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'A behavioural analysis of time inconsistency in macroeconomic policy-making'

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Abstract

As central bankers around the world struggle to contain inflation, the efficacy of inflation targeting is being challenged. Was inflation targeting only ever *seeming* to work because it had no work to do? In addressing these questions, this paper distinguishes then reconciles time inconsistency concepts from rational expectations and behavioural economics to show that the inflation bias identified in rational expectations models will be magnified in the presence of behavioural present bias. The range of enforceable inflation targets decreases as present bias increases, suggesting that inflation targeting tools should be refined to address the inflationary impacts of policy-makers' present bias.

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Keywords: time-inconsistency, present bias, inflation targeting

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1 Introduction

Macroeconomic policy-makers' preoccupations with inflation diminished in the aftermath of the 2007/8 global financial crisis and the long period of low inflation which followed. Fears of deflation and recession grew and monetary policy was reoriented towards expansionary approaches associated with unconventional monetary policy and quantitative easing, and focus on the monetary policy constraints associated with a zero lower bound to interest rates (e.g. see Billi, Söderström, and Walsh 2023). However, with the resurgence of persistent inflationary pressures as a consequence of the COVID pandemic and its aftermath, alongside geo-political tensions, debates are returning to the issue of credibility in monetary policy-setting, alongside new concerns about the efficacy of inflation targeting. The conventional wisdom that inflation targeting is the best practice tool for moderating inflationary pressures is being challenged as central bankers around the world struggle to control inflation. Meanwhile, households are burdened by a 'double whammy' of persistent rises in prices and borrowing costs, these rises feeding into each other as central banks hike interest rates in their attempts to tame inflation. Questions are building about whether inflation targeting is faltering as a best-practice monetary policy tool. Was inflation targeting only ever *seeming* to work because it had no work to do?

Central bankers face the challenge that monetary policy is constrained by inflationary expectations and these are driven by a complex interplay between time preference and beliefs about future inflation. In unravelling time preference and beliefs, rational expectations theorists and behavioural economists analyse belief-formation in fundamentally distinct ways, using the phrase "time inconsistency" to capture concepts which seem mutually inconsistent. Yet this clash between time inconsistency in rational expectations models and behavioural economics has received limited attention in monetary policy debates. One way to reconcile the approaches is to separate the rational expectations concepts of time inconsistency in outcomes and beliefs (as manifested in expectations) from behavioural economic concepts of time inconsistent *preferences*. In rational expectations models of time in-

consistent expectations and outcomes, the inflation bias which emerges is a form of 'institutional bias' - reflecting the nature of the monetary policy institutions and the constraints which they face. By contrast, in behavioural economics, time inconsistent preferences are an 'intra-personal bias', reflecting a clash of a boundedly rational agent's preferences for the short-term versus the long-term, sometimes described as an "inter-temporal tussle" between a current and future self (Strotz 1955).

In the context of these monetary policy tensions, this paper brings together the rational expectations and behavioural economic approaches by distinguishing, then reconciling, the different forms of time inconsistency. In unravelling the implications for central banks' efforts to anchor inflationary expectations, an encompassing model is outlined, which shows that the inflationary bias associated with time inconsistency in rational expectations models will be amplified by behavioural intra-personal time inconsistency, with consequences dependent on the extent and type of time inconsistency exhibited by a monetary policy-maker.

In developing this analysis, section 2 outlines the foundations of the rational expectations approach and section 3 sets-out Barro and Gordon's extension of rational expectations into a model of temptation and reputation in monetary policy-making (Barro and Gordon 1983b, 1983a). Section 4 outlines key insights from behavioural economics about time inconsistency, and section 5 shows how the rational expectations approach can be reconciled with behavioural concepts of time inconsistency via an encompassing model, which embeds present bias into the Barro-Gordon model. Conclusions and policy-implications are explored in section 6.

