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International Evidence on the Interest Rate Effect in Dynamic IS Curves

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ABSTRACT
A number of studies have found little evidence of the effect of the interest rate in dynamic IS curves. We show that this is due to de-trending. The interest rate has a weak effect on the output gap even when controlling for wealth effects. However, when the IS curve is formulated in an error-correction form, we find a significant interest rate effect. Furthermore, we find that the nominal interest rate explains output dynamics better. Lastly, there are significant effects of long-term interest rates in emerging markets, which may justify the use of yield curve control policies in these economies.

KEYWORDS
Output gap; interest rate; IS curve; backward looking

JEL
C12; C2; E1

1. Introduction

This paper investigates the role of the interest rate in the dynamics of output, modeled in the form of the reduced form IS curve similar to that of Rudebusch and Svensson (1999). The view that the interest rate negatively affects output is standard in a number of monetary models, especially the ones that assume central banks use the nominal short-term interest rate as a policy instrument. The early models of inflation targeting such as those of Svensson (1997) and those that are in the collection by Taylor (1999) express this view. The small-scale new Keynesian models beginning with Clarida, Gali, and Gertler (1999) base their output dynamics on the consumption Euler which, when re-arranged, implies a negative real interest rate effect on output. DSGE models beginning with Rotemberg and Woodford (1997) and later Smets and Wouters (2003) all specify aggregate expenditure equations in which the real interest rate negatively affects the output gap.

Given the significance of the negative relationship between the interest rate and output in the transmission of monetary policy, Blinder (1997) mentions that the empirical strength of this relationship is "a bit of an embarrassment." The sensitivity of expenditures, especially business fixed investment is, according to Blinder, "at best, equivocal." Nelson (2001) does not find a significant negative interest rate effect for the UK in the backward-looking IS curve, leading to the finding that there is an "IS puzzle." Fair (2004) estimates expenditure equations for a number of countries and concludes that it is the nominal interest rate, not the real interest rate, which significantly affects expenditures. However, Fair's formulation is not a reduced form IS curve. Kara and Nelson (2004) investigate the stability of IS curves and find that "the backward-looking equations uniformly deliver positive or virtually zero interest-elasticity estimates when output is detrended by HP filtering or by broken trends." A similar finding is by Hafer and Jones (2008), who note that the real interest rate tends not to be significant in advanced economies, except for the US.

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Influential work on the backward-looking IS curve suggests that the baseline reduced-form of Rudebusch and Svensson (1999), is mis-specified because it omits important variables that affect output. On this basis, Goodhart and Hoffman (2005) extend the IS curve to include real house prices, real equity prices and real money supply. They find that the real interest rate has a significant and negative effect on output when the IS curve is extended along these lines. A related study is by Paradiso, Kumar, and Rao (2013) for the case of Australia. These authors find that the real interest rate has a significant negative relationship when the IS curve is extended to include the variables mentioned by Goodhart and Hoffman (2005).

In this paper, we make three contributions. Firstly, we provide a critical review of the recent literature on the IS curve by pointing out the inconsistency in the formulation of reduced form IS curves. Secondly, most of the studies on dynamic IS curves focus on advanced economies. We close this gap in the literature by extending the analysis to emerging market economies. This is important especially because inflation targeting in these economies is conducted using versions of the Quarterly Projection Model of the IMF formulated by Berg, Karam, and Laxton (2006). Such a model assumes a negative interest rate effect on the output gap. Thirdly, we propose an alternative explanation for the IS puzzle. This explanation leads us to formulate a reduced-form IS curve with significant negative interest rate effects, without the extensions that are suggested by recent literature. Following Goodhart and Hoffman (2005) and Hafer and Jones (2008), we conduct the study within the framework of the backward-looking IS curve.

More importantly, our main contributions to the existing literature follow from testing the following hypothesis: a) the relationship between output and the real short-term interest rate is negative and significant; b) the relationship between output and the nominal short-term interest rate is negative and significant; c) the relationship between output and the real long term interest rate is negative and significant; d) the relationship between output and the nominal long term interest rate is negative and significant; e) the error-correction version of the IS curve explains better the relationship between output and interest rates.

The structure of the paper is as follows: section 2 provides critical review of the recent literature on IS curves, section 3 outlines the theoretical framework of the paper, section 4 provides the analysis of the empirical results and section 5 is the conclusion.

2. Literature Review

Nelson (2001) is perhaps the first author to notice that reduced form IS curves contain a puzzle: the real interest rate did not have significant negative effects on the output gap in the UK. Nelson and Nikolov (2004) find a positive and insignificant effect of the real interest rate on the output gap. Among the explanations of such a puzzle, Nelson (2001) mentions: a) the endogeneity of monetary policy, b) the absence of forward-looking behavior, c) a failure to account for other variables such as real exchange rates and foreign output, d) sharp changes in the mean real interest rate and e) the exclusion of asset prices that theoretically affect output. Nelson (2001) does not consider the first four explanations as powerful to account for the IS puzzle. However, the last one—exclusion of asset prices offers a promising avenue.

It is in this context that the study by Goodhart and Hoffman (2005) appears. These authors proceed from a basic argument that the exclusion of relevant variables in the reduced-form IS curve would bias the estimate of the parameter on the real interest rate. If for example, the excluded variable is positively related to the real interest rate, the reduced-form estimate of the interest rate parameter would be biased downwards, even toward zero. This provides the basic motivation to extend the reduced-form IS curve specification of Rudebusch and Svensson (1999) to include asset prices such as real house prices and real equity prices, and real money balances. The same extension is found in Paradiso, Kumar, and Rao (2013) in the case of Australia and in the study by Hafer and Jones (2008) only real money balances are included.

The first problem with the empirical aspects of these studies is that the results are not robust to de-trending methods. Kara and Nelson (2004) address this issue because they estimate IS curves for output gaps derived from quadratic de-trending, the Hodrick-Prescott filter and the broken trend methods. They find that for Australia, the results are not robust to alternative de-trending methods. Paradiso, Kumar, and Rao (2013) obtain the same result. They use two types of output gaps: one is based on unobserved components and the other is based on quadratic de-trending. The results show that quadratic de-trending delivers IS curves that have a significant negative interest rate effect, whereas the output gap based on unobserved components delivers poor results. The results in Goodhart and Hoffman (2005) are based on output gaps derived from the Hodrick-Prescott filter. They did not test if the results are robust to alternative de-trending methods.

Hafer and Jones (2008) raise the second problem with the studies. They note that the left hand side is the output gap while the right hand side is the growth rate of real money or in the case of Paradiso, Kumar, and Rao (2013), and Goodhart and Hoffman (2005), the growth rate of real asset prices. Their concern is to come up with an intuitive interpretation of the co-efficient on the real growth rates, which they provide under the questionable assumption that the sum of the lagged co-efficient on the output gap is 1. However, the main problem, which they do not discuss, is how is it that the output gap is determined by a rate of growth of another variable, without any level effects of the latter variable? We show below that it is not theoretically possible to specify rates of growth without level effects, although it is possible to specify level effects without rates of growth.

Lastly, the literature has broadly emphasized the need for filtering in order to arrive at gap variables. The problem with filtering is that the results obtained from one method of de-trending may not be obtained when an alternative de-trending method is used. Specifically, if processes of different orders drive trend variables, this may bias estimates of parameters of interest toward zero. To illustrate this point, assume that for each observation t the following simple relationship holds:

$$z_t = \kappa x_t \tag{1}$$

Let z_t^* and x_t^* denote trend variables. In particular, assume that trend variables evolve according to the following processes, having abstracted from shocks:

$$z_t^* = \psi_1 z_{t-1}^* + \psi_2 z_{t-2}^* + \in_{zt} \tag{2}$$

and:

$$x_t^* = x_{t-1}^* + \in_{xt} \tag{3}$$

De-trending assumes that the relation in equation (1) holds even when variables are at their trends. Therefore, we can write equation (1) in gap terms as follows:

$$z_t - z_t^* = \kappa\left(x_t - x_t^*\right) + \xi_t \tag{4}$$

where $\xi_t = \in_{xt} - \in_{zt}$. Substituting equations (2) and (3) into equation (4) we obtain:

$$z_t - \psi_1 z_{t-1}^* - \psi_2 z_{t-2}^* = \kappa\left(x_t - x_{t-1}^*\right) + \xi_t \tag{5}$$

Now, note from equation (1) and equation (5) that:

$$\kappa x_t - \psi_1 \kappa x_{t-1}^* - \psi_2 \kappa x_{t-2}^* = \kappa\left(x_t - x_{t-1}^*\right) + \xi_t \tag{6}$$

From equation (6) we observe that there is no term that is associated with x_{t-2}^* on the right-hand side. For the equation to balance κ should therefore be equal to zero. Alternatively, as pointed out by Gujarati and Porter (2009: Chapter 13), the standard errors for the estimate of κ will be larger, making the estimate not significant. Suppose now that z_t follows an AR (1) process and x_t follows an AR (2) process. Specifically suppose:

$$z_t^* = z_{t-1}^* + \in_{zt} \tag{7}$$

and:

$$x_t^* = \rho_1 x_{t-1}^* + \rho_2 x_{t-2}^* + \in_{xt} \tag{8}$$

equation (4) can be written as:

$$\kappa x_t - \kappa x_{t-1}^* = \kappa\left(x_t - \rho_1 x_{t-1}^* + \rho_2 x_{t-2}^*\right) + \xi_t \tag{9}$$

Once again, there is no term associated with x_{t-2}^* on the left-hand side, which implies that κ should equal zero. Lastly, suppose that z_t^* evolves according to equation (7) and that $x_t^* = x^* + \in_{xt}$, a constant. This means that:

$$z_t - z_t^* = \kappa(x_t - x^*) + \xi_t \tag{10}$$

Equation (10) implies that at the steady state z_t^* is no longer a random walk as in equation (7), but it is a constant κx^*. This point is especially relevant to the review of the literature, because many authors tend to assume that the steady state interest rate is constant. The above examples show that, given different orders for the processes that drive the trend variables, the estimates of the parameters of interest are likely to be biased toward zero.

