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Traditional output dynamics: A structural perspective

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ABSTRACT

We provide theoretical underpinnings to the traditional IS curve by using the concept of basic and non-basic goods and services in the consumption basket. An extended version of this IS curve incorporates the effects of functional income distribution by appealing to rule-of-thumb behavior. An empirical analysis for both emerging and advanced economies shows that this IS curve does not suffer from the "IS puzzle," a weakness that affects its new Keynesian counterpart, when a measure of the nominal interest rate is used. The interest rate negatively and significantly affects output. Secondly, the second-order term typically specified in the output dynamics does not arise from structural consumption behavior. Thirdly, although we find significant rule-of-thumb behavior in that the labor share is statistically significant, optimal behavior dominates economies. Lastly, basics make up an overwhelming component of the consumption basket, which explains the sluggish response of output to shocks. The implication is that there is a need to extend the basic two-equation model into a 3-equation system by adding the dynamics of the labor share.

1. Introduction

This paper revisits the dynamics of output in light of some of the disturbing empirical evidence about the new Keynesian IS curve. The new Keynesian approach derives macroeconomic relationships from optimization and it thus provides the parameters in these relationships with a clear theoretical interpretation. A key outcome of this optimization process is forward-looking behavior. However, the empirical evidence for forward-looking behavior appears weak. For example, beginning with Fuhrer (1997), in the literature on inflation dynamics there is a strand which questions the empirical relevance of forward-looking behavior. In a series of studies, Rudd and Whelan (2005,2007) also find that inflation dynamics are backward-looking. In the same vein Fair (2008) and Nason and Smith (2008) find little evidence of forward-looking behavior in inflation dynamics.

Turning to output dynamics, very little work has been done on the empirical significance of forward-looking behavior. Having observed that purely forward-looking specifications are at odds with the data, Fuhrer (2000) proposed habit formation as a way to induce sluggish output response to shocks. Perhaps the only study that most directly tests the significance of forward-looking behavior in output dynamics is Fuhrer and Rudebusch (2004). In this study, Fuhrer and Rudebusch find little evidence of forward-looking behavior. They also find that the more backward-looking the behavior, the higher is the effect of the real interest rate on output. Unfortunately, except for Bilbiie (2008),Stracca (2010),Bilbiie and Straub (2012),Ascari et al. (2021) and Haque and Magnusson (2022), not much has been written in this line of research. Instead, many researchers assume the hybrid specification proposed by

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Fuhrer (2000) because the optimization process produces a forward-looking term.

Given the significance of backward-looking behavior in macro-models, this paper derives a backward-looking IS curve to describe output dynamics like models such as Rudebusch and Svensson (1999). Many researchers criticize backward-looking models or reject these models out of hand on the grounds that they suffer from the Lucas Critique and that they do not have theoretical underpinnings. However, there is no consensus in the literature on these points. For example, Kara and Nelson (2004) find that a forward-looking IS curve is more stable than its backward-looking counterpart. On the other hand, Estrella and Fuhrer (2002) find that some forward-looking models suffer from the Lucas Critique more than backward-looking models. Lastly, Paradisoet al. (2013) find that the backward-looking IS curve fits Australian data better than the forward-looking IS curve. In addition, Goodhart and Hoffman (2005) prefer the backward-looking IS curve for the G7 over its forward-looking counterpart.

There is also the problem of the interest rate effect in forward-looking models. Although Kara and Nelson (2004) find significant and correctly signed interest rate effects, Fuhrer and Rudebusch (2004) do not find such effects significant. Further evidence of the lack of interest rate effects in new Keynesian IS curves is provided by Stracca (2010) and Ascari et al. (2021,2024). Extending the new Keynesian IS curve to consider open economy factors, rule of thumb behavior, and habit formation does not help to improve the interest rate effect, as Haque and Magnusson (2022) have found. An attempt to explain this puzzle is from Bilbiie (2008) and Bilbiie and Straub (2012), who argue that there was a structural change in the US economy between 1979 and 1982. Specifically, there was limited asset market participation before 1979 compared to the period after 1982.

The empirical result about the lack of interest rate effects in the IS curve poses a challenge to policymakers. This challenge arises because several central banks use calibrated small-scale forward-looking models, or Quarterly Projection Models, similar to the one by Berg et al. (2006). In these models, it is assumed that the real interest rate negatively affects the output gap. Other central banks use large-scale models similar to the one proposed by Smets and Wouters (2003), in which the consumption and investment expenditure equations posit a negative effect of the real interest rate. However, as the studies by Ascari et al. (2021,2024) have shown, consumption and investment expenditures are not sensitive to real interest rate changes.

In light of the above problems with the new Keynesian IS curve, we revisit the traditional IS curve by providing it with theoretical underpinnings. We make three assumptions to derive our IS curve. Firstly, in terms of economic structure, we posit a two-class economy, which is standard in heterodox macro literature. The assumption of a two-class economy provides the theoretical basis for consideration of the role of functional income distribution, measured by the labor share, in driving output dynamics-an issue extensively discussed in Bhaduri and Marglin's(1990) seminal contribution. Secondly, following the literature spawned by Campbell and Mankiw (1989), later given more impetus by Fuhrer (2000) and Galí et al. (2004,2007), we assume the presence of optimizing and rule of thumb consumers. The presence of rule-of-thumb consumers provides an easy way to specify the labor share in our hybrid IS curve explicitly.

Thirdly, the consumption basket comprises two components: basic and non-basic goods and services, where basic goods and services evolve on the basis of past consumption patterns, reminiscent of the habit-formation idea of Fuhrer (2000). The distinct role of basic goods in consumption allows us to derive an optimization-based backward-looking IS curve.

The resultant IS curve has three features. Firstly, its dynamics are described by an AR (2) process, allowing flexibility to fit much of the output data. Secondly, in line with the aggregate demand side's specifications proposed by the heterodox literature such as Taylor (1985) and Bhaduri and Marglin (1990), our IS curve explicitly features the ambiguous effect of the labor share. By explicitly specifying the labor share as one of the output drivers, we go some way to bridge the gap between mainstream and heterodox macroeconomics. Thirdly, our IS curve is purely backward-looking but derived from optimization. This allows us to provide a structural interpretation of its parameters in the same way as its forward-looking new Keynesian counterpart. Fourthly, when some measure of past nominal interest rates is used, such as the nominal version of the moving average used by Rudebusch and Svensson (1999), our IS curve overcomes the IS puzzle, but its new Keynesian counterpart does not. This provides further empirical support to the finding by Fair (2004: 66) that the nominal, rather than the real, interest rate is relevant in expenditure equations. Fifthly, basic goods dominate consumption across all economies, which explains the sluggish behavior of consumption and, by extension, output to shocks. Lastly, optimizing behavior is dominant across economies.

The paper is structured as follows: Section 2 derives the traditional Keynesian IS curve, Section 3 estimates this IS curve for a number of countries, and Section 4 concludes with areas for future research.

2. The model

2.1. The set-up

We first assume an economy that is composed of two classes: wage earners and profit earners. Wage earners derive their income from wages, and profit earners derive their income from profits. Secondly, we assume that within the class of wage earners, there are two types of households. One type chooses the consumption level in an optimizing way, while the other uses a rule-of-thumb scheme to determine its consumption level. Thirdly, for simplicity, all profit earners use a rule-of-thumb scheme. This last assumption can be relaxed, but this will complicate the model without changing its substance. The introduction of rule-of-thumb behavior for consumption in macro-models can be found in Fuhrer (2000) and Galí et al. (2004,2007). Aggregate consumption is composed of profit earners' and wage earners' consumption as follows:

$$C_t = C_{ct} + C_{wt}, \tag{1}$$

where C_t is aggregate consumption, C_{ct} is profit earners, and C_{wt} is wage earners. Eq. (1) can be further written as:

$$C_t = C_{ct} + \widetilde{C}_{wt} + C^*_{wt}, \tag{2}$$

where C^*_{wt} is the level of consumption by optimizing wage earners, and $\widetilde{C}_{wt}$ is the level of consumption by rule-of-thumb wage earners.

The second set of assumptions relates to the types of goods consumed. We assume that, in general, the consumption basket consists of basic and non-basic goods and services. Therefore, each class in this economy consumes a combination of basics and non-basics. We elaborate on this assumption in more detail in the context of optimizing wage earners.