2 Rational expectations models of macroeconomic policy

In rational expectations models, time inconsistency is the outcome of a strategic game between rational policy-makers and rational private agents, with rationality defined in terms of the rational expectations hypothesis and

its constituent assumptions that rational agents make full use of all current and past information and make no systematic mistakes (Muth 1961; Lucas 1972; Sargent, Fand, and Goldfeld 1973). Preferences and beliefs come together in the form of forward-looking rational expectations. In the context of discretionary policy-making, a time inconsistent macroeconomic *outcome* emerges, not because of an inconsistent rate of time preference at the level of individual private agents or policy-makers, but because of misaligned incentives: policy-makers have incentives to inflate the economy; private agents face incentives to maintain their real wages by increasing their nominal wage demands when confronted with rising prices. The outcome of this strategic game between rational agents is a form of sub-optimal externality manifested as inflation bias (Kydland and Prescott 1977; Barro and Gordon 1983a).

This rational expectations analysis builds on the "policy ineffectiveness" critiques of Lucas, Sargent, Wallace and others, focused on the limitations of discretionary demand management and its reliance on counter-cyclical monetary and fiscal policy levers (Lucas 1972, 1976; Sargent and Wallace 1975, 1976). The Kydland and Prescott model established that an optimal control approach to achieving employment and inflation targets will not work when a macroeconomic policy-maker is engaged in a game against rational economic agents, as opposed to a game against nature (Kydland and Prescott 1977). Time inconsistency emerges within the context of rational expectations and inter-temporal utility maximisation, with models' micro-foundations consistent with subjective expected utility theory (Neumann and Morgenstern 1944/1953; Savage 1954). But this inconsistency is not an inconsistency of preferences. Instead, preferences are assumed to be independent, complete, stationary and consistent. Specifically for the rate of time preference, the discount function embedded within the intertemporal Euler relation is exponential in form and, consistent with time-separable utility, the rate of time preference (the discount rate) will be stable and inter-temporal trade-offs will be independent of when they occur.

Thus rational expectations models incorporate the standard discounted util-

ity model, with a constant discount rate:

$$max \sum_{t=1}^{\infty} u_\tau(c_\tau) D(\tau) d\tau \tag{1}$$

where u is utility and c is consumption and $D(\cdot)$ is the discount function:

$$D(t) = \delta^t = (\frac{1}{1+r})^t \approx e^{-rt} \tag{2}$$

and δ is the discount factor and r is the discount rate.

However, whilst an individual's rate of time preference may be stable and consistent, the outcome is not because of the strategic interactions between private agents and discretionary policy makers. A policy designed to be optimal in the first period is no longer optimal in the next period, and the cause of its sub-optimality is itself. The strategic game between rational private agents and policy-makers generates inflation bias as the outcome of the sub-optimal Nash equilibrium emerging from non-cooperative strategic decision-making (Kydland and Prescott 1977).

In the Kydland-Prescott model, discretionary demand management policy will be counter-productive as private agents shift their inflation expectations in response to announcements of discretionary policies or, when discretionary policies are anticpated, rationally anticipating the inflationary consequences of pushing an economy beyond full employment. So, a policy designed to be optimal ex-ante, assuming static expectations, will not be optimal ex-post because rational agents' expectations shift in response to the policy, reducing social welfare relative to a world in which a policy-maker credibly commits to a stable inflation target.

The implications from the Kydland-Prescott rational expectations approach focused on making the rules of the monetary policy game clear and transparent, building credibility to ensure that rational agents believe that policy-makers will stick to their targets, thus anchoring private agents' expectations - providing an 'ideal' compromise – escaping the inflationary bias of discre-

tionary policy-making but avoiding the rigidity and inflexibility of monetary policy based purely on rules, including price level rules, money supply growth rules (such as Friedman's k-percent rule) and monetary growth rules (Friedman 1960; Kilponen and Leitemo 2008; Billi, Söderström, and Walsh 2023).

3 Barro & Gordon's temptation-reputation model

Building on the Kydland-Prescott model of institutional time inconsistency, Barro and Gordon build on the Kydland-Prescott result that, when rational private agents know that policy-makers have incentives to "cheat" on their policy commitments in the short-term by inflating the economy beyond full employment equilibrium, then a non-cooperative equilibrium will emerge as the outcome of non-co-operative strategies between agents and policy-makers, but with additional complexity emerging from policy-makers' concerns about their credibility and reputation (Barro and Gordon 1983a, 1983b). Monetary policy-makers will be balancing short-term temptations to cheat on their inflation promises against long-term reputational benefits associated with a good record for credibility in monetary policy-setting (Barro and Gordon 1983a, 1983b).