3. Theoretical Framework

We now proceed to derive the backward-looking IS curve from the old Keynesian expenditure function. To crystallize the ideas in such a way as to link them with the specification in Goodhart and Hoffman (2005) and Paradiso, Kumar, and Rao (2013), write the reduced-form aggregate demand function as follows:

$$D_t = D\left(Y_t, (i_t - \pi_t)\frac{B_t}{P_t}, \frac{M_t + P_t^s E}{P_t}, Q_t^{\varphi} Y_t^{f\phi}\right) \tag{11}$$

Equation (11) is similar to the reduced-form private sector expenditure function in Tobin (1975) and later Turnovsky (1995) among others. It says aggregate expenditure is positively related to income Y_t. The second term captures the negative effect of the real burden of interest payments on debt, where $(i_t - \pi_t)$ is the real interest rate, i_t is the nominal interest rate, π_t is the inflation rate, B_t is nominal debt and P_t is the price level. The third term captures positive effects of private wealth on aggregate expenditure. Private wealth is made up of real money holdings and equity holdings, where M_t is nominal money holdings, P_t^s is the equity price and E is the number of shares outstanding. The fourth term captures the positive effects of net exports on aggregate expenditure, where the real exchange rate is Q_t and foreign output is Y_t^f.

We then assume a Keynesian output adjustment rule, where output changes in response to the excess of aggregate demand over output as follows:

$$\begin{aligned} Y_t - Y_{t-1} = {} & \beta\left[D\left(Y_{t-1}, (i_{t-1} - \pi_{t-1})\frac{B_{t-1}}{P_{t-1}}, \frac{M_{t-1} + P_{t-1}^s E}{P_{t-1}}, Q_{t-1}^{\varphi} Y_{t-1}^{f\phi}\right) - Y_{t-1}\right] + \theta(Y_{t-1} - Y_{t-2}) \\ & + \delta\left(\frac{M_{t-1}}{P_{t-1}} - \frac{M_{t-2}}{P_{t-2}}\right) + \lambda E\left(\frac{P_{t-1}^s}{P_{t-1}} - \frac{P_{t-2}^s}{P_{t-2}}\right) \end{aligned} \tag{12}$$

In equation (12) we assume that there is momentum in output adjustment and in components of private wealth. We now perform a first-order Taylor expansion on equation (12) to obtain the following equation:

$$\begin{aligned} y_t = {} & \left(\frac{Y^*_{t-1}}{Y^*_t}\right)[1+\beta(D_Y-1)+\theta]y_{t-1} - \theta\left(\frac{Y^*_{t-2}}{Y^*_t}\right)y_{t-2} - \beta\frac{D_r\widetilde{\mathrm{B}}^*_{t-1}}{Y^*_t}(i_{t-1}-\pi_{t-1}-r^*_{t-1}) \\ & - \beta\frac{D_r\widetilde{\mathrm{B}}^*_{t-1}}{Y^*_t}b_{t-1} + \left(\frac{P^{s*}_{t-1}E}{Y^*_t}\right)(\beta D_w+\lambda)p^s_{t-1} + \frac{\widetilde{\mathrm{M}}^*_{t-1}}{Y^*_t}(\beta D_w+\delta)m_{t-1} - \delta\frac{\widetilde{\mathrm{M}}^*_{t-2}}{Y^*_t}m_{t-2} \\ & - \lambda\frac{\widetilde{\mathrm{P}}^{s*}_{t-2}E}{Y^*_t}p^s_{t-2} + \beta\varphi D_q\left(\frac{Q^{*\varphi}Y^{f\phi}_{t-1}}{Y^*_t}\right)q_{t-1} + \beta\phi D_x\left(\frac{Q^{*\varphi}Y^{f*\phi}_{t-1}}{Y^*_t}\right)y^f_{t-1} \end{aligned} \tag{13}$$

In equation (13) the lower case letters denote percentage deviations from the steady state, "~" denotes the real variable and (*) denotes the steady state value of the relevant variable and D_x is the absolute value of the response of expenditure to changes in the variable x_t. We assume that at the steady state the growth rate of output is γ, the debt-output ratio is ϕ_b, velocity is ϕ_m and the ratio of stock market capitalization to output is ϕ_s. We can write equation (13) as follows:

$$\begin{aligned} y_t = {} & \left[\frac{1+\theta+\beta(D_Y-1)}{(1+\gamma)}\right]y_{t-1} - \frac{\theta}{(1+\gamma)^2}y_{t-2} - \left(\frac{\beta D_r\phi_b}{1+\gamma}\right)(i_{t-1}-\pi_{t-1}-r^*_{t-1}) - \left(\frac{\beta D_r r^*\phi_b}{1+\gamma}\right)b_{t-1} \\ & + \frac{\phi_s(\beta D_w+\lambda)}{1+\gamma}p^s_{t-1} + \frac{\phi_m}{1+\gamma}(\beta D_w+\delta)m_{t-1} - \frac{\delta\phi_m}{(1+\gamma)^2}m_{t-2} - \frac{\lambda\phi_s}{(1+\gamma)^2}p^s_{t-2} \\ & + \beta\varphi D_q(\frac{Q^{*\varphi}Y^{f\phi}_{t-1}}{Y^*_t})q_{t-1} + \beta\phi D_x(\frac{Q^{*\varphi}Y^{f*\phi}_{t-1}}{Y^*_t})y^f_{t-1} \end{aligned} \tag{14}$$

Now, in order to derive IS curves of the reduced-form that is found in the literature, we have to assume firstly, that $b_t = \xi^b_t$. This leads us to the following IS curve:

$$\begin{aligned} y_t = {} & [\frac{1+\theta+\beta(D_Y-1)}{(1+\gamma)}]y_{t-1} - \frac{\theta}{(1+\gamma)^2}y_{t-2} - (\frac{\beta D_r\phi_b}{1+\gamma})(i_{t-1}-\pi_{t-1}-r^*_{t-1}) \\ & + \frac{\phi_m}{1+\gamma}(\beta D_w+\delta)\Delta m_{t-1} - [\frac{\phi_m}{1+\gamma}(\beta D_w+\delta) + \frac{\delta\phi_m}{(1+\gamma)^2}]m_{t-2} + \frac{\phi_s(\beta D_w+\lambda)}{1+\gamma}\Delta p^s_{t-1} \\ & - [\frac{\phi_s(\beta D_w+\lambda)}{1+\gamma} + \frac{\lambda\phi_s}{(1+\gamma)^2}]p^s_{t-2} + \beta\varphi D_q(\frac{Q^{*\varphi}Y^{f\phi}_{t-1}}{Y^*_t})q_{t-1} + \beta\phi D_x(\frac{Q^{*\varphi}Y^{f*\phi}_{t-1}}{Y^*_t})y^f_{t-1} + \tilde{\xi}^b_t \end{aligned} \tag{15}$$

where $\tilde{\xi}^b_t = \left(\frac{\beta D_r r^*\phi_b}{1+\gamma}\right)\xi^b_t$. Next, we observe that rates of growth in equation (15) are intimately connected with their relevant levels, with lag 2. It is not possible to specify the rates of change without the levels. For example, if p^s_{t-2} is to disappear from equation (15) then we require that $\phi_s = 0$. However, this requirement also makes the rate of change Δp^s_{t-1} to disappear. This is the inconsistency, which affects the literature when it specifies rates of change without the levels. On the other hand, by setting $\lambda = \delta = 0$, we can obtain an IS curve without rates of change effects. In compact form, we can write the IS curve as follows:

$$\begin{aligned} y_t = {} & \alpha_{1y}y_{t-1} - \alpha_{2y}y_{t-2} - \alpha_r\left(i_{t-1}-\pi_{t-1}-r^*_{t-1}\right) + \alpha_q q_{t-1} + \alpha_{y^f}y^f_{t-1} + \alpha\Delta m_{t-1} + \alpha_{\Delta p}\Delta p^s_{t-1} - \alpha_m m_{t-2} \\ & - \alpha_p p^s_{t-2} + \tilde{\xi}^b_t \end{aligned} \tag{16}$$

where α_x is the parameter associated with variable x in equation (16). Equation(16) is an open economy IS curve, which includes financial variables similar to Borio, Disyatat, and Juselius (2017). We know theoretically that it is not possible to drop level variables and retain rates of changes in equation (16). Therefore, in testing whether adding variables that capture private wealth effects improves the IS curve, we have to run equation (16). A version that can be investigated is when the IS curve features level effects of the private wealth variables, without rates of change. In this case, the IS curve becomes:

$$y_t = \alpha_{1y}y_{t-1} - \alpha_{2y}y_{t-2} - \alpha_r\left(i_{t-1} - \pi_{t-1} - r^*_{t-1}\right) + \alpha_q q_{t-1} + \alpha_{y^f}y^f_{t-1} + \alpha_{\mathrm{m}}m_{t-1} + \alpha_p p^s_{t-1} + \tilde{\xi}^b_t \quad (17)$$

Lastly, the most basic IS curve that is said to be inadequate switches off the wealth effects in equation (14), which is the case where $D_w = \lambda = \delta = 0$. The IS curve then becomes:

$$y_t = \alpha_{1y}y_{t-1} - \alpha_{2y}y_{t-2} - \alpha_r\left(i_{t-1} - \pi_{t-1} - r^*_{t-1}\right) + \alpha_q q_{t-1} + \alpha_{y^f}y^f_{t-1} + \tilde{\xi}^b_t \quad (18)$$

We therefore estimate equations (16)—(18) and we also include the version that is estimated by Goodhart and Hoffman (2005) and Paradiso, Kumar, and Rao (2013). In order to show that de-trending creates problems for IS curve estimations, we present the results for an "error-correction" type model. The reason for this is that, since the above equations are percent deviations from trend, we can approximate their level forms by log-linear equations.