2.2. Rule of thumb behavior

We start by specifying the behavior of rule-of-thumb wage earners. The literature uses a variety of rule-of-thumb schemes. Campbell and Mankiw (1989),Fuhrer (2000),Galí et al. (2004,2007), Di Bartolomeo et al. (2011) and Furlanetto and Seneca (2012) posit that agents who follow the rule-of-thumb consume all their income. Amato and Laubach (2003) assume that these wage earners set their current consumption equal to past consumption. We assume that rule-of-thumb wage earners choose the level of consumption according to a Keynesian rule as follows:

$$\widetilde{C}_{wt} = \theta^c_w\left(\frac{W_{t-1}\widetilde{N}_{t-1}}{P_{t-1}}\right), \tag{3}$$

where W_t is the nominal wage rate, $\widetilde{N}_t$ is the number of rule-of-thumb wage earners, P_t is the price level, and θ^c_w is the fraction of rule-of-thumb wage earners' disposable income that is spent on consumption, or in Keynesian terms, their marginal propensity to consume. Note that in Eq. (3) our rule-of-thumb consumers do not have access to credit, which implies that these households do not participate in asset or credit markets. We can rewrite Eq. (3) as follows:

$$\widetilde{C}_{wt} = \theta^c_w(1-\gamma_0)S_{t-1}Y_{t-1}, \tag{4}$$

where γ_0 is the share of optimizing agents among wage earners. Note that the labor share is by definition given by $S_t = \frac{W_tN_t}{P_tY_t}$., where N_t is the number of wage earners. The profit earners' behavior can be analogously derived as follows:

$$C_{ct} = \theta^c_c(1-S_{t-1})Y_{t-1}, \tag{5}$$

where θ^c_c is the proportion of income that profit earners consume. This allows us to re-write Eq. (2) as follows:

$$C_t = C^*_{wt} + \theta^c_w((1-\gamma_0)S_{t-1})Y_{t-1} + \theta^c_c(1-S_{t-1})Y_{t-1}. \tag{6}$$

We can then linearize Eq. (6) to obtain the following:

$$\widehat{c}_t = \psi_0\widehat{c}^*_{wt} + (1-\psi_0)\left\{S_0\left[\theta^c_w(1-\gamma_0) - \theta^c_c\right]\theta^{cc}\widehat{s}_{t-1} + \left[\theta^c_w((1-\gamma_0)S_0) + \theta^c_c(1-S_0)\right]\theta^{cc}\widehat{y}_{t-1}\right\}, \tag{7}$$

where ψ_0 is the steady state ratio of optimal wage earners' consumption to total consumption, and $(1-\psi_0)$ is the steady state ratio of rule-of-thumb consumption to total consumption. The parameter θ^{cc} is the steady state ratio of output to total rule-of-thumb consumption. It is standard in heterodox literature to assume Kaldorian savings habits, which means that $\theta^c_w - \theta^c_c > 0$, implying that the consumption propensity of wage earners exceeds that of profit earners. Using Keynesian reasoning, the idea is that wage earners tend to have lower incomes than profit earners, and they have larger household sizes. Therefore, their marginal propensity to consume is higher. However, in our case, the intervention of the parameters $(1-\gamma_0)$ creates an ambiguity regarding the effects of the labor share on consumption, contrary to the old Kaldorian models.

2.3. Optimizing wage earners' households

As pointed out, the consumption basket comprises basic and non-basic goods and services. The component of basic goods includes the minimum means of subsistence, which was long discussed by classical economists such as Ricardo (2001: 58), who said this minimum depends on habit. Denote the amount of basic consumption goods by X_t and non-basic consumption by Z_t. Therefore, for optimizing wage earners, aggregate consumption is a CES aggregate of basics and non-basics so that:

$$C^*_{wt} = \left[(1-\alpha)^{\frac{1}{\eta}}X^{*\frac{\eta-1}{\eta}}_{wt} + \alpha^{\frac{1}{\eta}}Z^{*\frac{\eta-1}{\eta}}_{wt}\right]^{\frac{\eta}{\eta-1}}, \tag{8}$$

where "*" denotes a variable associated with optimizing agents. From Eq. (8) the aggregate price index is $P_t = \left[(1-\alpha)P^{1-\eta}_{xt} + \alpha P^{1-\eta}_{zt}\right]^{\frac{1}{1-\eta}}$, where P_{zt} is the price of a unit of the non-basic good, and P_{xt} is the price of a unit of the basic good. The basket of basic goods depends on past consumption habits. Specifically, like Fuhrer (2000), we assume that the basket of basic goods depends on the level and change in past consumption. This implies that while the formation of basics depends on the level of past consumption, the change in past consumption modifies the rate at which past consumption is converted into basic consumption. Based on this, the basket of basic goods evolves according to:

$$X_{wt}^{*}=b_{w}C_{t-1}\left(\frac{C_{t-1}}{C_{t-2}}\right)^{a}, \tag{9}$$

where b_w measures the degree to which past consumption is converted into basic consumption, a measures the effect of past consumption growth on current basics. Note that Eq. (9) is similar to the rule-of-thumb used by Galí and Gertler (1999) and Amato and Laubach (2003) about price-setting. In our case, we adapt this rule to describe the evolution of basics in the consumption basket. In addition, when $a = 0$, the formation of basics becomes similar to the habit-formation process used by Smets and Wouters (2003), among others. The instantaneous utility function that characterizes the tastes of the optimizing wage earners is:

$$U_{wt}=\frac{C_{wt}^{*1-\sigma}}{1-\sigma}. \tag{10}$$

Optimizing wage earners maximize Eq. (10) subject to the following budget constraint:

$$\frac{D_{t}^{w}}{P_{t}}=\frac{(1+i_{t}^{c})D_{t-1}^{w}}{P_{t}}-\gamma_{0}\frac{W_{t}N_{t}}{P_{t}}+C_{wt}^{*}, \tag{11}$$

where D_t^w is the nominal value of wage earners' household debt, the number of optimizing wage-earners is $\gamma_0 N_t$, and i_t^c is the nominal interest rate specified in the wage earners' debt contract. We assume that the nominal interest rate specified in the debt contract evolves according to: $i_t^c = \widetilde{i}_{t-1}$, where $\widetilde{i}_{t-1}$ is some measure of past interest rates. Following Rudebusch and Svensson (1999), this measure is $\bar{i}_t = \frac{1}{4}\sum_{j=0}^{3} i_{t-j}$. The standard first-order conditions are:

$$C_{wt}^{*-\sigma}=\lambda_{t}, \tag{12}$$

$$\lambda_{t}=\beta E_{t}\lambda_{t+1}\left(\frac{1+\widetilde{i}_{t-1}}{1+\pi_{t}^{e}}\right), \tag{13}$$

where π_t^e denotes expected inflation. We log-linearize the intertemporal condition and take deviations from the steady state to obtain the following relationship:

$$\widehat{c}_{wt}^{*}=\widehat{c}_{wt+1}^{*}-\frac{1}{\sigma}\left(\widetilde{i}_{t-1}-\pi_{t}^{e}-r_{t-1}^{*}\right), \tag{14}$$

where r_t^* is the steady state real interest rate. The optimal allocation of consumption expenditure is given by:

$$X_{wt}^{*}=(1-\alpha)p_{xt}^{-\eta}C_{wt}^{*}, \tag{15}$$

$$Z_{wt}^{*}=\alpha p_{zt}^{-\eta}C_{wt}^{*}, \tag{16}$$

where p_{xt} and p_{zt} are the relative prices of basic and non-basic goods. From Eqs. (15) and (16) we establish the optimal allocation of consumption expenditure between basics and non-basics as the following:

$$Z_{wt}^{*}=\left(\frac{\alpha}{1-\alpha}\right)\left(\frac{p_{zt}}{p_{xt}}\right)^{-\eta}X_{wt}^{*}. \tag{17}$$

Log-linearizing Eq. (17) and taking deviations from the steady state, we obtain:

$$\widehat{z}_{wt}^{*}=\widehat{x}_{wt}^{*}-\eta(\widehat{p}_{zt}-\widehat{p}_{xt}). \tag{18}$$

From Eqs. (8), (15) and (16), we can write the linearized consumption basket as follows:

$$\widehat{c}_{wt}^{*}=\omega_{wx}\widehat{x}_{wt}^{*}+\omega_{wz}\widehat{z}_{wt}^{*}. \tag{19}$$

where $\omega_{wz} = \frac{P_{z0}Z_0}{P_0 C_0}$ and $\omega_{wx} = \frac{P_{x0}X_0}{P_0 C_0}$ are the steady-state shares of non-basics and basics in total consumption expenditure. Substituting $\widehat{c}_{wt}^{*}$ from Eq. (14) using Eq. (19), the intertemporal condition is as follows:

$$\omega_{wx}\widehat{x}_{wt}^{*}+\omega_{wz}\widehat{z}_{wt}^{*}=\omega_{wx}\widehat{x}_{wt+1}^{*}+\omega_{wz}\widehat{z}_{wt+1}^{*}-\frac{1}{\sigma}\left(\widetilde{i}_{t-1}-\pi_{t}^{e}-r_{t-1}^{*}\right). \tag{20}$$

We then use Eq. (18) to substitute $\widehat{z}_{wt+1}^{*}$ and make $\widehat{z}_{wt}^{*}$ the subject of the formula to obtain the following equation:

$$\widehat{z}_{wt}^{*}=E_{t}\widehat{x}_{wt+1}^{*}-\frac{1}{\sigma}\left(\widetilde{i}_{t-1}-\pi_{t}^{e}-r_{t-1}^{*}\right)+\omega_{wz}\eta(\Delta\widehat{p}_{xt+1}-\Delta\widehat{p}_{zt+1}). \tag{21}$$

Further log-linearizing Eq. (9) we have the following equation:

$$\widehat{x}^*_{wt} = \widehat{c}_{t-1} + a\Delta\widehat{c}_{t-1}. \tag{22}$$

Taking Eq. (22) one step forward and inserting the resultant equation into Eq. (21) we obtain the following:

$$\widehat{z}^*_{wt} = \widehat{c}_t + a\Delta\widehat{c}_t - \frac{1}{\sigma}\left(\widetilde{i}_{t-1} - \pi^e_t - r^*_{t-1}\right) + \omega_{wz}\eta(\Delta\widehat{p}_{xt+1} - \Delta\widehat{p}_{zt+1}). \tag{23}$$