However, policy-makers' temptation to cheat will be moderated by policy-makers' concerns about their reputation and its impact on the credibility of their policy-targets. If policy-makers are aware that their policy levers will be blunted in the future if their reputations are damaged today, then they will realise that future policy targets will be harder to achieve when their reputations are tarnished. Given that concerns about reputation are essentially forward-looking, the present value of future reputation will be determined by a policy-maker's discount function. Specifically, forward-looking decision-makers, with a lower rate of time preference, i.e. a lower discount rate, will value their reputations more highly than decision-makers with a higher discount rate. It follows that forward-looking policy-makers will be less likely to cheat on their commitments, even though - if they

were playing just a one-shot game - they would otherwise revert to a non-cooperative strategy (Friedman 1971; Axelrod and Hamilton 1981; Axelrod 1984).

In establishing this result, Barro and Gordon specify the policy-maker's objective function as:

$$z_t = (a/2)(\pi_t)^2 - b_t(\pi_t - \pi^e{}_t) \tag{3}$$

where $a, b_t > 0$, π_t is inflation at time t, and $\pi^e{}_t$ are inflationary expectations at time t. To link with a non-accelerating rate of inflation target (NAIRU) target, this will be achieved when $\pi_t = \pi^e{}_t$. When the economy deviates away from the NAIRU, there will be a cost in terms of inflation bias, given by:

$$(a/2(\pi_t)^2) \tag{4}$$

where a is a parameter capturing the cost of inflation to the policy-maker, as manifested in the form of an inflation bias.

But there will also be benefits from inflationary policies, e.g. from increases in employment and/or government revenue. These will be given by:

$$b_t(\pi_t - \pi^e{}_t) \tag{5}$$

where b is a parameter capturing the benefits to the policy-maker of deviations in inflation above inflationary expectations, specifically in terms of pushing unemployment below the NAIRU.

Taking account of these benefits and costs and expressing in expected present value terms, the policy-maker will be minimising the following loss function:

$$Z_t = E[z_t + (1/(1+r_t)) \cdot z_{t+1} + (1/(1+r_t)(1+r_{t+1})) \cdot z_{t+2} + ...] \tag{6}$$

where r_t denotes the discount rate between period t and t+1, and the dis-

count factor is given by:

$$q_{\mathrm{t}} = \frac{1}{(1 + r_{\mathrm{t}})} \tag{7}$$

In Barro and Gordon's model, when policy-makers transgress by cheating on their policy commitments to a NAIRU target, then they will be punished. This punishment is delivered via enforcement from private agents, who adjust their expectations to the detriment of the policy-maker, making it harder for policy-makers to achieve their NAIRU targets in the future. With exponential discounting, the expected present value of this enforcement cost is given by:

$$Enforcement = E[q_{\mathrm{t}}(z_{\mathrm{t}+1} - z^{*}{}_{\mathrm{t}+1})] = \tilde{q} \cdot (1/2)(\bar{b}^2)a \tag{8}$$

The policy-maker balances this cost against their temptation, i.e. the benefits they will accrue in the short-term if they cheat on their commitments.

$$Temptation = (1/2)(\bar{b})^2/a \tag{9}$$

So the policy-maker will cheat on their commitments where the benefits captured in the temptation relation (10) are greater than the costs captured in the enforcement relation (9).

In the context of inflationary and stagflationary episodes through the 1970s and 1980s, these theoretical insights were embedded within the received wisdom in macroeconomic policy-making which shifted towards advocacy of inflation targeting and central bank independence as solutions to the problem of a discretionary policy-makers' temptations to cheat on their commitments, highlighting the salience of central bankers' reputations. These institutional reforms focused on ensuring that central bankers and their advisory monetary policy committees anchored consumers' inflationary expectations by credibly committing to a low but feasible inflation target. The rationale is that, if private agents believe that central bankers are committed to the inflation target and will not be tempted to inflate the economy, then private

agents will moderate their nominal wage demands and the inflation target will become self-fulfilling. Thus, monetary policy-makers will more easily anchor private agents' inflationary expectations, and make their job of controlling inflation easier in the long-term, leveraging the reputation they have built for keeping their promises.