4. Empirical Analysis

4.1. The Output Gap Version of the IS Curve Using the Real Interest Rates

In order to estimate the backward looking IS curve, we use data from the Federal Reserve Bank of St. Louis (FRED) database. The data is quarterly, comprising of real GDP to measure output, the Treasury bill rate measures the short-term interest rate, the US real GDP captures foreign output for many of the countries. In terms of de-trending, we use the HP-filter. The results for the quadratic trend filtering method are not different from those obtained from the HP filter and so they are not reported. Among the emerging markets, for Turkey we could not find 10-year government bond yields as a measure of the long-term interest rate. Data for India was relatively short, starting in 2012. Therefore, when the short-term interest rate is used in the IS estimation, we consider data from Turkey and when long-term interest rates are used, we consider data from India. In addition, we have presented unit root test results for the variables, and BDS test results on a few specifications. To save space, these results are presented and interpreted in Appendix A.

Table 1 provides estimates of equation (16). The real short-term interest rate enters this IS curve. We observe that only for two of the advanced economies, the IS relationship exists. For the rest of the economies, it does not. The real interest rate exhibits a positive sign, and it is largely not significant. For emerging markets, the results are different, most of the economies exhibit the IS relationship, except for two economies. Overall, therefore, we conclude that this specification of the IS curve does not fit the data for most of the advanced economies, although it does for most of the emerging markets.

We also test the specification used by Goodhart and Hoffman (2005) and Paradiso, Kumar, and Rao (2013). The results for this specification are presented in Table A2 of Appendix A. Once again, we conclude that, for many of the advanced economies, this specification of the IS curve does not fit the data, although it works for emerging markets. Now that we have found that the specification that features rates of change of real money and share price does not fit the data, we proceed to test whether a specification that features only the gaps of these variables fits the data. We report the results for this specification in Table A3 of appendix A. Although a number of countries exhibit a negative sign on the real interest rate parameter, the parameter nevertheless remains insignificant.

Now that we have found that the real short term interest rate is not significant in driving the output gap, it may be argued that the real short term interest rate is not the appropriate variable to use in estimating IS curves. Durable expenditures are financed through long-term debt instruments such as mortgage loans, fixed capital equipment is also financed through long term loans therefore it may be appropriate to consider the possible effect of the long-term interest rate on aggregate expenditure. To estimate the IS curve using the long-term interest rate, we use the 10-year government bond yield to measure the long rate. Table 2 shows that using the real long rate does not improve the results either. For advanced economies only Iceland and the EU exhibit a negative and significant sign on the real long rate. For other economies the sign is mostly positive, and therefore wrong. The same pattern of

Table 1. Estimates of the IS curve (real short rate), equation (16).

	Advanced Markets							
	Aus.	Can.	EU.	Jap.	NZ	Norway	UK	US
Sample	`72-`19	`79-`19	`96-`19	`94-`19	`94-`19	`94-`19	`88-`19	`95-`19
c	−0.00	−0.00	0.00	0.00**	−0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
y_{t-1}	0.67*	0.96*	0.58*	0.69*	0.62*	0.04	1.18*	0.76*
	(0.08)	(0.08)	(0.15)	(0.09)	(0.15)	(0.09)	(0.13)	(0.11)
y_{t-2}	−0.10	−0.26*	0.16	0.01	−0.14	−0.06	−0.38*	−0.02
	(0.08)	(0.07)	(0.15)	(0.13)	(0.12)	(0.09)	(0.15)	(0.12)
$\tilde{r}_{t-1}$	0.09*	0.02	0.15	0.12	0.05	−0.24*†	−0.14*	0.07
	(0.04)	(0.04)	(0.13)	(0.23)	(0.11)	(0.14)	(0.06)	(0.05)
y^f_{t-1}	0.07	0.09	0.23*	−0.04	−0.18*	0.11	0.13*†	−0.01
	(0.05)	(0.06)	(0.06)	(0.13)	(0.08)	(0.14)	(0.06)	(0.04)
q_{t-1}	−0.01	−0.01	0.00	−0.00	0.02	−0.01	0.01	−0.03**
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)
Δp^s_{t-1}	−0.00	0.00	–	0.01	−0.00	0.00	0.00	0.00
	(0.01)	(0.00)	–	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)
Δm_{t-1}	0.05*	0.07*	0.05	−0.07	0.04	−0.10*	0.03*	−0.03
	(0.02)	(0.02)	(0.05)	(0.16)	(0.04)	(0.04)	(0.01)	(0.04)
p^s_{t-2}	0.02*	0.01	–	0.01	0.03**	0.02*	0.00	0.02**
	(0.01)	(0.01)	–	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
m_{t-2}	−0.02	−0.05**	0.12	0.04	−0.04	0.26*	−0.02**	0.10*
	(0.03)	(0.03)	(0.11)	(0.12)	(0.06)	(0.07)	(0.01)	(0.04)

	Emerging Markets							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
Sample	`97-`19	`97-`19	`96-`19	`93-`19	`95-`19	`71-`19	`94-`19	`98-`19
c	0.00	0.00	0.00	0.00	0.00**	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
y_{t-1}	0.72*	0.89*	1.26*	0.80*	0.34*	0.82*	0.44*	0.58*
	(0.08)	(0.10)	(0.16)	(0.12)	(0.10)	(0.11)	(0.21)	(0.10)
y_{t-2}	−0.08	−0.28*	−0.36*	−0.28*	0.21*	−0.08	−0.15*	0.06
	(0.09)	(0.10)	(0.15)	(0.09)	(0.09)	(0.11)	(0.10)	(0.11)
$\tilde{r}_{t-1}$	0.03	−0.11*	−0.04	0.01	−0.23*†	−0.06*	−0.22*†	−0.10**
	(0.02)	(0.06)	(0.05)	(0.04)	(0.11)	(0.03)	(0.10)	(0.06)
y^f_{t-1}	−0.28*	0.19*	−0.01	0.29**	−0.33*	0.07	−0.44*	0.36
	(0.10)	(0.09)	(0.08)	(0.17)	(0.13)	(0.05)	(0.16)	(0.30)
q_{t-1}	0.00	−0.04*	−0.04*	0.06*	−0.01	0.02*	0.09*	−0.01
	(0.01)	(0.01)	(0.02)	(0.03)	(0.02)	(0.01)	(0.03)	(0.04)
Δp^s_{t-1}	0.02*	0.00	0.01	0.00	−0.00	−0.01*	−0.01	0.02**
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Δm_{t-1}	−0.09	−0.02	0.00	0.06*	0.03	0.08*	0.06	−0.01
	(0.08)	(0.05)	(0.00)	(0.02)	(0.05)	(0.02)	(0.06)	(0.03)
p^s_{t-2}	0.01	0.03*	0.01	−0.02	0.05*	0.16*	0.05*	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)
m_{t-2}	0.18*	0.14*	−0.00	−0.16*	0.11*	−0.01	0.02	−0.10**
	(0.07)	(0.07)	(0.03)	(0.07)	(0.05)	(0.02)	(0.09)	(0.05)

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%, †4-quarter moving average, ‡8-quarter moving average.

results holds for emerging markets, many of these economies do not accept output gap version of the IS curve where the real long rate is the variable of interest.

Based on the above results, we conclude that the output gap version of the IS curve in which the real interest rate is used is broadly rejected by the data for both advanced and emerging market economies. This result is in contrast to the one in Goodhart and Hoffman (2005), who found that augmenting the baseline IS curve of Rudebusch and Svensson (1999) with asset prices and real money holdings helps generate the significant and negative relationship between the interest rate and the output gap.

Table 2. Estimation of the IS curve (real long rate), equation (16).

