEM revealed a significant positive coefficient of the interest rate lagged one quarter compared to an interest rate coefficient (no lag, which is not significant in the SEM (see Table 1). However, the Null hypothesis that the sum of all interest rate coefficients is zero cannot be rejected by a Wald test. Therefore, the seemingly contradictory result of an interest rate impact on growth can be explained by specification issues in our case.

6. SUMMARY AND CONCLUSIONS

In this paper we have explored the empirical effects of interest rates on aggregate investment. Single equation as well as simultaneous equations methods were applied to estimate an augmented accelerator model of aggregate investment in levels terms as well as GDP shares. The main findings are as follows: Income as an investment determinant consistently proves significant thus confirming the accelerator hypothesis. Institutional factors such as freedom to invest or financial freedom do not have an impact on investment. Regarding the central hypothesis of a positive interest elasticity of investment, the results are surprising. Contrary to the traditional belief that lowering interest rates boosts investment, our results showed that those claims do not receive empirical support for the Euro zone. Macroeconomic investment is inelastic to interest rate changes.

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https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=MNA.Q.Y.I8.W2.S1.S1.B.B1GQ._Z._Z._Z.EUR.V.N (gross domestic product)

https://www.bundesbank.de/dynamic/action/de/statistiken/zeitreihen-datenbanken/zeitreihen-datenbank/723452/723452?tsId=BBK01.SU0304 (converted to quarterly)

https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html (ECB key rates)

https://sdw.ecb.europa.eu/quickview.do?org.apache.struts.taglib.html.TOKEN=8e0534ec3169e6e725c673f5c516d5ef&SERIES_KEY=143.FM.Q.U2.EUR.4F.MM.EONIA.HSTA&resetBtn=+Reset+Settings&start=&end=&trans=N (EONIA interest rate)

Appendix 1. Unit root tests (with intercept).

ADF test				
Investment – GDP ratio	1% CV = -3.51	Level = -1.16	1. Diff. = -13.76	→ I(1)
Interest Rate		Level = -1.63	1. Diff. = -4.44	→ I(1)
Growth Rate		Level = -4.18		→ I(0)
DF – GLS test				
Investment – GDP ratio	1% CV = -2.59	Level = -1.04	1. Diff. = -3.15	→ I(1)
Interest Rate		Level = -1.29	1. Diff. = -3.28	→ I(1)
Growth Rate		Level = -4.01		→ I(0)
KPSS test				
Investment – GDP ratio	1% CV = 0.74	Level = 0.597		→ I(0)
Interest Rate		Level = 0.998	1. Diff. = 0.048	→ I(1)
Growth Rate		Level = 0.169		→ I(0)
Ng-Perron test (only MZa test reported)				
Investment – GDP ratio	1% CV = -13.8	Level = -2.04	1. Diff. = -5.75	→ I(2)
Interest Rate		Level = -4.58	1. Diff. = -17.2	→ I(1)
Growth Rate		Level = -28.2		→ I(0)

Appendix 2. Phillips-Ouliaris co-integration test.

Series: INTEREST IQ
Sample (adjusted): 1999Q1 2019Q4
Included observations: 84 after adjustments
Null hypothesis: Series are not cointegrated
Cointegrating equation deterministic component: constant C
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth)
No d.f. adjustment for variances

Dependent	tau-statistic	Prob.*	z-statistic	Prob.*
INTEREST	-0.931	0.914	-4.280	0.784
Investment Rate IQ	-1.673	0.691	-8.983	0.408

Note: *MacKinnon (1996) p-values.

Appendix 3. Johansen cointegration test

Sample (adjusted): 2000Q1 2019Q4
Included observations: 80 after adjustments
Trend assumption: Linear deterministic trend
Series: INTEREST IQ
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value 0.05	Prob.**
None	0.061	5.592	15.495	0.743
At most 1	0.007	0.553	3.841	0.457

Note: Trace test indicates no cointegration at the 0.05 level.
**MacKinnon, Haug, and Michelis (1999) p-values.

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**Critical Value 0.05**	**Prob.****
None	0.061	5.039	14.265	0.737
At most 1	0.007	0.553	3.841	0.457

Note: Max-eigenvalue test indicates no cointegration at the 0.05 level.
**MacKinnon et al. (1999) p-values.