4 Time inconsistency in behavioural economics

The focus in behavioural economics is on boundedly rational decision-makers who use heuristics to guide their decisions, making them susceptible to behavioural bias (Simon 1955; Gigerenzer and Selten 2002; Kahneman 2003; Baddeley 2006. This approach is substantively different from the rational expectations models described in the preceding section, in which rational agents are assumed to be fully informed, making no systematic mistakes. However, the simplifying assumptions of rational, independent, self-interested and homogenous agents that enable aggregation in conventional macroeconomic models are fundamentally inconsistent with key insights from behavioural economics. In behavioural economics, time inconsistency reflects an intra-personal struggle between different 'selves', building on Strotz's insights about time preferences reflecting "inter-temporal tussles" between different incarnations of the individual through time, with preferences of the 'present self" and future selves colliding (Strotz 1955; Frederick, Loewenstein, and O'Donoghue 2002). These tussles manifest in present bias and preference reversals. For example, when a person is planning for a long distant future, they may believe themselves capable of resisting temptation, but when temptation becomes more immediate and tangible, then their preferences change and they are not able to resist temptation after all: preference for self-control reverses.

This behavioural time inconsistency is fundamentally different from the phenomenon of time inconsistency identified in rational expectations models. Time inconsistency in behavioural economics is about preferences at a microeconomic level. Individual's time preferences are unstable, reflect-

ing what some behavioural economists describe as an intra-personal, inter-temporal tussle between their current and future self with respect to their preferences for today versus the future (Strotz 1955; Frederick, Loewenstein, and O'Donoghue 2002; O'Donoghue and Rabin 2015; Cohen et al. 2020). Behavioural discount functions capture this time inconsistency in different ways, in the form of hyperbolic or quasi-hyperbolic discount functions (Laibson 1997; Harris and Laibson 2002; O'Donoghue and Rabin 2000). behavioural time inconsistency is manifested as shifts in an individual's rate of time preference depending on the time horizons over which they are constructing their choices. The value of future rewards is disproportionately low relative to the value of current rewards leading to a disproportionate focus on short-term rewards and a mismatch between long-run intentions and short-run actions. This generates present bias: the discount rate shifts over time, capturing a disproportionate impatience in the short-term versus the long-term, with preferences weighted towards immediate, tangible rewards over delayed, intangible costs (O'Donoghue and Rabin 1999, 2000, 2001).

Mathematically behavioural/intra-personal time-inconsistency can be captured using hyperbolic and quasi-hyperbolic discount functions, where the discount rate varies according to when the payoffs are received (Laibson 1997; Harris and Laibson 2002). Specifically, quasi-hyperbolic discounting (QHD) is set out in Laibson (1997) as follows:

$$D(t) = \beta\delta^t = \beta[\frac{1}{1+\rho r}]^t \tag{10}$$

where δ represents the time-consistent rate of time preference, and β is the present bias parameter. Specifically, QHD generates a problem of present bias, reflecting the fact that the discount rate is not constant, as in the exponential discounting (ED) functions of rational expectations models, but will vary according to when the payoffs are received – leading to shifts in the discount rate over time. For example, if I suffer from present bias: when I choose between rewards today and tomorrow, I might prefer rewards today; but when I'm choosing between rewards in a year versus a year and a day,

then I might prefer to wait the extra day. My rate of time preference will be unstable, shifting over time.

The specification of the QHD function is encompassing in the sense that it nests standard ED function – in which the rate of time preference is stable, and the QHD function – in which the rate of time preference is unstable. Specifically: with ED, $\beta = 1$ and preferences are time-consistent; with QHD $0 < \beta < 1$ and short-term rewards will be over-weighted relative to long-term rewards – generating present bias associated with a discount function of this form:

$$D(t) = \beta\delta^t = \beta[\frac{1}{1+r}]^t \tag{11}$$

where δ represents the time-consistent rate of time preference, and β is the present bias parameter, capturing time-inconsistent preferences for immediate gratification. If $\beta = 1$, then preferences are time-consistent; but if β is less than 1 then the agent will over-weight short-term rewards relative to long-term rewards, and the inter-temporal Euler consumption relation will break down.