	Advanced Markets								
	Aus.	Can.	EU.	Jap.	NZ	US	UK	Norway	Iceland
Sample	\`72-\`19	\`79-\`19	\`96-\`19	\`94-\`19	\`97-\`19	\`80-\`19	\`87-\`19	\`93-\`19	\`95-\`20
c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
y_{t-1}	0.71*	0.92*	0.62*	0.61*	0.88*	0.96*	1.14*	0.12	0.04
	(0.09)	(0.08)	(0.14)	(0.12)	(0.08)	(0.07)	(0.10)	(0.10)	(0.09)
y_{t-2}	−0.08	−0.29*	0.17	0.01	−0.18*	−0.21*	−0.27*	0.06	0.21*
	(0.08)	(0.06)	(0.14)	(0.12)	(0.06)	(0.07)	(0.10)	(0.09)	(0.08)
$\widetilde{RR}_{t-1}$	0.09*	0.08**	0.38*	0.05	−0.09	−0.06	0.07	−0.03	0.09
	(0.04)	(0.04)	(0.12)	(0.10)	(0.08)	(0.05)	(0.05)	(0.07)	(0.13)
p^s_{t-1}	0.02*	0.02*	–	0.02*	0.00	0.02*	0.00	0.03*	0.02*
	(0.00)	(0.01)	–	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)
m_{t-1}	0.02	−0.08*	0.03	0.13	0.06**	0.09*	−0.01	0.06*	0.07*
	(0.02)	(0.03)	(0.12)	(0.09)	(0.03)	(0.04)	(0.01)	(0.03)	(0.05)
y^{US}_{t-1}	0.07	0.17*	0.31*	0.00	0.10	–	0.05	−0.11	0.51
	(0.05)	(0.06)	(0.07)	(0.10)	(0.10)	–	(0.06)	(0.14)	(0.31)
q_{t-1}	−0.01	−0.03*	0.01	0.00	0.00	0.00	0.00	−0.01	0.05
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.04)
g_{t-1}	−0.03	−0.09*	–	0.11	−0.25*	−0.11*	−0.04**	−0.03	0.06
	(0.03)	(0.03)	–	(0.10)	(0.04)	(0.05)	(0.02)	(0.03)	(0.12)
$\bar{R}^2$	0.67	0.90	0.82	0.81	0.78	0.88	0.94	0.56	0.56
	Emerging Markets								
	Brazil	Chile	Czech	India	Mexico	Poland	Russia	SA	S. Korea
Sample	\`96-\`19	\`04-\`19	\`01-\`19	\`12-\`19	\`01-\`18	\`99-\`19	\`03-\`18	\`93-\`19	\`01-\`21
c	0.00	0.00	0.00	0.00	0.00	0.00	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
y_{t-1}	0.75*	0.74*	1.02*	1.13*	0.97*	0.54*	0.88*	0.93*	0.76*
	(0.14)	(0.10)	(0.09)	(0.12)	(0.10)	(0.12)	(0.07)	(0.13)	(0.10)
y_{t-2}	−0.10	−0.32*	−0.12	−0.06	−0.26*	0.25	0.02	−0.15	−0.20*
	(0.13)	(0.12)	(0.08)	(0.14)	(0.08)	(0.10)	(0.05)	(0.11)	(0.08)
$\widetilde{RR}_{t-1}$	0.05*	0.00	0.07	−0.01*	−0.09	0.21**	0.002*	0.03	0.19*
	(0.02)	(0.08)	(0.06)	(0.00)	(0.07)	(0.12)	(0.00)	(0.02)	(0.08)
p^s_{t-1}	0.03*	0.03*	0.01*	0.04*	0.02*	0.03*	0.02*	0.02	0.02*
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
m_{t-1}	0.04	0.17*	0.01	0.10	−0.04	0.03	0.03	−0.03	0.03
	(0.04)	(0.07)	(0.01)	(0.06)	(0.03)	(0.04)	(0.03)	(0.02)	(0.04)
y^{US}_{t-1}	−0.09	0.49*	0.13	−0.15	0.29*	−0.15	−0.20*	0.07	−0.07
	(0.07)	(0.15)	(0.08)	(0.27)	(0.12)	(0.12)	(0.10)	(0.08)	(0.06)
q_{t-1}	0.00	−0.02	−0.02	−0.07**	−0.01	−0.04*	0.03*	0.01	0.01
	(0.01)	(0.03)	(0.02)	(0.04)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
g_{t-1}	0.04	−0.02	0.04	0.00	0.07	−0.04	0.01	0.00	−0.06
	(0.05)	(0.04)	(0.05)	(0.00)	(0.04)	(0.06)	(0.02)	(0.01)	(0.07)
$\bar{R}^2$	0.77	0.88	0.97	0.98	0.94	0.78	0.99	0.88	0.80

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%, †4-quarter moving average, ‡8-quarter moving average.

4.2. *The Output Gap Version of the IS Curve Using Nominal Interest Rates*

One of the specifications that is explored by Goodhart and Hoffman (2005) features the nominal interest rate separately specified from the inflation rate. Fair (2004: Chapter 3) argues that the nominal interest rate could be the relevant variable because agents could form inflation expectations by assuming that $\pi^e_t = \pi^*$, thereby making variations in the real interest rates to be wholly due to the nominal interest rate. In addition, the inflation rate could negatively affect aggregate expenditure by eroding the real value of private wealth. With these motivations of the nominal interest rate in the IS curve, Table 3 reports the results for the nominal short-term interest rate.

Table 3. Estimation of the IS curve (nominal short rate), equation (16).

	Advanced Markets								
	Aus	Canada	EU.	Japan	NZ	US	UK	Norway	Iceland
Sample	`72-`19	`72-`19	`96-`19	`94-`19	`95-`19	`80-`19	`87-`19	`93-`19	`96-`19
c	0.00	0.00	0.00*	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
y_{t-1}	0.70*	0.96*	0.82*	0.58*	0.78*	0.88*	1.12*	0.08	0.01
	(0.08)	(0.08)	(0.16)	(0.12)	(0.13)	(0.09)	(0.11)	(0.09)	(0.11)
y_{t-2}	−0.03	−0.26*	0.14	−0.04	−0.23**	−0.07*	−0.24**	0.05	0.17
	(0.07)	(0.07)	(0.13)	(0.13)	(0.13)	(0.10)	(0.13)	(0.08)	(0.10)
$\tilde{i}_{t-1}$	−0.08*†	−0.12*	−0.51*	−0.90**‡	−0.03	−0.14*†	−0.15*	−0.11	0.21
	(0.03)	(0.04)	(0.25)	(0.46)	(0.12)	(0.06)	(0.05)	(0.09)	(0.17)
p^s_{t-1}	0.02*	0.02*	–	0.02*	0.01	0.02*	0.01	0.04*	0.02**
	(0.00)	(0.01)	–	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
m_{t-1}	0.03*	−0.04	−0.05	0.20*	0.06	0.03	−0.01	0.09*	0.07
	(0.02)	(0.03)	(0.14)	(0.08)	(0.05)	(0.03)	(0.01)	(0.03)	(0.05)
y^{US}_{t-1}	0.06	0.18*	0.28*	0.04	−0.02	–	0.07	−0.11	0.62*
	(0.05)	(0.04)	(0.10)	(0.11)	(0.10)	–	(0.06)	(0.12)	(0.23)
q_{t-1}	0.00	−0.01	0.02	−0.01	0.00	0.00	0.01	−0.01	0.07
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)	(0.06)
g_{t-1}	−0.04	−0.08*	–	0.07	−0.21*	−0.11*	−0.05**	−0.03	0.04
	(0.03)	(0.03)	–	(0.09)	(0.07)	(0.04)	(0.02)	(0.03)	(0.12)
$\bar{R}^2$	0.70	0.90	0.78	0.81	0.67	0.87	0.91	0.65	0.60
	Emerging Markets								
	Brazil	Chile	Czech	Mexico	Poland	Russia	S. Kor.	SA	Turkey
Sample	`93-`19	`98-`19	`96-`19	`93-`19	`95-`19	`03-`19	`94-`21	`93-`19	`98-`19
c	0.00	0.00*	0.00	0.00	0.00	0.00*	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
y_{t-1}	0.83*	0.84*	1.19*	0.78*	0.35*	0.71*	0.72*	0.90*	0.60*
	(0.11)	(0.08)	(0.16)	(0.08)	(0.12)	(0.12)	(0.08)	(0.12)	(0.11)
y_{t-2}	−0.14	−0.18*	−0.30*	−0.12	0.24*	0.13	−0.10	−0.22	−0.06
	(0.11)	(0.09)	(0.11)	(0.08)	(0.09)	(0.11)	(0.07)	(0.09)	(0.10)
$\tilde{i}_{t-1}$	−0.03	−0.20*	−0.09*	−0.01	−0.15*	0.00	−0.11*	0.05**	−0.14*
	(0.03)	(0.06)	(0.03)	(0.03)	(0.06)	(0.00)	(0.05)	(0.03)	(0.07)
p^s_{t-1}	0.02*	0.02*	0.01*	0.03*	0.04*	0.03*	0.02*	0.03*	0.05*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
m_{t-1}	0.02	0.15*	−0.01	−0.04	0.06	0.04	0.09**	−0.02	−0.18*
	(0.04)	(0.04)	(0.01)	(0.02)	(0.04)	(0.03)	(0.05)	(0.01)	(0.05)
y^{US}_{t-1}	−0.07	0.27*	0.01	0.14	−0.13	−0.03	−0.10*	0.06	0.24
	(0.08)	(0.08)	(0.06)	(0.12)	(0.13)	(0.02)	(0.04)	(0.06)	(0.30)
q_{t-1}	0.01	−0.03**	−0.04*	0.01	−0.01	0.03**	0.04*	0.01	−0.03
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.05)
g_{t-1}	0.05	−0.05	0.00	0.04	0.09	0.00	0.00	0.01	0.01
	(0.04)	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.05)	(0.02)	(0.06)
$\bar{R}^2$	0.82	0.86	0.93	0.93	0.70	0.98	0.90	0.90	0.80

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%, †4-quarter moving average, ‡8-quarter moving average.