From Eq. (19) we can write non-basic consumption as:

$$\widehat{z}^*_{wt} = \frac{1}{\omega_{wz}}\widehat{c}^*_{wt} - \frac{\omega_{wx}}{\omega_{wz}}(\widehat{c}_{t-1} + a\Delta\widehat{c}_{t-1}). \tag{24}$$

Using Eq. (24) to eliminate $\widehat{z}^*_{wt}$ from Eq. (23) we obtain the following equation:

$$\widehat{c}^*_{wt} = [\omega_{wx}(1+a) - \omega_{wz}a]\widehat{c}_{t-1} - \omega_{wx}a\widehat{c}_{t-2} + \omega_{wz}(1+a)\widehat{c}_t - \frac{\omega_{wz}}{\sigma}\left(\widetilde{i}_{t-1} - \pi^e_t - r^*_{t-1}\right) + \omega_{wz}\eta(\Delta\widehat{p}_{xt+1} - \Delta\widehat{p}_{zt+1}). \tag{25}$$

Using Eq. (25) to eliminate $\widehat{c}^*_{wt}$ from Eq. (7), we can write Eq. (7) as follows:

$$\widehat{c}_t = \widetilde{a}_1\widehat{c}_{t-1} - \widetilde{a}_2\widehat{c}_{t-2} - \widetilde{a}^r\left(\widetilde{i}_{t-1} - \pi^e_t - r^*_{t-1}\right) + \widetilde{a}^y\widehat{y}_{t-1} + \widetilde{a}^s\widehat{s}_{t-1} + \xi^c_t, \tag{26}$$

where:

$$\widetilde{a}_1 = \psi_0\left(\frac{\omega_{wx}(1+a) - \omega_{wz}a}{1-\psi_0\omega_{wz}(1+a)}\right), \widetilde{a}_2 = \left(\frac{\psi_0\omega_{wx}a}{1-\psi_0\omega_{wz}(1+a)}\right), \widetilde{a}^r = \left[\frac{\psi_0\omega_{wz}}{\sigma(1-\psi_0\omega_{wz}(1+a))}\right], \widetilde{a}^s = (1-\psi_0)\frac{\theta^{cc}S_0\left(\theta^c_w(1-\gamma_0) - \theta^c_c\right)}{1-\psi_0\omega_{wz}(1+a)}, \widetilde{a}^y = (1-\psi_0)\frac{\theta^{cc}\left[\theta^c_w(1-\gamma_0)S_0 + \theta^c_c(1-S_0)\right]}{1-\psi_0\omega_{wz}(1+a)}, \xi^c_t = \left(\frac{\psi_0\omega_{wz}\eta}{1-\psi_0\omega_{wz}(1+a)}\right)(\Delta\widehat{p}_{xt+1} - \Delta\widehat{p}_{zt+1}).$$

Note that in Eq. (26) ξ^c_t denotes relative price shocks. Eq. (26) is the structural traditional Keynesian consumption-based IS curve. It is a second-order dynamic consumption function, augmented with output and the labor share, which arise from the existence of rule-of-thumb consumers. The complexity of $\widetilde{a}^r$ allows us to engage with the argument advanced by Bilbiie (2008) and Bilbiie and Straub (2012) that a sufficient increase in asset market participation ψ_0 can cause a flip in the sign of $\widetilde{a}^r$, thereby leading to the IS puzzle. We take this issue up in the empirical section.

Further note that in new Keynesian specifications, the consumption Euler is used as the basis to arrive at the reduced-form output-based IS curve. While this can be done using the specification in Eq. (26), we would miss a nuanced understanding of why the labor share carries an ambiguous sign given that in relation to consumption, Kaldorian savings habits imply a definite sign. In other words, as pointed out by Dutt (1984),Taylor (1985) and Bhaduri and Marglin (1990) among others, the intervention of investment behavior in the transition from the consumption-based to the output-based IS curve causes ambiguity of the sign of the labor share, despite the assumption of Kaldorian habits.

2.4. The open-economy extension

The IS curve that we have derived above assumes a closed-economy setup. Extending it to an open-economy setup requires that we restate the consumption basket in terms of the domestic and imported foreign good. We then write:

$$C^*_{wt} = \left[(1-\omega)^{\frac{1}{\chi}}C^{*\frac{\chi-1}{\chi}}_{w,dt} + \omega^{\frac{1}{\chi}}Z^{*\frac{\chi-1}{\chi}}_{w,mt}\right]^{\frac{\chi}{\chi-1}}, \tag{27}$$

where "*" denotes a variable associated with optimizing agents, $C^*_{w,dt}$ is the consumption basket of domestic goods and $Z^*_{w,mt}$ is the consumption of the imported good. From Eq. (27) the aggregate price index is $P_t = \left[(1-\omega)P^{1-\chi}_{dt} + \omega P^{1-\chi}_{mt}\right]^{\frac{1}{1-\chi}}$, where P_{mt} is the price of a unit of the imported good and P_{dt} is the price of a unit of a unit of the domestic good. The utility function is the same as in Eq. (10). Denote total imported goods and services by Z_{mt}. We assume that imported goods and services are bought at contract prices one period in advance so that the contract price for these goods is $\widetilde{E}_{t-1}P^f_{t-1}(1+\pi_t)$, where $\widetilde{E}_{t-1}$ is the nominal exchange rate that prevailed at time $t-1$, and P^f_{t-1} is the foreign price that prevailed at time $t-1$ and π_t is the price inflation rate. The resource constraint is the same as in Eq. (11).

The optimal allocation of consumption expenditure between the domestic and foreign goods is:

$$Z^*_{w,mt} = \left(\frac{\omega}{1-\omega}\right)\left(\frac{p_{mt}}{p_{dt}}\right)^{-\chi}C^*_{w,dt}. \tag{28}$$

Let $Q_t = \frac{\widetilde{E}_tP^f_t}{P_t}$ be the real exchange rate. Log-linearizing Eq. (28) we have:

$$\widehat{z}^{*}_{w,mt} = \widehat{c}^{*}_{w,dt} - \chi\widehat{q}_{t-1} + \chi\widehat{p}_{dt}. \tag{29}$$

Note that $\widehat{c}^{*}_{w,dt}$ is given by Eq. (19). Therefore, using Eq. (19) to substitute $\widehat{c}^{*}_{w,dt}$ from Eq. (29) we obtain:

$$\widehat{z}^{*}_{w,mt} = \omega_{wx}\widehat{x}^{*}_{wt} + \omega_{wz}\widehat{z}^{*}_{wt} - \chi\widehat{q}_{t-1} + \chi\widehat{p}_{dt}. \tag{30}$$

We then use Eq. (18) to substitute $\widehat{z}^{*}_{wt}$ to obtain the following equation:

$$\widehat{z}^{*}_{w,mt} = \widehat{x}^{*}_{wt} - \chi\widehat{q}_{t-1} + \chi\widehat{p}_{dt} - \omega_{wz}\eta(\widehat{p}_{zt} - \widehat{p}_{xt}). \tag{31}$$

From Eq. (22) this in turn implies that:

$$\widehat{z}^{*}_{w,mt} = \widehat{c}_{t-1} + a\Delta\widehat{c}_{t-1} - \chi\widehat{q}_{t-1} + \chi\widehat{p}_{dt} - \omega_{wz}\eta(\widehat{p}_{zt} - \widehat{p}_{xt}). \tag{32}$$

Rule-of-thumb importers are a fraction$(1-\gamma_0)$ of wage earners. All profit earners import based on rule-of-thumb behavior. They import using the following Keynesian schemes:

$$\widetilde{Z}_{mt} = \theta^{c}_{w,m}(1-\gamma_0)S_{t-1}Y_{t-1} + \theta^{c}_{c,m}(1-S_{t-1})Y_{t-1}, \tag{33}$$

where $\theta^{c}_{w,m}$, and $\theta^{c}_{c,m}$ are fractions of income that rule-of-thumb wage earners' and profit earners' households use to import, respectively. Linearizing Eq. (33) we obtain:

$$\widetilde{z}_{mt} = \phi_m^{-1}\alpha^{y}_{m}\widehat{y}_{t-1} + \phi_m^{-1}\alpha^{s}_{m}\widehat{s}_{t-1}, \tag{34}$$

where ϕ_m^{-1} is the inverse of the steady state import-output ratio, $\alpha^{y}_{m} = \left[\theta^{c}_{w,m}(1-\gamma_0)S_0 + \theta^{c}_{c,m}(1-S_0)\right]$ and $\alpha^{s}_{m} = S_0\left(\theta^{c}_{w,m}(1-\gamma_0) - \theta^{c}_{c,m}\right)$. Aggregate imports are therefore given by:

$$\widehat{z}_{mt} = \gamma_m(1+a)\widehat{c}_{t-1} - \gamma_m a\widehat{c}_{t-2} - \gamma_m\chi\widehat{q}_{t-1} + (1-\gamma_m)\phi_m^{-1}\alpha^{y}_{m}\widehat{y}_{t-1} + (1-\gamma_m)\phi_m^{-1}\alpha^{s}_{m}\widehat{s}_{t-1} + \gamma_m\chi\widehat{p}_{dt} - \gamma_m\omega_{wz}\eta(\widehat{p}_{zt} - \widehat{p}_{xt}), \tag{35}$$

where γ_m is the steady state ratio of optimal imports to total imports and $(1-\gamma_m)$ is the ratio of rule-of-thumb imports to total imports. Lastly, exports are analogously derived following McCallum and Nelson (2000) as imports in the foreign economy. In addition, we simply assume that there are no rule-of-thumb consumers in the foreign economy. Therefore, the export function becomes:

$$x_{xt} = \left(1+a^{f}\right)\widehat{c}^{f}_{t-1} - a^{f}\widehat{c}^{f}_{t-2} + \chi^{f}\widehat{q}_{t-1} + \chi^{f}\widehat{p}^{f}_{dt} - \omega^{f}_{wz}\eta^{f}\left(\widehat{p}^{f}_{zt} - \widehat{p}^{f}_{xt}\right), \tag{36}$$

where $\widehat{p}^{f}_{dt}$ is the relative price of the foreign good, $\widehat{p}^{f}_{xt}$ is the foreign price of basics, $\widehat{p}^{f}_{zt}$ is the relative foreign price of the non-basics and the superscript "f" denotes a foreign economy variable or parameter. We now turn to aggregate output dynamics.