5 An encompassing approach

As explored above, there are fundamental inconsistencies between the rational expectations and behavioural approaches to time inconsistency. The first focuses on inconsistencies in beliefs/expectations and outcomes; the second is about inconsistencies as reflecting shifts over time in a given individual's rate of time preference. However, the approaches can be reconciled by disentangling the distinction between *institutional* time inconsistency – consistent with rational expectations, and the *intra-personal* time inconsistency emerging from time inconsistent preferences in behavioural economics. Given dynamic strategic games between policy-makers and rational agents in the rational expectations models explored above, institutional time inconsistency creates an *institutional* present bias. Its behavioural corollary, emerging when assumptions of perfectly rational decision-making and rational expectations are relaxed, is *behavioural present bias* – a product of

intra-personal time inconsistency.

The different impacts of behavioural present bias on macroeconomic policy-making can be captured by constructing a hybrid encompassing model which embeds a quasi-hyperbolic discount function into Barro and Gordon's policy-maker loss function, in place of a standard exponential discount functions (Laibson 1997; Harris and Laibson 2002).

5.1 A Behavioural Reputational Model of Policy-making

behavioural time inconsistency can be embedded into the Barro-Gordon model by replacing the standard exponential discount function with a behavioural discount function, specifically Laibson's quasi-hyperbolic discounting function (Laibson 1997; Harris and Laibson 2002). This also builds a hybrid model which nests the rational expectations and behavioural time inconsistency hypotheses.

Replacing the q from equation (7) with the behavioural quasi-hyperbolic discount factor gives:

$$D(t) = \beta\delta^t = \beta[\frac{1}{1+r}]^{\mathrm{t}} \tag{12}$$

where $0 < \beta < 1$

Temptation is, by definition, an immediate impulse and is not about an intertemporal balancing act, so the Barro-Gordon temptation relation is not changed by incorporating a behavioural discount function. The Enforcement relation, however, does change because it is about the present value of consequences in the future from cheating today. Allowing for present bias, this becomes:

$$Enforcement = \beta\delta \cdot (1/2)(\bar{b}^2)a \tag{13}$$

Note that the present bias parameter is less than 1 i.e. $0 < \beta < 1$ so it follows that $\beta\delta < q$. Therefore, with the present bias associated with quasi-hyperbolic discounting, the present value of the enforcement costs

from cheating are less. Therefore, *ceteris paribus*, the likelihood that the policy-maker will cheat is increasing in the present bias parameter β. Thus, behavioural present bias magnifies the inflation bias identified in rational expectations models. Note also that when $\beta = 1$, Barro and Gordon's rational expectations result holds because, in that case, $\beta\delta = q$.

In a macroeconomic policy framework, inflationary bias created by institutional present bias will be magnified in the context of behavioural present bias, but separating inter-personal and intra-personal time inconsistency to identify institutional present bias versus behavioural present bias is a complex task. This section explores some of the implications of these complexities specifically in the context of the macroeconomic policy debates, building on the Barro and Gordon model introduced above.

5.2 Heterogeneity in Types of Discounters

An empirical advantage for microeconomic models incorporating behavioural discount functions is the wide-ranging experimental evidence from psychological and behavioural economic studies confirming that present bias is endemic in decision-making by humans and other animals, demonstrating that individuals' rate of time preference is not stable as assumed in standard economic discounted utility models. However, intra-temporal time inconsistency at a macroeconomic scale is difficult to model theoretically or estimate empirically, reflecting aggregation problems. Whilst behavioural macroeconomic hypotheses can be modelled using simulation and agent-based modelling methods (see for example Angeletos et al. 2001), these approaches do not easily enable the empirical separation of hypotheses about an unstable rate of time preference set out in behavioural economics from a high but stable discount rates set within a rational expectations framework.

It follows that, in identifying different types of monetary policy-makers, a problem emerges in unravelling high discount rates and present bias. This is an important distinction for two reasons. First, a high discount rate with no present bias creates only institutional time inconsistency - there will be

inflation bias but it will not be magnifed by present bias, as set-out in the model above. Second, inflation targeting is a solution to institutional present bias but it assumes rational policy-makers incentivised to commit to credible inflation targets. Once present bias is added into the mix, it is not clear that current models of inflation targeting are an effective way to deal with policy-makers' present bias.