The results show that the nominal short term interest rate also does not improve the results for advanced economies. Nevertheless, we observe that for emerging markets there are four economies that exhibit the correct sign on the interest rate. Still, we observe that for many countries, the output gap version of the IS curve does not describe the data. There are some economies that exhibit non-significant parameters, or parameters with the wrong sign. Table 4 shows the results in the case of the nominal long rate. We observe that still the long rate does not improve the results. In fact, the nominal long rate performs worse than the nominal short rate. The nominal long rate works only for the EU and Iceland, and it fails in the other

Table 4. Estimation of the IS curve (nominal long rate), equation (16).

	Advanced Markets								
	Aus.	Canada	EU.	Japan	NZ	US	UK	Norway	Iceland
Sample	`72-`19	`79-`19	`96-`19	`94-`19	`87-`19	`80-`19	`87-`19	`93-`19	`95-`19
c	−0.00	0.00	0.00	0.00	−0.00	−0.00	−0.00	0.00	0.01
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
y_{t-1}	0.70*	0.96*	0.71*	0.53*	0.85*	0.91*	1.18*	0.06	0.03
	(0.09)	(0.08)	(0.12)	(0.12)	(0.08)	(0.09)	(0.10)	(0.09)	(0.09)
y_{t-2}	−0.08	−0.31*	0.19**	0.11	−0.17*	−0.14	−0.34*	0.06	0.18*
	(0.08)	(0.07)	(0.10)	(0.08)	(0.07)	(0.09)	(0.11)	(0.08)	(0.07)
$\tilde{R}_{t-1}$	−0.001	−0.00	−0.64*‡	0.05	0.03	0.01	0.01	−0.02	−0.18
	(0.01)	(0.01)	(0.30)	(0.05)	(0.03)	(0.02)	(0.01)	(0.03)	(0.16)
p^s_{t-1}	0.02*	0.02*	–	0.02*	0.01	0.02*	0.01**	0.04*	0.02*
	(0.00)	(0.01)	–	(0.01)	(0.01)	(0.01)	(0.01)	(0.10)	(0.01)
m_{t-1}	0.04*	−0.05*	−0.07	0.19*	0.05	0.08*	−0.02*	0.06*	0.09*
	(0.02)	(0.02)	(0.14)	(0.09)	(0.03)	(0.04)	(0.01)	(0.03)	(0.04)
y^{US}_{t-1}	0.07	0.16*	0.07	−0.04	0.04	–	0.06	−0.21**	0.65*
	(0.05)	(0.05)	(0.11)	(0.08)	(0.10)	–	(0.06)	(0.12)	(0.15)
q_{t-1}	0.00	−0.03*	0.02	0.01	0.00	−0.01	−0.00	−0.01	0.05
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.04)
g_{t-1}	−0.04	−0.08*	–	0.13	−0.24*	−0.09*	−0.04	−0.03	0.10
	(0.03)	(0.04)	–	(0.10)	(0.04)	(0.05)	(0.02)	(0.03)	(0.11)
$\bar{R}^2$	0.69	0.89	0.85	0.85	0.76	0.87	0.92	0.61	0.62
	Emerging Markets								
	Brazil	Chile	Czech	India	Mexico	Poland	Russia	SA	S. Kor.
Sample	`97-`19	`05-`19	`00-`19	`13-`19	`01-`18	`00-`19	`03-`18	`93-`19	`01-`21
c	0.00	0.00	0.00	0.00	0.00	0.00	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
y_{t-1}	0.78*	0.66*	1.02*	1.14*	0.86*	0.55*	0.88*	0.92*	0.70*
	(0.12)	(0.10)	(0.09)	(0.12)	(0.11)	(0.15)	(0.07)	(0.12)	(0.11)
y_{t-2}	−0.11	−0.32*	−0.12	−0.06	−0.19*	0.18**	0.02	−0.22*	−0.18*
	(0.11)	(0.11)	(0.09)	(0.14)	(0.08)	(0.11)	(0.05)	(0.09)	(0.08)
$\tilde{R}_{t-1}$	−0.001	−0.14	0.11	−0.01*	−0.26*	−0.17*	0.002*	0.06	0.24*
	(0.04)	(0.25)	(0.09)	(0.00)	(0.11)	(0.08)	(0.00)	(0.07)	(0.12)
p^s_{t-1}	0.03*	0.04*	0.01*	0.04*	0.03*	0.03*	0.02*	0.03*	0.02*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
m_{t-1}	0.03	0.18*	0.00	0.10	−0.04**	0.06	0.04	−0.02	0.06
	(0.04)	(0.06)	(0.01)	(0.06)	(0.03)	(0.04)	(0.03)	(0.02)	(0.04)
y^{US}_{t-1}	−0.09	0.53*	0.09	−0.15	0.24**	−0.19	−0.20*	0.03	−0.06
	(0.08)	(0.16)	(0.09)	(0.27)	(0.12)	(0.12)	(0.10)	(0.07)	(0.06)
q_{t-1}	0.00	−0.02	−0.04**	−0.07**	0.00	−0.02	0.03	0.01	0.03
	(0.01)	(0.02)	(0.02)	(0.04)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
g_{t-1}	0.06	−0.04	0.07	−0.00	0.08**	0.00	0.01	0.00	−0.04
	(0.05)	(0.03)	(0.05)	(0.00)	(0.04)	(0.05)	(0.01)	(0.02)	(0.07)
$\bar{R}^2$	0.80	0.92	0.98	0.98	0.93	0.76	0.99	0.90	0.78

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%, †4-quarter moving average, ‡8-quarter moving average.

economies. For emerging markets, only in India does the long rate appear to work, in the rest of the economies it also fails.

The results above are comprehensive enough for us to conclude that, within the context of the output gap version of the IS curve, the various measures of the interest rate gaps perform poorly. In the various specifications that we have tested, we have augmented the IS curve with some of the variables that the literature suggests should be added in order to improve the interest rate effect on the output gap, without much success. We therefore conclude that the output gap version of the IS curve is broadly rejected by the data. To complete this section, we present the results for the basic output gap is curve for the nominal short-term interest rate in Table 5 and the results for the real short-term interest

Table 5. Estimation of the basic output gap IS curve (nominal short rate).

	Advanced Markets								
	Aus.	Canada	EU.	Japan	NZ	US	UK	Norway	Iceland
Sample	`72-`19	`79-`19	`94-`19	`94-`19	`94-`19	`64-`19	`86-`19	`79-`19	`95-`19
c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
y_{t-1}	0.72*	1.07*	0.77*	0.72*	0.84*	1.05*	1.21*	0.38*	0.10
	(0.08)	(0.08)	(0.12)	(0.09)	(0.12)	(0.08)	(0.13)	(0.07)	(0.08)
y_{t-2}	−0.03	−0.34*	0.12	−0.08	−0.11	−0.22*	−0.34*	0.19*	0.11
	(0.08)	(0.07)	(0.12)	(0.10)	(0.12)	(0.08)	(0.14)	(0.09)	(0.14)
$\tilde{i}_{t-1}$	−0.05*	−0.10*	−0.40*	−0.71*	−0.20*	−0.15*	−0.16*	−0.17*	0.39*
	(0.02)	(0.05)	(0.20)	(0.32)	(0.10)	(0.08)	(0.04)	(0.08)	(0.19)
y_{t-1}^{US}	0.18*	0.23*	0.29*	0.17**	−0.01	0.10*	0.12*	0.24*	0.57*
	(0.05)	(0.06)	(0.09)	(0.09)	(0.07)	(0.03)	(0.05)	(0.08)	(0.16)
q_{t-1}	0.00	0.00	0.02	−0.01	0.01	−0.01	0.02	−0.04	0.13*
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)
$\bar{R}^2$	0.72	0.88	0.78	0.75	0.75	0.80	0.89	0.51	0.49
	Emerging Markets								
	Brazil	Chile	Czech	India	Mexico	Poland	Russia	SA	S. Kor.
Sample	`97-`19	`97-`19	`96-`19	`12-`20	`93-`19	`95-`19	`00-`19	`71-`19	`94-`21
c	0.00	0.00	0.00	0.01*	0.00	0.00	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
y_{t-1}	0.95*	1.03*	1.32*	0.91*	0.81*	0.51*	1.17*	0.99*	0.74*
	(0.09)	(0.07)	(0.10)	(0.20)	(0.12)	(0.12)	(0.11)	(0.11)	(0.16)
y_{t-2}	−0.24*	−0.22*	−0.43*	0.04	−0.42*	0.22*	−0.22*	−0.11	−0.13
	(0.10)	(0.10)	(0.12)	(0.06)	(0.08)	(0.10)	(0.10)	(0.12)	(0.11)
$\tilde{i}_{t-1}$	−0.10*	−0.26*	−0.08*	0.02*	−0.07*	−0.14**	0.001**	−0.09*	−0.23*
	(0.02)	(0.08)	(0.02)	(0.00)	(0.03)	(0.08)	(0.00)	(0.03)	(0.09)
y_{t-1}^{US}	0.09	0.34*	0.11*	−1.96*	0.76*	0.25*	0.10	0.12*	−0.11*
	(0.06)	(0.10)	(0.05)	(0.55)	(0.20)	(0.10)	(0.07)	(0.05)	(0.05)
q_{t-1}	0.02**	−0.03**	−0.04*	0.25*	0.02	−0.01	0.01**	0.02*	0.07*
	(0.01)	(0.02)	(0.02)	(0.09)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
$\bar{R}^2$	0.83	0.84	0.92	0.95	0.82	0.61	0.97	0.81	0.76

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%.

rate in Table A4 of appendix A. We find that the nominal short term interest rate variable has the correct sign and is significant for eight (8) advanced economies and seven (7) emerging economies. This supports the use of nominal rather than real interest rates in dynamic IS curves.