2.5. *Aggregate output dynamics*

Assuming that at macroeconomic equilibrium, output equals consumption by abstracting from investment and government spending, the linearized macro-balance equation is:

$$\widehat{y}_t = \phi_c\widehat{c}_t + \phi_x\widehat{x}_{xt} - \phi_m(\widehat{z}_{mt} + \widehat{q}_{t-1}). \tag{37}$$

Using Eq. (37) to express $\widehat{c}_t$ in terms of $\widehat{y}_t$, and using Eq. (26) we have the dynamics of output as follows:

$$\widehat{y}_t = \delta_y\widehat{y}_{t-1} - \delta_{yy}\widehat{y}_{t-2} - \delta_r\left(\widetilde{i}_{t-1} - \pi^{e}_{t} - r^{*}_{t-1}\right) + \delta_s\widehat{s}_{t-1} + \delta^{f}_{y}\widehat{y}^{f}_{t-1} - \delta^{f}_{yy}\widehat{y}^{f}_{t-2} + \delta_q\widehat{q}_{t-1} + \epsilon_t, \tag{38}$$

where we assume that higher order domestic and foreign output terms, and the combination of relative price shocks are captured by the error term ϵ_t and $\delta_y = (\widetilde{a}_1 + \widetilde{a}^{y} - \phi_m\gamma_m(1+a) - (1-\gamma_m)\alpha^{y}_{m})$, $\delta_{yy} = (\widetilde{a}_2 - \phi_m a\gamma_m)$, $\delta_r = \phi_c\widetilde{a}^{r}$, $\delta_s = (\phi_c\widetilde{a}^{s} - (1-\gamma_m)\alpha^{s}_{m})$, $\delta^{f}_{y} = \phi_x(1+a^{f})$, $\delta^{f}_{yy} = \phi_x a^{f}$ and $\delta_q = \left[\phi_m(\gamma_m\chi - 1) + \phi_x\chi^{f}\right]$. Eq. (38) is the open-economy extension of the backward-look IS curve of Rudebusch and Svensson (1999), except that the labor share appears explicitly in our case. The significance of the labor share signals the existence of rule-of-thumb consumers. A similar IS curve, absent the labor share, is also used by Goodhart and Hoffman (2005), Paradisoet al. (2013) and Alovokpinhou et al. (2024) to investigate the effect of the interest rate on output.

3. Empirical evidence

3.1. *Data and estimation strategy*

We test the empirical strength of our derived IS curve by using data from eight advanced economies and eight emerging market economies, where data for all the variables that are in Eqs. (26) and (38) is available. Data is sourced from the Federal Reserve Bank of St. Louis. However, the labor share is derived from the OECD database. We have homogenized the samples across countries to start from 2000 to 2019. The only exception is Mexico, whose labor share series starts from 2008 to 2019, so estimations for Mexico that involve the labor share have a shorter sample than the rest of the countries. In terms of frequency, we use quarterly data.

The variables are measured as follows: output is measured using real GDP, consumption is measured using real consumption expenditure, the interest rate is measured using the 90-day Treasury bill rate, foreign output is US real GDP for most countries and for the US, foreign output is the EU real GDP and the real exchange rate is measured using the real effective exchange rate. The labor share is measured by dividing the nominal compensation of employees by nominal GDP. We control for outliers and possible breaks using dummy variables for each country. The measure of past interest rates that borrowers and lenders use on their debt contracts is $\bar{i}_t = \frac{1}{k}\sum_{j=0}^{k-1} i_{t-j}$, as in Rudebusch and Svensson (1999), where k varies per country.

We detrend the data using the HP filter. We note that Hamilton (2018) does not recommend the use of the HP filter; however, there is literature that shows that Hamilton's proposed filter does not improve upon the HP filter; for example, Drehmann and Yetman (2018),Hall and Thomson (2021) and Franke et al. (2023). Therefore, we also present results based on detrending using the quadratic time trend in the Appendix. Broadly, the results are qualitatively similar to those of the HP filter. In terms of estimation method, we use Ordinary Least Squares with Newey and West (1987) heteroscedasticity and autocorrelation consistent standard errors to estimate the backward-looking IS curves, and for the new Keynesian IS curve, we use GMM.

Given the structure of the equations, it is very difficult to identify all the parameters that underlie them. Studies that investigate the role of rule-of-thumb consumers tend to rely on parameter calibration, e.g., Gali et al. (2004) and Furlanetto and Seneca (2012). Alternatively, these studies, e.g., Gali et al. (2007), present reduced-form evidence. Consequently, we also present reduced-form evidence of the Keynesian consumption and output dynamics that we have derived.

We also perform a semi-structural estimation. Now, the parameters in Eq. (38) are hopelessly complex, so we cannot attempt a structural estimation to recover them. In any case, there are more parameters than variables and, so we cannot identify the underlying parameters. However, regarding Eq. (26), we can attempt a structural estimation under the assumption of log-utility, which is used in the literature on rule-of-thumb behavior. Under this assumption, we have $\sigma = 1$. The parameters in Eq. (26) would then be:

$$\widetilde{a}_1 = \psi_0\left(\frac{\omega_{wx}(1+a)-\omega_{wz}a}{1-\psi_0\omega_{wz}(1+a)}\right), \widetilde{a}_2 = \left(\frac{\psi_0\omega_{wx}a}{1-\psi_0\omega_{wz}(1+a)}\right), \widetilde{a}^r = \left(\frac{\psi_0\omega_{wz}}{1-\psi_0\omega_{wz}(1+a)}\right), \widetilde{a}^s = (1-\psi_0)\frac{\theta^{cc}S_0\left(\theta^c_w(1-\gamma_0)-\theta^c_c\right)}{1-\psi_0\omega_{wz}(1+a)} \widetilde{a}^y$$
$$= (1-\psi_0)\frac{\theta^{cc}\left[\theta^c_w((1-\gamma_0)S_0)+\theta^c_c(1-S_0)\right]}{1-\psi_0\omega_{wz}(1+a)}$$

Note in addition that $\omega_{wz} = (1-\omega_{wx})$. Furthermore, if, from reduced-form evidence, we find that the parameter for $\widehat{c}_{t-2}$ is not significant, we can set $a = 0$ in our structural estimation. This makes the formation of basics follow the same process as the formation of habits used by, for example, Smets and Wouters (2003). This further simplifies the parameters to be:

$$\widetilde{a}_1 = \psi_0\left(\frac{\omega_{wx}}{1-\psi_0\omega_{wz}}\right), \widetilde{a}_2 = 0, \widetilde{a}^r = \left(\frac{\psi_0\omega_{wz}}{1-\psi_0\omega_{wz}}\right)$$

$$\widetilde{a}^s = (1-\psi_0)\frac{\theta^{cc}S_0\left(\theta^c_w(1-\gamma_0)-\theta^c_c\right)}{1-\psi_0\omega_{wz}}$$

$$\widetilde{a}^y = (1-\psi_0)\frac{\theta^{cc}\left[\theta^c_w((1-\gamma_0)S_0)+\theta^c_c(1-S_0)\right]}{1-\psi_0\omega_{wz}}$$

Table 1
Reduced-form estimates of the basic consumption-based IS curve (Eq. (26): $\psi_0 = 1,\ \sigma = 1$).