One way to separate the scenarios is to distinguish types of monetary policy-makers, building on behavioural economists' typology of discounters. Angeletos et al observe that some hyperbolic discounters value commitment, and thus hold illiquid assets as for them the cost of doing so is offset by the value of commitment (Angeletos et al. 2001). Thus, intra-personal time inconsistency may be moderated if agents embed pre-commitment mechanisms into their decision-making - an insight that connects with inflation targeting if inflation targeting can be understood as a pre-commitment device used by central bankers in controlling their temptation to inflate the economy.

O'Donoghue and Rabin develop the QHD approach to capture heterogenity in types of discounters, as determined by their β (O'Donoghue and Rabin 2000, 1999, 2001). O'Donoghue and Rabin postulate that different individuals will respond in different ways to the potential for pre-commitment, depending on their type (O'Donoghue and Rabin 1999, 2001). They identify four types, categorised according to two factors: first, the extent to which they are aware of their time-inconsistency; and second, what they do to overcome their predispositions towards present bias and preference reversals. Adapting these definitions to the macroeconomic policy-making ecosystem, macroeconomic policy-makers can be categorised as follows:

1. **Myopic**: Myopic types decide on the basis of static preferences. They are essentially uber-naïfs in that they not only fail to recognise the pitfall of time inconsistency but also fail to recognise the dynamic nature of the problems they face. So they are not forward-looking at all: their present bias parameter approaches zero, leading to a situation equiva-

lent to an infinite rate of time preference, and so their discount factor on future rewards approaches zero. A "one-shot game" discretionary policy-maker is myopic in this sense, being focused only on the current period. Arguably, the myopic policy-maker is the traditional Keynesian discretionary policy-maker, focusing policy choices on boosting current income and expenditure.

2. **Naïve**: These types are forward-looking but completely unaware of their time inconsistency and likelihood of preference reversal. They naïvely assume that their future selves will behave tomorrow as they do today and so their actual and perceived present bias is captured by $\hat{\beta} = 1 > \beta$, where $\hat{\beta}$ is their own estimate of their present bias (i.e. that they don't suffer from it, believing that they have a perfect capacity for self-control over time), and β is their actual present bias parameter. Thus, naïfs' preferences formed in time $t + n$ will be identical to those anticipated in time t because they do not take into account their own time inconsistency when planning future actions. They choose their plans as viewed from today's perspective.

   Applied to macroeconomic policy-making, naïve policy-makers would believe that they were making time consistent policy decisions taking the long-term perspective into account, and so would be unaware when their policy choices are time inconsistent. In line with the models outlined above, this monetary policy-making stance would increase the likelihood of inflation bias. O'Donoghue and Rabin allow that some naïfs may be only partially naïve, i.e. individuals who are partially aware of their changing preferences but not entirely and so underestimate their magnitude, that is: $\hat{\beta} \in (\beta, 1)$.

3. **Resolute**: These individuals are aware of, and anticipate *ex-ante*, their own intra-personal time inconsistency and so bind themselves to pre-commitment strategies – for an individual decision-maker, they might bind themselves with commitment mechanisms such as long-term contracts and illiquid investments. The "tie me to the mast"

example of Ulysses is often used to illustrate this idea. If their pre-commitment strategies are effective in removing present bias, then $\hat{\beta} = \beta = 1$. The corollary in macroeconomics, is a policy-makers is the policy-maker who binds themselves to a policy target, specifically a monetary-policy maker committing to an inflation target,and agreeing to costly sanctions for deviating from the inflation target. This type of policy-maker would also be equivalent to a disciplined policy-maker within the rational expectations framework.