4.3. The Error-Correction Version of the IS Curve Using Nominal Interest Rates

We have noted that if a relation is stated in terms of percent deviation from trend, its level form can be approximated by a log-linear equation. Therefore, instead of de-trending the data using some filtering, we instead apply an error-correction-type framework to estimate the reduced-form IS curve. That is, instead of using the output gap, we use the growth rate of real output. In the tables below, $\tilde{x}$ denotes the actual level of the variable x except for the interest rate.

Table 6 reports the results. As can be observed, the real short-term interest rate now exhibits a correct sign in most of the economies. Only in Japan does it exhibit a positive sign, but not significant. For the other economies, it has a negative sign. For emerging markets, only the Czech Republic has a wrong but not significant sign. These results are clearly much better than those obtained using the output gap version of the IS curve. We also present the results for the real long-term interest rate (see Table A5 in appendix A). These results are not better than those for the real short-term rate. They in fact appear to be similar to those obtained from the output gap version of the

Table 6. Estimates of the augmented IS curve based on error-correction (real short rate), equation (16).

	Advanced Markets								
	Aus	Canada	EU.	Japan	NZ	US	UK	Norway	Iceland
Sample	\`72-\`19	\`79-\`19	\`96-\`19	\`94-\`19	\`94-\`19	\`80-\`19	\`87-\`19	\`93-\`19	\`95-\`20
c	−1.14*	1.68*	−1.21*	4.62*	1.96*	0.86*	1.66*	6.01*	−13.84*
	(0.37)	(0.00)	(0.40)	(1.94)	(0.85)	(0.21)	(0.73)	(1.00)	(2.29)
$\tilde{y}_{t-1}$	0.81*	1.41*	0.67*	0.81*	0.93*	1.25*	1.34*	0.39*	0.22*
	(0.09)	(0.06)	(0.13)	(0.06)	(0.12)	(0.07)	(0.09)	(0.08)	(0.09)
$\tilde{y}_{t-2}$	0.02	−0.508	0.17	–	−0.07	−0.29*	−0.45*	0.32*	0.34*
	(0.09)	(0.07)	(0.12)	–	(0.13)	(0.07)	(0.12)	(0.10)	(0.08)
r_{t-1}	−0.02	−0.02	0.16**	0.10	−0.19*	−0.08*	−0.04	−0.11**	−0.09**
	(0.03)	(0.03)	(0.09)	(0.08)	(0.09)	(0.03)	(0.05)	(0.06)	(0.05)
$\tilde{p}^s_{t-1}$	0.01**	0.01*	–	0.01*	0.01	0.01*	−0.00	0.01*	0.01
	(0.00)	(0.00)	–	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\tilde{m}_{t-1}$	0.04*	0.00	0.07*	0.04	0.04**	0.01*	−0.01	−0.01	0.06*
	(0.01)	(0.00)	(0.02)	(0.03)	(0.02)	(0.00)	(0.00)	(0.01)	(0.02)
$\tilde{y}^{US}_{t-1}$	0.11*	0.06*	0.21*	0.07	0.07**	–	0.08*	0.21*	0.44*
	(0.04)	(0.02)	(0.00)	(0.03)	(0.04)	–	(0.04)	(0.05)	(0.08)
$\tilde{q}_{t-1}$	−0.00	0.00	0.01	−0.01	−0.00	0.01	0.01	0.04*	0.10*
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.00)
$\bar{R}^2$	0.999	0.999	0.999	0.989	0.998	0.999	0.999	0.996	0.99

	Emerging Markets								
	Brazil	Chile	Czech	Mexico	Poland	Russia	S. Kor.	SA	Turkey
Sample	\`97-\`19	\`97-\`19	\`96-\`19	\`93-\`19	\`95-\`19	\`00-\`19	\`94-\`19	\`71-\`19	\`98-\`19
c	0.73*	4.47*	1.14*	2.54*	0.67*	1.40*	2.03*	0.49*	−0.60*
	(0.21)	(1.08)	(0.44)	(0.77)	(0.17)	(0.66)	(0.42)	(0.09)	(0.19)
$\tilde{y}_{t-1}$	0.93*	1.03*	1.16*	1.12*	0.45*	0.80*	1.06*	1.11*	1.03*
	(0.03)	(0.12)	(0.12)	(0.09)	(0.09)	(0.11)	(0.09)	(0.13)	(0.13)
$\tilde{y}_{t-2}$	–	−0.24*	−0.23*	−0.23*	0.26*	0.14**	−0.17*	−0.22**	−0.12
	–	(0.11)	(0.11)	(0.11)	(0.07)	(0.07)	(0.08)	(0.11)	(0.14)
r_{t-1}	−0.03*	−0.13**	0.01	−0.08*	−0.18*	−0.04*	−0.12*	−0.06*	−0.06**
	(0.01)	(0.07)	(0.05)	(0.03)	(0.05)	(0.02)	(0.06)	(0.02)	(0.03)
$\tilde{p}^s_{t-1}$	0.02*	0.04*	0.01*	0.00	0.02*	0.02*	0.01*	0.01*	0.00
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
$\tilde{m}_{t-1}$	0.01	0.06	−0.01	0.01	0.11*	−0.02**	0.05*	0.02*	0.07*
	(0.01)	(0.02)	(0.01)	(0.01)	(0.03)	(0.01)	(0.02)	(0.01)	(0.02)
$\tilde{y}^{US}_{t-1}$	0.26**	0.06	0.12*	0.06*	0.07*	−0.02	0.05	0.06*	1.78
	(0.15)	(0.04)	(0.02)	(0.03)	(0.03)	(0.02)	(0.04)	(0.01)	(0.54)
$\tilde{q}_{t-1}$	−0.01	−0.01	−0.01	−0.01*	−0.04*	0.01	−0.01	0.02*	0.01*
	(0.01)	(0.02)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.03)
$\bar{R}^2$	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%.

IS curve. Therefore, at this stage, we conclude that the error-correction version of the IS curve, with the real short-term interest rate, is the best specification compared to all specifications that we have considered thus far.

We now turn to the results involving the nominal short-term interest rate. Table 7 shows that the results for the IS relationship hold for most of the advanced economies, except in Australia and Japan. Almost all emerging market economies, except Brazil, also exhibit a strong IS relationship, where the nominal interest rate exhibits a correct negative sign that is statistically significant. Table 8 reports the results for the nominal long rate. For many of the advanced economies, except once again for Australia, the EU and Japan, the results show that the IS relation exists. Note that the coefficient is relatively high compared to the output gap version of Rudebusch and Svensson (1999). For emerging markets, only in Brazil, Czech Republic and in Mexico, does the nominal long rate not exhibit significance.

Table 7. Estimates of the augmented IS curve based on error-correction (nominal short rate), equation (16).

	Advanced Markets								
	Aus.	Canada	EU.	Japan	NZ	US	UK	Norway	Iceland
Sample	`92-`19	`79-`19	`96-`19	`94-`19	`87-`19	`80-`19	`87-`19	`93-`19	`95-`20
c	−1.33*	2.11*	−2.26*	5.28*	1.47*	1.23*	0.97	6.34*	−13.99*
	(0.38)	(0.46)	(0.50)	(2.16)	(0.73)	(0.31)	(0.85)	(1.02)	(2.10)
$\tilde{y}_{t-1}$	0.87*	1.29*	0.85*	0.82	0.94*	1.22*	1.39*	0.40*	0.20*
	(0.07)	(0.07)	(0.15)	(0.11)	(0.13	(0.09)	(0.12)	(0.08)	(0.08)
$\tilde{y}_{t-2}$	−0.06	−0.39*	0.04	−0.03	−0.03	−0.27*	−0.43*	0.29*	0.38*
	(0.08)	(0.07)	(0.14)	(0.12)	(0.13)	(0.09)	(0.16)	(0.08)	(0.07)
i_{t-1}	−0.02	−0.12*	−0.25**	0.17	−0.21*	−0.12*	−0.10*	−0.14*	−0.16**
	(0.02)	(0.03)	(0.13)	(0.17)	(0.10)	(0.03)	(0.03)	(0.06)	(0.08)
$\tilde{p}^{s}_{t-1}$	0.01**	0.02*	–	0.01*	0.01**	0.02*	−0.00	0.01*	0.01*
	(0.00)	(0.00)	–	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\tilde{m}_{t-1}$	0.04*	0.01	0.12*	0.05	0.02	0.01**	−0.01	−0.01	0.05*
	(0.01)	(0.00)	(0.02)	(0.03)	(0.02)	(0.01)	(0.00)	(0.01)	(0.02)
$\tilde{y}^{US}_{t-1}$	0.12*	0.05*	0.19*	0.04	0.05	–	0.03	0.22*	0.46*
	(0.04)	(0.02)	(0.04)	(0.03)	(0.04)	–	(0.05)	(0.05)	(0.08)
$\tilde{q}_{t-1}$	−0.00	−0.00	0.02**	−0.00	−0.00	0.01	0.01**	0.03**	0.08*
	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
$\bar{R}^2$	0.999	0.999	0.999	0.989	0.998	0.999	0.999	0.996	0.99