	Emerging Market Economies							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
$\widehat{c}_{t-1}$	1.04*	1.11*	1.02*	1.29*	1.07*	1.59*	1.26*	0.77*
	(0.10)	(0.15)	(0.09)	(0.17)	(0.11)	(0.10)	(0.10)	(0.10)
$\widehat{c}_{t-2}$	−0.19**	−0.24	−0.11	−0.42**	−0.13	−0.61*	−0.39*	0.04
	(0.11)	(0.16)	(0.10)	(0.24)	(0.10)	(0.11)	(0.09)	(0.09)
$\widetilde{r}_{t-1}$	−0.02	0.14	0.04	−0.13	0.02	0.06*	−0.14	0.00
	(0.07)	(0.08)	(0.08)	(0.11)	(0.10)	(0.02)	(0.12)	(0.05)
R^2	0.75	0.80	0.84	0.84	0.87	0.94	0.82	0.68
	Advanced Economies							
	Australia	Canada	EU	Japan	NZ	US	UK	Norway
$\widehat{c}_{t-1}$	1.07*	1.24*	1.30*	0.76*	0.72*	1.21*	1.21*	0.95*
	(0.16)	(0.11)	(0.13)	(0.09)	(0.10)	(0.11)	(0.11)	(0.14)
$\widehat{c}_{t-2}$	−0.22	−0.40*	−0.30**	0.03	0.15	−0.28*	−0.23	−0.14
	(0.18)	(0.14)	(0.15)	(0.06)	(0.09)	(0.13)	(0.14)	(0.18)
$\widetilde{r}_{t-1}$	−0.35*	−0.09	0.00	0.57*	−0.25	−0.14**	−0.38**	−0.03
	(0.16)	(0.09)	(0.05)	(0.21)	(0.15)	(0.08)	(0.19)	(0.08)
R^2	0.77	0.86	0.93	0.75	0.66	0.87	0.86	0.66

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

3.2. The basic consumption-based IS curve

The first set of results concerns the consumption-based IS curve in Eq. (26) but with $\psi_0 = 1$, i.e. there is no rule of thumb behavior. Table 1 reports the results for the real short-term interest rate. The significance of the real interest rate in driving consumption appears to be weak in many of the economies in our sample. Only two economies in our sample, the UK and the US, exhibit correctly signed and significant interest rate effects. Alovokpinhou et al. (2024) find similar results in their empirical investigation of the international evidence of interest rate effects in IS curves. These authors investigate the significance of both the short-term and long-term real interest rates and find that these variables exhibit either wrongly signed coefficients or are not significant. This result is the IS puzzle noted by Nelson (2001). It is also a feature that afflicts forward-looking IS curves, as first investigated by Fuhrer and Rudebusch (2004).

In light of this challenge, we use the nominal interest rate, which we found to be consistent with the data. This is in line with the findings by Fair (2004: 66). Theoretically, the use of the nominal interest rate has implications for expected inflation. Fair (2015) posits that the significance of the nominal interest rate, as opposed to the real interest rate, may be rationalized by assuming that expected inflation is constant, especially if the central bank is credible and agents think it targets a fixed inflation rate. Secondly, instead of assuming a constant steady state nominal interest rate, we have detrended the nominal interest rate in the same way as we detrended output, i.e. using the HP-filter.

Table 2 reports the results from reduced-form estimations of the basic consumption-based IS curve. The results show that this IS curve is mainly consistent with the data across most economies. An important observation is that the parameter associated with $\hat{c}_{t-2}$ is not significant in many countries. This raises two implications. The first implication is that the underlying parameter a is not statistically significant. The second implication is that the structural behavior of consumption does not account for the second-order dynamics of output that is typically observed in the data. For example, the seminal paper by Rudebusch and Svensson (1999) specifies output dynamics as driven by an AR (2) process. Since the second lag of consumption is insignificant, it follows that consumption behavior is not the source of the second output lag.

Overall, the results support the empirical validity of the basic consumption-based IS relationship since the interest rate is correctly signed and statistically significant. Suppose as Bilbiie (2008) and Bilbiie and Straub (2012) maintain, that the cause of perverse interest rate effects is an institutional factor such as limited asset market participation. In that case, such a factor should affect our model as well. We therefore conclude that the perverse sign problem is a problem that is specific to the new Keynesian IS curve.

The next set of results presents structural estimates of the basic consumption-based IS curve. Table 3 shows that, in this baseline case where there are no rule-of-thumb consumers, the consumption basket is overwhelmingly composed of basic goods and services. Only in Japan do basic goods make up 58 % of the consumption basket. Note that the parameter associated with the growth rate of consumption in the formation of basic goods a is not significant in several economies and in some, it carries the wrong sign. This broadly confirms the reduced-form evidence in Table 2.

Overall, the reduced-form results are plausible, and the structural results produce viable weights for basic goods in the consumption basket. At this stage, only the parameter associated with the growth rate of consumption in the formation of basic goods exhibits a perverse sign, and it is not significant in some economies. We next explore the results obtained from extended versions of the consumption-based IS curve.

Table 2
Reduced-form estimates of the basic consumption-based IS curve (Eq. (26): $\psi_0 = 1, \ \sigma = 1$).

	Emerging Market Economies							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
$\hat{c}_{t-1}$	0.88*	0.99*	1.05*	1.27*	1.04*	1.51*	1.13*	0.73*
	(0.08)	(0.11)	(0.08)	(0.18)	(0.11)	(0.07)	(0.11)	(0.10)
$\hat{c}_{t-2}$	−0.21*	0.04	−0.13	−0.39	−0.11	−0.57*	−0.23*	0.04
	(0.09)	(0.10)	(0.09)	(0.26)	(0.12)	(0.07)	(0.10)	(0.09)
$\tilde{i}_{t-1}$	−0.25*	−0.35*	−0.21*	−0.15**	−0.08**	−0.14*	−0.45**	−0.21**
	(0.06)	(0.11)	(0.10)	(0.09)	(0.04)	(0.06)	(0.27)	(0.12)
R^2	0.77	0.87	0.83	0.84	0.86	0.95	0.84	0.70
	Advanced Economies							
	Australia	Canada	EU	Japan	NZ	US	UK	Norway
$\hat{c}_{t-1}$	1.00*	1.23*	1.14*	0.73*	0.69*	1.16*	1.17*	0.92*
	(0.00)	(0.10)	(0.11)	(0.08)	(0.12)	(0.11)	(0.09)	(0.15)
$\hat{c}_{t-2}$	−0.20**	−0.37*	−0.10	−0.06	−0.14	−0.22**	−0.22**	−0.16
	(0.12)	(0.13)	(0.13)	(0.08)	(0.10)	(0.12)	(0.12)	(0.18)
$\tilde{i}_{t-1}$	−0.54*	−0.18**	−0.20*	−1.72**	−0.29**	−0.18*	−0.53*	−0.08**
	(0.19)	(0.10)	(0.05)	(0.91)	(0.17)	(0.08)	(0.22)	(0.04)
R^2	0.76	0.87	0.92	0.73	0.69	0.88	0.83	0.65

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

Table 3
Structural estimates of the basic consumption-based IS curve (Eq. (26): $\psi_0 = 1,\ \sigma = 1$).

	Emerging Market Economies							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
ω_{wx}	0.92*	0.70*	0.97*	0.90*	0.96*	0.89*	0.98*	0.98*
	(0.12)	(0.07)	(0.09)	(0.30)	(0.04)	(0.06)	(0.15)	(0.12)
a	0.02	−0.05	−0.10	0.30**	−0.01	0.41*	0.27*	−0.18*
	(0.09)	(0.14)	(0.08)	(0.15)	(0.15)	(0.09)	(0.00)	(0.08)
R^2	0.76	0.85	0.85	0.77	0.80	0.90	0.82	0.71
	Advanced Economies							
	Australia	Canada	EU	Japan	NZ	US	UK	Norway
ω_{wx}	0.69*	0.89*	0.85*	0.58*	0.78*	0.84*	0.74*	0.98*
	(0.12)	(0.09)	(0.02)	(0.23)	(0.12)	(0.05)	(0.15)	(0.02)
a	0.09	0.27*	0.19**	−0.07	−0.24**	0.22*	0.07	0.18
	(0.10)	(0.10)	(0.10)	(0.07)	(0.12)	(0.10)	(0.12)	(0.17)
R^2	0.72	0.81	0.93	0.81	0.67	0.88	0.75	0.64

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

3.3. *Extended consumption-based IS curve*

The next set of results concerns the extended version of the consumption-based IS curve. In this case, we admit rule of thumb behavior. In terms of estimation strategy, we note two points. Firstly in the case of Eq. (21), $\widehat{c}_{t-1}$ and $\widehat{y}_{t-1}$ are highly correlated. This may bias the estimation of the parameters, especially of $\widehat{y}_{t-1}$, towards zero, because $\widehat{c}_{t-1}$ is likely to contain most of the variation in $\widehat{c}_t$ that is explained by $\widehat{y}_{t-1}$. Secondly, and flowing from the first point, in estimating Eq. (26) we tended to find insignificant output and labor share effects. To deal with this possible estimation bias, we estimate Eq. (26) by recalling that Eq. (7) can be written as follows:

$$\widehat{c}_t = \psi_0 \widehat{c}^*_{wt} + \varphi_s(\widehat{s}_{t-1} + \widehat{y}_{t-1}) + \varphi_y \widehat{y}_{t-1}, \tag{39}$$

where $\varphi_s = (1-\psi_0)S_0\left[\theta^c_w(1-\gamma_0) - \theta^c_c\right]\theta^{cc}$ and $\varphi_y = (1-\psi_0)\theta^{cc}\left[\theta^c_w(1-\gamma_0)S_0 + \theta^c_c(1-S_0)\right]$. Estimating Eq. (26) by combining the determinants of the rule-of-thumb behavior in this way produced realistic results, which we present in Table 4. Once again, the nominal interest rate is correctly signed and significant in most economies. The coefficient for $\widehat{c}_{t-2}$ is not significant in some of the economies. This once again shows that the AR (2) process in output may not be based on the structural consumption behavior in these

Table 4
Reduced-form estimates of the extended consumption-based IS curve (Eq. (26)).