	Emerging Markets								
	Brazil	Chile	Czech	Mexico	Poland	Russia	S. Kor.	SA	Turkey
Sample	`97-`19	`97-`19	`96-`19	`93-`19	`95-`19	`00-`19	`94-`19	`71-`19	`98-`19
c	0.76*	3.38**	0.59	3.70*	1.04*	1.40*	2.32*	0.37*	1.06
	(0.36)	(0.93)	(0.44)	(0.83)	(0.34)	(0.66)	(0.34)	(0.10)	(1.12)
$\tilde{y}_{t-1}$	0.94*	1.02*	1.15*	0.83*	0.49*	0.80*	0.94*	1.08*	1.10*
	(0.04)	(0.08)	(0.10)	(0.10)	(0.09)	(0.11)	(0.11)	(0.12)	(0.11)
$\tilde{y}_{t-2}$	–	−0.17*	−0.18**	0.02	0.31*	0.14**	−0.06	−0.15	−0.20**
	–	(0.07)	(0.03)	(0.08)	(0.08)	(0.07)	(0.11)	(0.11)	(0.11)
i_{t-1}	−0.02	−0.15*	−0.09*	−0.04**	−0.09*	−0.04*	−0.17*	−0.08*	−0.13**
	(0.02)	(0.05)	(0.03)	(0.02)	(0.04)	(0.02)	(0.05)	(0.02)	(0.07)
$\tilde{p}^{s}_{t-1}$	0.02*	0.03*	0.01*	0.01*	0.02*	0.02*	0.01*	0.01**	0.01
	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)
$\tilde{m}_{t-1}$	0.01	0.04*	−0.01	0.01	0.08*	0.02*	0.05*	0.01	−10.01
	(0.02)	(0.02)	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.01)	(0.03)
$\tilde{y}^{US}_{t-1}$	−0.02	0.04	0.08*	0.08*	−0.01	−0.02	0.04	0.05*	0.08
	(0.04)	(0.04)	(0.02)	(0.02)	(0.05)	(0.02)	(0.04)	(0.01)	(0.08)
$\tilde{q}_{t-1}$	−0.01	−0.02	−0.04*	−0.03*	−0.05*	0.01	−0.01	0.02**	−0.06
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.05)
$\bar{R}^2$	0.998	0.999	0.999	0.998	0.998	0.998	0.999	0.999	0.999

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%.

However, in other economies, the interest rate parameters are correctly signed and significant. Note that the size of the parameter is comparable to that which is obtained in advanced economies, which implies that the lending channel in both the advanced and emerging market economies is similar.

The above results show that the output gap version of the IS curve is broadly rejected by the data in both advanced and emerging market economies. However, the error-correction version is broadly consistent with the data. There are however two economies that require further analysis; Australia and Japan. The case of Japan can be explained by the prolonged near-zero nominal interest rates, which meant that variations in output were not much caused by changes in the nominal interest rates. The case of Australia requires a different explanation. Paradiso, Kumar, and Rao (2013) find that the IS curve that is based on the output gap that is constructed using the quadratic trend, augmented with monetary aggregates and stock prices, best explains output fluctuations in Australia. Our discomfort with this result is that it is not robust to the de-trending method.

Table 8. Estimation of the IS curve based on error-correction (nominal long rate), equation (16).

	Advanced Markets								
	Aus.	Canada	EU.	Japan	NZ	US	UK	Norway	Iceland
Sample	\`72-\`19	\`79-\`19	\`96-\`19	\`94-\`19	\`87-\`19	\`80-\`19	\`87-\`19	\`93-\`19	\`95-\`20
c	−1.34*	1.66*	−1.84*	4.86*	1.53**	1.08*	1.63*	6.54*	−14.17*
	(0.39)	(0.46)	(0.66)	(1.71)	(0.78)	(0.34)	(0.71)	(1.15)	(2.35)
$\tilde{y}_{t-1}$	0.88*	1.31*	0.76*	0.75*	0.85*	1.26*	1.41*	0.46*	0.18*
	(0.07)	(0.07)	(0.12)	(0.06)	(0.11)	(0.10)	(0.12)	(0.09)	(0.09)
$\tilde{y}_{t-2}$	−0.07	−0.39*	−0.01	–	0.05	−0.30*	−0.49*	0.24*	0.37*
	(0.08)	(0.07)	(0.14)	–	(0.11)	(0.09)	(0.14)	(0.09)	(0.07)
R_{t-1}	−0.02	−0.17*	0.23**	0.63*	−0.20*	−0.19*	−0.19*	−0.24**	−0.50**
	(0.03)	(0.06)	(0.14)	(0.19)	(0.09)	(0.06)	(0.06)	(0.12)	(0.29)
$\tilde{p}^s_{t-1}$	0.01**	0.01*	–	0.00	0.01*	0.01*	−0.00	0.01*	0.00
	(0.00)	(0.00)	–	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
$\tilde{m}_{t-1}$	0.04*	0.00	0.11*	0.09*	0.01	0.01	−0.00	−0.01	0.04*
	(0.01)	(0.00)	(0.03)	(0.03)	(0.02)	(0.01)	(0.00)	(0.01)	(0.02)
$\tilde{y}^{US}_{t-1}$	0.12*	0.04**	0.32*	0.04	0.07	–	0.05	0.18*	0.48*
	(0.04)	(0.02)	(0.08)	(0.02)	(0.05)	–	(0.04)	(0.05)	(0.08)
$\tilde{q}_{t-1}$	−0.00	0.00	0.01	−0.01	0.00	0.01*	0.01**	0.04*	0.09*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)
$\bar{R}^2$	0.999	0.999	0.999	0.991	0.998	0.999	0.999	0.997	0.99
	Emerging Markets								
	Brazil	Chile	Czech	India	Mexico	Poland	Russia	SA	S. Kor.
Sample	\`96-\`19	\`04-\`19	\`00-\`19	\`12-\`19	\`01-\`18	\`57-\`19	\`00-\`18	\`71-\`19	\`01-\`19
c	0.82**	3.27*	1.10	4.41	7.67*	0.57	2.64	0.44*	3.75*
	(0.42)	(0.90)	(0.74)	(5.93)	(0.63)	(0.42)	(1.76)	(0.11)	(1.35)
$\tilde{y}_{t-1}$	1.00*	1.09*	1.09*	1.01*	0.55*	0.64*	1.08*	1.12*	0.90*
	(0.12)	(0.11)	(0.12)	(0.50)	(0.08)	(0.13)	(0.22)	(0.12)	(0.10)
$\tilde{y}_{t-2}$	−0.08	−0.21**	−0.16	−0.07	0.05	0.20**	−0.30**	−0.19**	−0.08
	(0.11)	(0.12)	(0.10)	(0.18)	(0.08)	(0.11)	(0.16)	(0.11)	(0.09)
R_{t-1}	−0.01	−0.57*	−0.04	−0.47*	−0.02	−0.22*	−0.14*	−0.08*	−0.25**
	(0.10)	(0.23)	(0.07)	(0.19)	(0.09)	(0.09)	(0.05)	(0.03)	(0.15)
$\tilde{p}^s_{t-1}$	0.02*	0.02*	0.01*	0.03*	−0.00	0.02*	0.03*	0.01*	0.03*
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)
$\tilde{m}_{t-1}$	0.02	0.02	−0.01	0.12*	0.05*	0.05**	0.03*	0.00	0.09*
	(0.02)	(0.03)	(0.01)	(0.05)	(0.01)	(0.03)	(0.03)	(0.01)	(0.03)
$\tilde{y}^{US}_{t-1}$	−0.02	0.01	0.11*	−0.22	0.32*	0.03	−0.05	0.05*	−0.06
	(0.03)	(0.04)	(0.05)	(0.23)	(0.05)	(0.07)	(0.05)	(0.01)	(0.08)
$\tilde{q}_{t-1}$	−0.01	−0.02	−0.02	−0.04	−0.01	−0.02	0.01	0.01*	−0.01
	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
$\bar{R}^2$	0.998	0.997	0.999	0.999	0.999	0.999	0.999	0.999	0.999

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%.

4.4. The Error-Correction Version of the Baseline IS Curve

The last set of results relate to the baseline IS curve, without any extensions. In other words, we remove real money holdings and the stock price, so that the error-correction version is similar to the baseline model of Rudebusch and Svensson (1999). The aim is to test if the error-correction version of the IS curve requires the extensions for it to work. Table 9 reports the results. It can be seen that although this is not the best specification, it is far better than the baseline output gap version of the IS curve. However, when it comes to advanced economies, this specification performs poorly, except for one economy, New Zealand.

We now turn to the nominal version of the baseline specification. Table 10 reports the results. It can be observed that all the countries have the correct signs on the interest rate parameter. The only exception is Japan, which can be explained by the prolonged near-zero interest rate situation. The

Table 9. Estimation of the baseline IS curve (real short rate), equation (17).

	Advanced Markets							
	Aus.	Can.	EU.	Jap.	NZ	Norway	UK	US
Sample	`72-`19	`79-`19	`96-`19	`94-`19	`94-`19	`79-`19	`86-`19	`80-`19
c	−0.43*	1.22*	0.48*	6.44*	0.32	2.04*	1.86*	−0.11
	(0.21)	(0.42)	(0.24)	(2.54)	(0.33)	(0.90)	(0.52)	(0.10)
$\tilde{y}_{t-1}$	0.87*	1.46*	0.80*	1.00*	0.93*	0.65*	1.45*	1.33*
	(0.10)	(0.06)	(0.12)	(0.12)	(0.13)	(0.08)	(0.10)	(0.08)
$\tilde{y}_{t-2}$	0.06	−0.53*	0.06	−0.21	0.06	0.25*	−0.55*	−0.36*
	(0.10)	(0.06)	(0.13)	(0.10)	(0.13)	(0.08)	(0.11)	(0.08)
r_{t-1}	−0.04	−0.02	0.11*	0.06	−0.14**	0.01	−0.05	0.06**
	(0.03)	(0.03)	(0.03)	(0.02)	(0.08)	(0.05)	(0.04)	(0.04)
$\tilde{y}^{US}_{t-1}$	0.08*	0.06*	−0.01*	0.06*	−0.00	0.08**	0.08*	0.04
	(0.01)	(0.02)	(0.01)	(0.02)	(0.03)	(0.05)	(0.03)	(0.04)
$\tilde{q}_{t-1}$	0.00	0.00	−0.03	−0.02**	−0.00	−0.03	0.01	0.00
	(0.70)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.00)
	Emerging Markets							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
Sample	`97-`19	`97-`19	`96-`19	`93-`19	`95-`19	`71-`19	`94-`19	`98-`19
c	0.06	0.52*	0.77*	2.69*	0.26*	0.15**	1.06*	−0.40*
	(0.09)	(0.26)	(0.22)	(0.10)	(0.12)	(0.08)	(0.39)	(0.42)
$\tilde{y}_{t-1}$	1.27*	1.26*	1.64*	1.16*	0.63*	0.24*	1.25*	1.08*
	(0.09)	(0.10)	(0.15)	(0.16)	(0.11)	(0.12)	(0.07)	(0.15)
$\tilde{y}_{t-2}$	−0.32*	−0.27*	−0.69*	−0.29**	0.32*	−0.28*	−0.30*	−0.22
	(0.09)	(0.10)	(0.15)	(0.15)	(0.09)	(0.11)	(0.08)	(0.14)
r_{t-1}	0.00	−0.08	0.04	−0.08**	−0.15*	−0.07*	−0.10	−0.09**
	(0.09)	(0.09)	(0.05)	(0.04)	(0.06)	(0.02)	(0.10)	(0.05)
$\tilde{y}^{US}_{t-1}$	0.04*	−0.00	0.08*	0.11**	0.06	0.04*	0.07	0.33*
	(0.02)	(0.05)	(0.02)	(0.06)	(0.05)	(0.01)	(0.04)	(0.09)
$\tilde{q}_{t-1}$	0.01**	−0.02	−0.00	−0.01*	−0.04*	0.01**	−0.00	0.01
	(0.01)	(0.02)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%.

baseline IS curve therefore describes the data, provided it is formulated in an error-correction framework and with the nominal interest rate.

The above results highlight three key findings. Firstly, the output gap version of the IS curve is generally rejected by the data. Even if empirically this version of the IS curve appears to work, it is not robust to alternative de-trending methods. This makes it difficult for general application for purposes of informing macroeconomic policy. The empirical strength of the interest rate effect in these IS curves remains questionable and weak. These findings are in line with the observation by Blinder (1997), and studies by Nelson (2001), Fuhrer and Rudebusch (2004), Stracca (2010), and Haque and Magnusson (2022). Secondly, the nominal interest rate appears to be more relevant than the real interest rate in many countries. This result is in line with the finding by Fair (2004, 66). Thirdly, the nominal long-term interest rate plays an important role in many emerging market economies. This opens up possibilities that in these economies, some form of yield curve control can be used to manage fluctuations in economic activity.

5. Conclusion

The reduced-form IS curve is an important part of small-scale models that are used for policy analysis. The quarterly projection models, which are an important part of many central banks'

Table 10. Estimation of the baseline IS curve (nominal short rate), equation (17).

	Advanced Markets							
	Aus.	Can.	EU.	Jap.	NZ	Norway	UK	US
Sample	`72-`19	`79-`19	`96-`19	`94-`19	`94-`19	`79-`19	`86-`19	`80-`19
c	−0.38*	1.01*	0.86*	7.40*	0.83*	2.35*	1.10*	0.24*
	(0.18)	(0.40)	(0.32)	(2.01)	(0.35)	(0.64)	(0.46)	(0.08)
$\tilde{y}_{t-1}$	0.87*	1.43*	1.00*	0.99**	0.95*	0.61*	1.39*	1.33*
	(0.10)	(0.07)	(0.12)	(0.12)	(0.11)	(0.08)	(0.11)	(0.09)
$\tilde{y}_{t-2}$	0.06	−0.48*	−0.03	−0.23**	0.00	0.28*	−0.44*	−0.37*
	(0.10)	(0.07)	(0.13)	(0.14)	(0.12)	(0.09)	(0.12)	(0.10)
i_{t-1}	−0.05*	−0.06*	−0.61**	−0.22	−0.19**	−0.19*	−0.10*	−0.10*
	(0.02)	(0.03)	(0.36)	(0.34)	(0.10)	(0.05)	(0.03)	(0.03)
$\tilde{y}^{US}_{t-1}$	0.07*	0.04**	−0.06	0.06*	0.03	0.07**	0.03	0.03
	(0.03)	(0.02)	(0.08)	(0.02)	(0.04)	(0.04)	(0.02)	(0.03)
$\tilde{q}_{t-1}$	0.01	−0.00	0.01	−0.02	−0.00	−0.00	0.01*	0.01*
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.00)	(0.00)
	Emerging Markets							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
Sample	`97-`19	`97-`19	`96-`19	`93-`19	`95-`19	`71-`19	`94-`19	`98-`19
c	0.16**	0.85*	0.31	2.32*	−0.21	0.20*	1.27*	0.27
	(0.09)	(0.24)	(0.19)	(0.77)	(0.27)	(0.07)	(0.45)	(0.82)
$\tilde{y}_{t-1}$	1.23*	1.15*	1.44*	1.33*	0.79*	1.11*	1.14*	1.15*
	(0.09)	(0.07)	(0.11)	(0.14)	(0.12)	(0.11)	(0.10)	(0.12)
$\tilde{y}_{t-2}$	−0.28*	−0.15*	−0.46*	−0.42*	0.16	−0.16	−0.18**	−0.24*
	(0.09)	(0.07)	(0.11)	(0.14)	(0.11)	(0.11)	(0.09)	(0.12)
i_{t-1}	−0.01**	−0.25*	−0.08*	−0.07*	−0.06**	−0.10*	−0.16**	−0.09**
	(0.02)	(0.05)	(0.03)	(0.03)	(0.02)	(0.02)	(0.09)	(0.05)
$\tilde{y}^{US}_{t-1}$	0.04*	−0.04	0.04*	0.06*	0.11*	0.04*	0.04	0.12**
	(0.02)	(0.05)	(0.02)	(0.03)	(0.05)	(0.01)	(0.05)	(0.07)
$\tilde{q}_{t-1}$	0.02	−0.06*	−0.03*	−0.03*	−0.07*	0.01*	−0.00	−0.05
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.04)

Notes: HAC std. errors in parentheses, *significant at 5%, **significant at 10%.

toolkit, are used to set interest rates. Yet, as was long mentioned by Blinder (1997), and shown by Nelson (2001), Fuhrer and Rudebusch (2004), Stracca (2010) and more recently Haque and Magnusson (2022), the empirical strength of the interest rate effect in these IS curves remains questionable and weak. The literature on backward-looking IS curves has reached a point where, following Goodhart and Hoffman (2005), there seems to be agreement that in order to obtain strong and negative interest rate effects, there is a need to augment these curves with variables such as real money holdings and asset prices in order to capture wealth effects.

In this paper, we revisit the evidence on the interest rate effect in reduced-form IS curves by considering a broad set of economies: advanced and emerging market. We have shown that, firstly, the extensions that are based only on rates of changes of asset prices and money holdings may be theoretically misspecified. Secondly, even if such extensions are applied, they appear not to be robust. Our results do not deliver the significance of the interest rate effect that is found in the literature. Thirdly, we have shown that the output gap version of the IS curve is broadly rejected by the data. This result is robust to whether we use the real or nominal, short or long-term interest rates.

We then estimate an alternative, "error-correction" version of the reduced-form IS curve. Instead of de-trending output using some filtering technique, we take first-differences. The results show that this version of the IS curve is broadly preferable—it delivers strong, negative interest rate effects in both advanced and emerging market economies. Furthermore, we find that the nominal interest rate, rather than the real interest rate, best explains output dynamics—a result that is consistent with Fair (2004, 66). Lastly, the error-correction version of the IS curve does not require extensions to capture wealth effects in order for the interest rate effect to be correctly signed and significant.

We therefore conclude that the major reason behind the empirical weakness of the interest rate effect in the output gap versions of the reduced form IS curves is de-trending. Through an example, we have shown that estimates that are based on de-trended variables, whose trends are driven by processes of different autoregressive orders, could be biased toward zero. Another reason that accounts for weaknesses in the interest rate effect, even within the error-correction setup, is the use of the real, rather than the nominal, interest rate. Thus, using the output gap version of the IS curve can lead to concluding that there is no significant and negative relationship between output and interest rates. The output gap version of the IS curve might even lead researchers and policymakers to use unnecessary and complicated economic models, thus, making policy decisions using models that are not necessary.

One area for future research is to provide a more rigorous explanation of why the de-trending of variables using filters instead of differencing could bias estimates based on gap variables. Another area for future research is an equivalent investigation of the interest rate effect in forward-looking, new Keynesian IS curves, building on Fuhrer and Rudebusch (2004), Kara and Nelson (2004), Stracca (2010), and more recently, Haque and Magnusson (2022). Furthermore, and in line with studies such as those by Ozcelebi (2021) and Ozcelebi and Izgi (2023), we recommend that future researchers use the BDS test or the modified BDS test to test whether the relationship between the variables in the model is linear or nonlinear.

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