	Emerging Market Economies							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
$\widehat{c}_{t-1}$	0.95*	1.01*	0.81*	1.59*	0.89*	1.20*	1.20*	0.74*
	(0.14)	(0.11)	(0.13)	(0.38)	(0.10)	(0.15)	(0.08)	(0.13)
$\widehat{c}_{t-2}$	−0.26*	−0.07	−0.06	−0.35*	−0.04	−0.42*	−0.20**	−0.07
	(0.09)	(0.10)	(0.12)	(0.15)	(0.08)	(0.08)	(0.11)	(0.10)
$\widetilde{i}_{t-1}$	−0.26*	−0.38*	−0.18**	−1.11*	−0.15*	−0.12**	−0.43**	−0.19**
	(0.11)	(0.09)	(0.09)	(0.45)	(0.04)	(0.07)	(0.24)	(0.11)
$\widehat{s}_{t-1}$ +	−0.37**	−0.06**	0.12**	−0.08	0.13*	0.13*	0.11**	0.32*
$\widehat{y}_{t-1}$	(0.22)	(0.04)	(0.07)	(0.08)	(0.03)	(0.07)	(0.06)	(0.13)
$\widehat{y}_{t-1}$	0.24	0.12	0.06	−0.59	−0.05	0.05	−0.23	−0.24
	(0.17)	(0.12)	(0.07)	(0.36)	(0.05)	(0.10)	(0.16)	(0.15)
R^2	0.79	0.90	0.83	0.85	0.92	0.92	0.88	0.67
	Advanced Economies							
	Australia	Canada	EU	Japan	NZ	USA	UK	Norway
$\widehat{c}_{t-1}$	0.94*	1.29*	1.34*	0.84*	0.56*	1.05*	1.08*	0.75*
	(0.14)	(0.12)	(0.13)	(0.08)	(0.12)	(0.14)	(0.09)	(0.12)
$\widehat{c}_{t-2}$	−0.14	−0.29*	−0.36*	−0.01	0.18*	−0.15	−0.24*	−0.32*
	(0.13)	(0.12)	(0.12)	(0.06)	(0.07)	(0.12)	(0.11)	(0.15)
$\widetilde{i}_{t-1}$	−0.81*	−0.26**	−0.09**	−0.48*	−0.35*	−0.13**	−0.45**	−0.11*
	(0.20)	(0.15)	(0.05)	(0.91)	(0.16)	(0.07)	(0.26)	(0.05)
$\widehat{s}_{t-1}$ +	−0.07**	0.11**	0.09*	0.11**	0.10**	−0.09*	0.12**	−0.06**
$\widehat{y}_{t-1}$	(0.04)	(0.06)	(0.04)	(0.06)	(0.06)	(0.04)	(0.07)	(0.03)
$\widehat{y}_{t-1}$	0.04	−0.15*	−0.07*	−0.22*	0.18*	0.14*	0.02	0.31*
	(0.10)	(0.06)	(0.03)	(0.07)	(0.10)	(0.07)	(0.14)	(0.11)
R^2	0.86	0.89	0.94	0.83	0.77	0.90	0.85	0.79

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

economies.

We also note that the co-efficient associated with the term $(\widehat{s}_{t-1} + \widehat{y}_{t-1})$ is negative in some economies, implying that $[\theta_w^c(1-\gamma_0) - \theta_c^c] < 0$. This does not necessarily mean that Kaldorian savings habits are violated; it likely means that γ_0, the fraction of wage earners who are optimizing, is sufficiently large, the marginal propensity of profit earners is sufficiently large, the marginal propensity of wage earners is not large enough or a combination of these. This appears to be the case in a few economies, while the rest exhibit a positive sign. The significance of the term associated with the labor share indicates that rule of thumb behavior is present and significant.

The next step is to present results from a semi-structural estimation. The reported results are semi-structural because φ_s and φ_y are still reduced-form parameters. In addition, since the reduced-form parameter that is associated with $\widehat{c}_{t-2}$ is not significant in some economies, we simplify our semi-structural estimation by setting $a = 0$.

Table 5 reports the results. The share of basics in consumption remains quite high. For example, in Chile, the share of basics is 74 %, whereas in the baseline case, it was 70 %. The share of wage earners that optimize is 89 %. In the case of the US, the share of basics is also 85 %, which is comparable to the estimate of the habit-formation parameter found by Smets and Wouters (2007), which is 71 % based on a longer sample than ours. The share of rule-of-thumb behavior is 10 %, which is far lower than the estimates of Albonico et al. (2023) and Di Bartolomeo et al. (2011), who estimate this parameter to be 45 % in the US. These differences could be due to differences in sample periods and size. In some advanced economies, the share of consumption from optimizing agents exceeded 1, so we constrained the parameter ψ_0 to equal 1. This is the case for Canada, EU and the UK. Overall, the proportion of consumption by wage earners who optimize is quite high across all economies. We note that in some countries, φ_y has a perverse, negative sign, although it is not significant.

The above results show that the extended consumption-based IS curve is mainly consistent with the data across many economies. The share of basics is relatively high. Optimizing behavior is dominant relative to rule-of-thumb behavior. For many economies, we have $\varphi_s > 0$, this means that the proportion of income that is consumed by profit earners θ_c^c is sufficiently small, i.e., $\theta_c^c < \theta_w^c(1-\gamma_0)$, which in turn implies that Kaldorian savings habits, given by $\theta_c^c < \theta_w^c$, the hold among rule of thumb consumers. The next set of results concerns the output-based IS curve.

3.4. *Reduced-form estimation of the output-based IS curve*

The next set of results in Table 6 presents reduced-form evidence from the output-based IS curve, which is Eq. (38). As can be observed, the coefficient on the second lag of output is sometimes insignificant in some economies. Where it is significant, it is likely due to other factors but not structural consumption behavior. In addition, there is no IS puzzle in the estimations. The interest rate enters the IS curve with a correct sign, which is statistically significant.

We now proceed to the results for the extended IS curve in Table 7. We observe that there is no IS puzzle. In most economies, the labor share is significant, which theoretically implies that there is rule-of-thumb behavior. The significance of the second-order term remains mixed.

Based on the above results, we conclude that our structural traditional Keynesian IS curve fits the data and does not suffer from the problems that afflict its new Keynesian counterpart when the measure of the interest rate based on past interest rates is used. We have

Table 5
Semi-structural estimates of the extended consumption-based IS curve (Eq. (26): $\sigma = 1$).

	Emerging Market Economies							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
ω_{wx}	0.76*	0.74*	0.90*	0.86*	0.91*	0.77*	0.80*	0.99*
	(0.06)	(0.07)	(0.10)	(0.35)	(0.04)	(0.08)	(0.07)	(0.13)
ψ_0	0.75*	0.89*	0.82*	0.65*	0.72*	0.91*	0.93*	0.59*
	(0.11)	(0.08)	(0.07)	(0.17)	(0.06)	(0.08)	(0.08)	(0.13)
φ_s	1.06*	1.25**	0.68*	1.27*	0.45*	−0.85	−0.62	0.00
	(0.53)	(0.72)	(0.30)	(0.17)	(0.16)	(1.68)	(2.29)	(0.30)
φ_y	−1.10	−0.33	−0.01	−0.03	0.43*	1.26	0.11	0.75*
	(0.88)	(0.29)	(0.28)	(0.16)	(0.06)	(1.01)	(0.80)	(0.25)
R^2	0.78	0.90	0.86	0.94	0.85	0.89	0.87	0.85
	Advanced Economies							
	Australia	Canada	EU	Japan	NZ	USA	UK	Norway
ω_{wx}	0.48*	0.90*	0.85*	0.25*	0.76*	0.85*	0.93*	0.99*
	(0.07)	(0.11)	(0.03)	(0.08)	(0.06)	(0.06)	(0.04)	(0.11)
ψ_0	0.91*	1.00	1.00	0.95*	0.69*	0.90*	1.00	0.74*
	(0.04)	-	-	(0.04)	(0.13)	(0.08)	-	(0.11)
φ_s	0.16	-	-	−1.20	0.69	1.05**	-	0.51
	(0.64)	-	-	(1.02)	(0.42)	(0.56)	-	(0.37)
φ_y	−0.45	-	-	0.26	0.04	−0.45	-	0.00
	(0.34)	-	-	(0.43)	(0.33)	(0.57)	-	(0.13)
R^2	0.83	–	0.97	0.76	0.72	0.89	0.97	0.63

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

Table 6
Reduced-form estimates of the output-based IS curve (Eq. (38): $\psi_0 = 1,\ a^f = 0$).

Emerging Market Economies

	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
$\hat{y}_{t-1}$	0.93*	0.90*	1.28*	0.98*	0.61*	1.03*	0.71*	0.85*
	(0.10)	(0.10)	(0.09)	(0.12)	(0.13)	(0.09)	(0.13)	(0.14)
$\hat{y}_{t-2}$	−0.30*	−0.17	0.29*	−0.51*	0.22*	−0.33*	−0.19**	−0.30**
	(0.10)	(0.12)	(0.09)	(0.09)	(0.09)	(0.11)	(0.11)	(0.17)
$\tilde{i}_{t-1}$	−0.15*	−0.16*	−0.12**	−0.18*	−0.27*	−0.09**	−0.40*	−0.17**
	(0.06)	(0.08)	(0.07)	(0.07)	(0.08)	(0.05)	(0.14)	(0.10)
$\tilde{q}_{t-1}$	0.03*	−0.05*	−0.06*	0.00	0.04	0.00	0.04*	0.03
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.05)
$\hat{y}^f_{t-1}$	0.07	0.24*	−0.04	0.74*	0.12	0.17*	0.01	0.51**
	(0.07)	(0.11)	(0.08)	(0.25)	(0.12)	(0.06)	(0.10)	(0.26)
R^2	0.81	0.84	0.94	0.88	0.73	0.90	0.71	0.71

Advanced Economies

	Australia	Canada	EU	Japan	NZ	USA	UK	Norway
$\hat{y}_{t-1}$	0.66*	1.04*	0.69*	0.59*	0.72*	0.84*	1.38*	0.33*
	(0.09)	(0.09)	(0.11)	(0.16)	(0.15)	(0.13)	(0.12)	(0.06)
$\hat{y}_{t-2}$	−0.02	−0.38*	0.26*	−0.39*	−0.03	−0.09	−0.60*	−0.04
	(0.12)	(0.07)	(0.12)	(0.14)	(0.12)	(0.14)	(0.11)	(0.09)
$\tilde{i}_{t-1}$	−0.31**	−0.17**	−0.42*	−3.86*	−0.26**	−0.20**	−0.30*	−0.05**
	(0.17)	(0.10)	(0.16)	(1.79)	(0.14)	(0.10)	(0.12)	(0.02)
$\tilde{q}_{t-1}$	0.00	0.01	0.02	−0.23**	0.01	−0.02*	0.02**	−0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
$\hat{y}^f_{t-1}$	0.02	0.17*	0.14	0.46*	−0.03	0.16*	0.05	0.43*
	(0.04)	(0.08)	(0.10)	(0.12)	(0.09)	(0.06)	(0.04)	(0.08)
R^2	0.65	0.90	0.82	0.71	0.61	0.87	0.93	0.58

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

Table 7
Reduced-form estimates of the extended output-based IS curve (Eq. (38): $a^f = 0$).

Emerging Market Economies

	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
$\hat{y}_{t-1}$	0.87*	0.75*	1.37*	0.81*	0.57*	0.81*	0.77*	0.86*
	(0.11)	(0.09)	(0.10)	(0.28)	(0.14)	(0.13)	(0.12)	(0.13)
$\hat{y}_{t-2}$	−0.34*	−0.15	−0.34*	−0.47*	0.25*	−0.24*	−0.18	−0.17
	(0.09)	(0.11)	(0.09)	(0.09)	(0.09)	(0.11)	(0.13)	(0.12)
$\tilde{i}_{t-1}$	−0.18*	−0.15**	−0.14**	−0.76*	−0.31*	−0.09**	−0.38*	−0.15**
	(0.07)	(0.08)	(0.08)	(0.37)	(0.08)	(0.05)	(0.15)	(0.08)
$\hat{s}_{t-1}$	−0.25*	−0.08*	0.16**	−0.12**	0.11**	−0.12*	0.08**	0.25**
	(0.12)	(0.03)	(0.08)	(0.07)	(0.06)	(0.05)	(0.05)	(0.14)
$\hat{y}^f_{t-1}$	0.06	0.19*	−0.07	0.89	0.25*	0.30*	−0.01	0.26
	(0.07)	(0.09)	(0.10)	(0.54)	(0.12)	(0.09)	(0.11)	(0.23)
$\tilde{q}_{t-1}$	0.03*	−0.04*	−0.09*	−0.01	0.01	0.00	0.03**	0.03
	(0.01)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.05)
R^2	0.86	0.86	0.95	0.86	0.74	0.91	0.66	0.83

Advanced Economies

	Australia	Canada	EU	Japan	NZ	USA	UK	Norway
$\hat{y}_{t-1}$	0.64*	1.23*	0.54*	0.64*	0.64*	0.79*	1.29*	0.32*
	(0.08)	(0.11)	(0.09)	(0.11)	(0.18)	(0.11)	(0.13)	(0.07)
$\hat{y}_{t-2}$	−0.06	−0.59*	0.31*	−0.33*	0.06	−0.11	−0.51*	−0.04
	(0.12)	(0.10)	(0.09)	(0.08)	(0.19)	(0.14)	(0.13)	(0.09)
$\tilde{i}_{t-1}$	−0.28**	−0.21*	−0.56*	−2.57*	−0.35**	−0.21**	−0.30*	−0.05**
	(0.14)	(0.11)	(0.22)	(0.90)	(0.21)	(0.11)	(0.13)	(0.02)
$\hat{s}_{t-1}$	0.06**	0.12**	−0.44*	0.12**	−0.11**	−0.10*	0.10*	0.07**
	(0.03)	(0.07)	(0.19)	(0.07)	(0.07)	(0.04)	(0.04)	(0.04)
$\hat{y}^f_{t-1}$	0.03	0.21*	0.15	0.36*	−0.13	0.17*	0.07	0.63*
	(0.05)	(0.07)	(0.14)	(0.09)	(0.10)	(0.08)	(0.05)	(0.14)
$\tilde{q}_{t-1}$	0.00	0.02	0.00	−0.02	0.00	−0.02**	0.02	−0.02
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
R^2	0.68	0.90	0.83	0.84	0.71	0.85	0.91	0.69

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

also found that the IS puzzle does not arise in our model, regardless of whether there are rule-of-thumb consumers. Goodhart and Hoffman (2005) and Paradiso et al. (2013) found that adding more forcing variables such as oil prices, money growth, and asset prices helps generate a negative and significant effect on the interest rate on the output gap. Our results show that these additional variables are unnecessary to make the interest rate effect correctly signed and significant.

3.5. The nominal interest rate in the new Keynesian IS curve?

Our finding is that the traditional Keynesian IS curve overcomes the IS puzzle when the moving average of the nominal interest rate is used. However, this result rests on using the nominal, rather than the real, interest rate. Fair (2004) dedicates a chapter to investigating the effects of the interest rate on expenditure equations. Fair (2004: 61) writes, "it will be seen that the data rather strongly support the use of nominal over real interest rates in most expenditure equations". Fair posits that this could be due to agents' expected inflation being constant, so that the nominal and real interest rate are perfectly correlated. We, therefore, further investigate whether using the nominal interest rate in the new Keynesian consumption and output-based IS curves generates the correct and significant interest rate effects.

The theoretical motivation for an interest rate measure such as $\widetilde{i}_t$ in the new Keynesian setup is, once again, that borrowers and lenders enter into debt contracts in which the contract interest rate is a measure of past interest rates. We assume habit formation of up to two lags of consumption. These assumptions allow us to estimate the following consumption-based IS curve, which we adapt from Fuhrer and Rudebusch (2004):

$$\widehat{c}_t = \alpha_1\widehat{c}_{t-1} + \alpha_2\widehat{c}_{t-2} + \mu E_t\widehat{c}_{t+1} - \alpha^r\left(\widetilde{i}_{t-1} - \widetilde{i}^*_{t-1}\right), \tag{40}$$

where we have assumed that the expected inflation rate is a constant inflation target of the central bank, i.e. $E_t\pi_{t+1} = \pi^*$, as suggested by Fair (2004: 66). Note that we included the lag of the nominal interest rate based on the assumption that the interest rate that agents use in entering into debt or lending contracts are contract rates which depend on the measure of past interest rate. However, we mention that the following results are not affected by whether the measure of past nominal interest rate is lagged or not. The output version of the equation is:

$$\widehat{y}_t = \delta_1\widehat{y}_{t-1} + \delta_2\widehat{y}_{t-2} + \gamma E_t\widehat{y}_{t+1} - \delta^r\left(\widetilde{i}_{t-1} - \widetilde{i}^*_{t-1}\right). \tag{41}$$

Table 8 reports the results for Eq. (40), which we estimated using GMM, where the set of endogenous instruments is similar to those in Fuhrer and Rudebusch (2004) and Bilbiie and Straub (2012). We do not consider exogenous instruments because, as Fair (2008) argues, one has to use variables that are part of the model as instruments. The use of higher lags that do not appear in the model, even if these lags are for endogenous variables, violates the principle mentioned by Fair.

The results from Table 8 show that there are several cases where the new Keynesian consumption-based IS curve exhibits correctly signed interest rate effects. The challenge is that these interest rate effects are not significant. Therefore, the new Keynesian IS curve

Table 8
GMM estimation of the new Keynesian consumption IS curve (Eq. (40)).

	Emerging Market Economies							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
$\widehat{c}_{t-1}$	0.61*	0.66*	0.70*	0.55*	0.45*	0.62*	0.22**	0.42*
	(0.15)	(0.21)	(0.23)	(0.12)	(0.20)	(0.22)	(0.12)	(0.16)
$\widehat{c}_{t-2}$	−0.09	0.08	−0.04	−0.08	0.02	−0.08	0.14**	0.06
	(0.07)	(0.06)	(0.10)	(0.08)	(0.10)	(0.11)	(0.08)	(0.10)
$\widehat{c}_{t+1}$	0.39	0.34**	0.30	0.61*	0.57*	0.49*	0.75*	0.51*
	(0.28)	(0.20)	(0.33)	(0.10)	(0.15)	(0.15)	(0.15)	(0.15)
$\widetilde{i}_t$	−0.08	−0.24	0.05	−0.10	−0.02	0.00	−0.04	−0.01
	(0.13)	(0.20)	(0.16)	(0.09)	(0.03)	(0.06)	(0.20)	(0.06)
R^2	0.85	0.92	0.86	0.91	0.90	0.97	0.87	0.76
	Advanced Economies							
	Australia	Canada	EU	Japan	NZ	US	UK	Norway
$\widehat{c}_{t-1}$	0.57*	0.38*	0.51*	0.29	0.70*	0.55*	0.20	0.54*
	(0.20)	(0.18)	(0.22)	(0.18)	(0.12)	(0.08)	(0.40)	(0.10)
$\widehat{c}_{t-2}$	−0.01	0.06	−0.02	0.08	0.05	−0.05	0.10	−0.08
	(0.11)	(0.10)	(0.10)	(0.11)	(0.09)	(0.06)	(0.11)	(0.06)
$\widehat{c}_{t+1}$	0.44*	0.64*	0.52*	0.93*	0.15	0.51*	0.74*	0.56*
	(0.16)	(0.13)	(0.13)	(0.41)	(0.19)	(0.05)	(0.34)	(0.08)
$\widetilde{i}_t$	−0.36	−0.05	0.01	1.26	−0.08	0.02	0.42	0.01
	(0.33)	(0.09)	(0.04)	(1.73)	(0.15)	(0.04)	(0.51)	(0.02)
R^2	0.87	0.92	0.96	0.39	0.74	0.94	0.85	0.80

Note: HAC std. errors in parentheses, *significant at 5 %, ** significant at 10 %. Instruments: $(\widehat{c}_t,\ i_t)$-(1–4) lags.

suffers from the IS puzzle even when the nominal interest rate is used. As can be observed by setting $\mu = 0$, Eq. (40) becomes Eq. (26) with $\psi_0 = 1$, and the IS puzzle accordingly will disappear. We therefore conclude that the problem of lack of interest rate effects in new Keynesian IS curves may have to do with forward-looking behavior. As Fuhrer and Rudebusch (2004) put it, "it is important to note that many of the cases in which we obtain larger estimates of μ entail imprecise or economically negligible estimates of the link between output and real interest rates". The next set of results in Table 9 concerns Eq. (41), the output-based IS curve. The results remain the same, the interest rate effect is not significant and it is wrongly signed in many economies.

The above results cast doubt on the argument that limited asset participation could be the reason behind the perverse interest rate sign in new Keynesian IS curves, as maintained by Bilbiie (2008) and Bilbiie and Straub (2012). This is because limited asset market participation is an institutional factor that should affect both backward and forward-looking agents. However, we find overwhelmingly that in the backward-looking IS curve, there is no inversion of aggregate demand through the positive sign of the interest rate. Instead, we posit that the problem of the IS puzzle may have to do with forward-looking behavior, for which, as Fuhrer and Rudebusch (2004) have found, there is little evidence.

4. Conclusion

There is overwhelming evidence that the new Keynesian IS curve, in its various formulations, does not fit the data. Nelson (2001) noticed that the interest rate in these curves either carries a wrong sign or is not statistically significant. The same finding is reported by Fuhrer and Rudebusch (2004),Stracca (2010) and more recently Ascari et al. (2021) and Haque and Magnusson (2022). The second problem relates to forward-looking behavior. Fuhrer and Rudebusch (2004) find little evidence that forward-looking behavior characterizes consumption or output dynamics, while Stracca (2010) finds that forward-looking behavior is dominant.

Given this disturbing evidence regarding the empirical validity of the new Keynesian IS curve, we revisited the traditional IS curve by giving it some theoretical underpinnings. We first assumed a two-class economy in which a section of wage earners optimize and the rest follow rule-of-thumb behavior, together with profit earners. This allows for the role of functional income distribution in determining output fluctuations. Secondly, the consumption basket comprises basic and non-basic goods and services. This idea draws from classical economists and is related to the concept of habit formation. These assumptions led us to an AR (2) structural Keynesian IS curve similar to one used by Rudebusch and Svensson (1999) and Estrella (2003) but augmented with the labor share, which we extended also to incorporate open-economy factors. We then estimated this theory-based traditional Keynesian IS curve to check if it fits the data.

Our findings are as follows. Firstly, basic goods constitute an overwhelming portion of the consumption basket. Basic goods generally constitute >70 % of the consumption basket in almost all the economies in our sample. In some economies, this portion can be assumed to constitute the full consumption basket. This explains the sluggish output response to shocks. Secondly, optimizing behavior is dominant compared to rule-of-thumb behavior. >60 % of consumption is by optimizing agents in emerging markets, and >70 % is by optimizing agents in advanced economies. Thirdly, and related to the second finding, the labor share is significant in many economies in our sample. Fourthly, our IS curve does not exhibit the IS puzzle when we use the nominal version of the measure of past nominal interests similar to the one in Rudebusch and Svensson (1999). We find correctly signed and statistically significant interest rate effects on consumption and output without additional forcing variables as suggested by the literature. This result holds regardless of whether rule of thumb behavior is present or absent. Therefore, monetary policy has a direct effect on the output gap.

Our findings have three implications. Firstly, if limited asset market participation, as suggested by Bilbiie (2008) and Bilbiie and Straub (2012), is the reason behind the IS puzzle, it should also affect the traditional Keynesian IS curve. We find this not to be the case. The source of the IS puzzle may have to be sought in the forward-looking behavior implied by the new Keynesian specification. Secondly, despite our finding that rule-of-thumb behavior is significant, more work has to be done to ascertain its importance in shaping the business cycle. Amato and Laubach (2003),Galí et al. (2004) and Furlanetto and Seneca (2012) find that rule-of-thumb behavior changes the dynamic responses of variables to shocks. In contrast, Di Bartolomeo (2011) and Albonico et al. (2023) conclude that despite such behavior, estimated DSGE models produce business cycle properties similar to models without rule-of-thumb behavior. However, all these models assume real interest rate effects in forward-looking expenditures, an assumption not supported by the data.

Thirdly, we draw attention to the centrality of functional income distribution in structuralist Keynesian business cycle models, from which DSGE modellers may learn. The seminal contributions by Dutt (1984),Taylor (1985) and Bhaduri and Marglin (1990) suggest that functional income distribution is a crucial variable in macroeconomic analysis. This is also made clear in the work by Chiarella and Flaschel (2000), which found expression in the monetary model by Flaschel et al. (2001) and Asada et al. (2006), among others. These authors identified stabilizing and destabilizing feedback channels that arise when functional income distribution is specified in macroeconomic models. This means that, from the modelling point of view, the baseline 2D system specified by Rudebusch and Svensson (1999) needs to be extended into a 3D one so that, as in Franke et al. (2006) and Proano (2012), the law of motion of the labor share is taken into account. Lastly, the IS curve we have derived can be generalized so that each of the wage-earning and profit-earning classes has both rule-of-thumb and optimizing agents.

Author statement

I the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. I have no conflict of interest to declare. Have not received any funding for the research in the manuscript.

Table 9
GMM estimation of the new Keynesian output IS curve (Eq. (41)).

	Emerging Market Economies							
	Brazil	Chile	Czech	Mexico	Poland	SA	S.Korea	Turkey
$\hat{y}_{t-1}$	0.62*	0.39	0.92*	0.75*	0.72*	1.08*	0.63*	0.69*
	(0.08)	(0.28)	(0.21)	(0.18)	(0.12)	(0.47)	(0.12)	(0.15)
$\hat{y}_{t-2}$	−0.11**	−0.09	−0.26*	−0.20**	0.22**	−0.29**	−0.11	−0.11
	(0.06)	(0.10)	(0.12)	(0.11)	(0.12)	(0.17)	(0.09)	(0.09)
$\hat{y}_{t+1}$	0.48*	0.71*	0.33*	0.45*	−0.01	0.14	0.45*	0.36*
	(0.08)	(0.26)	(0.13)	(0.12)	(0.20)	(0.42)	(0.16)	(0.13)
$\tilde{i}_{t-1}$	−0.04	0.12	−0.06	−0.01	−0.16*	−0.09	−0.07	−0.03
	(0.05)	(0.13)	(0.06)	(0.09)	(0.07)	(0.13)	(0.15)	(0.05)
R^2	0.86	0.89	0.96	0.93	0.60	0.89	0.76	0.83
	Advanced Economies							
	Australia	Canada	EU	Japan	NZ	US	UK	Norway
$\hat{y}_{t-1}$	0.31*	0.80*	1.22*	0.43*	0.78*	0.47*	0.67*	0.31*
	(0.15)	(0.07)	(0.27)	(0.16)	(0.16)	(0.17)	(0.12)	(0.10)
$\hat{y}_{t-2}$	0.19	−0.23*	0.18*	0.05	−0.14	0.03	−0.12	0.01
	(0.14)	(0.06)	(0.08)	(0.12)	(0.11)	(0.13)	(0.08)	(0.10)
$\hat{y}_{t+1}$	0.76*	0.42*	−0.33	0.72*	0.13	0.53*	0.47*	0.62*
	(0.15)	(0.06)	(0.31)	(0.17)	(0.19)	(0.10)	(0.07)	(0.10)
$\tilde{i}_{t-1}$	−0.37	0.06	−0.72*	2.00**	−0.06	−0.01	−0.14	0.00
	(0.23)	(0.07)	(0.24)	(1.08)	(0.14)	(0.05)	(0.14)	(0.03)
R^2	0.61	0.94	0.55	076	0.56	0.91	0.96	0.40

Note: HAC std. errors in parentheses, *significant at 5 %, ** significant at 10 %. Instruments: $(\hat{y}_t,\ i_t)$-(1–4) lags.

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jmacro.2024.103640.

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