4. **Sophisticated**: These individuals anticipate their own time-inconsistency. Sophisticates are aware that their preferences change in the future and so decide not to participate, to avoid the negative consequences of inconsistency. The common analogy is Ulysses deciding to take a take a different route to avoid the "irresistible and deadly call of the Sirens" (Hey and Panaccione, 2011). For these types, $\hat{\beta} = \beta$ in theory, but without practical implications given their decision to avoid the inter-temporal conflict. Hypothetically, in a macroeconomic policy context, this would be a policy-maker who anticipates the dilemma identified by Lucas and others, and therefore abstains from intervening. This has no real-world corollary for monetary policy-makers because they have a legislated mandate to intervene - though in different ways in different economies, depending on the specific legislation.

5.3 A behavioural typology of macroeconomic policy-makers

Applying the O'Donoghue-Rabin typology to the discount functions from the Barro & Gordon's model of temptation and enforcement (reproduced in Figure 1) enables identification of various types of policy-makers within the hybrid model set-out above - as summarised in Table 1 and depicted in Figure 2. A behaviourally myopic policy-maker will have a $\beta = 0$ (equivalent to $\rho \to \infty$) and will be completely myopic – leading to a corner solution, as depicted by the dashed horizontal line coincident with the x axis. This would be equivalent to a traditional Keynesian discretionary policy-maker who worries only about the current situation.

	patient *low* ρ	**impatient** *high* ρ
$\beta = 0$	behaviourally myopic	behaviourally myopic
$0 < \beta < 0.5$	naïve	naïve
$0.5 < \beta < 1$	sophisticate	sophisticate
$\beta = 1$	resolute, time consistent	rationally myopic

Table 1: Different combinations of discount rate and present bias

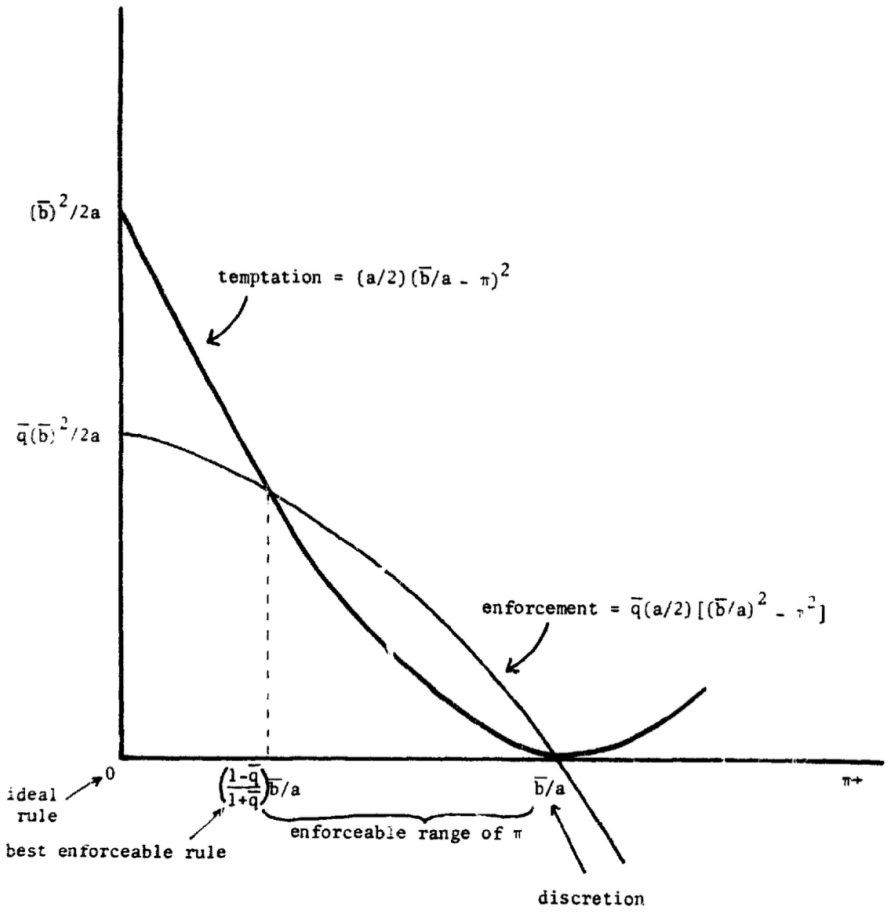

Fig. 1. Temptation and enforcement.

Figure 1: Temptation-Enforcement Model (Barro & Gordon 1983b, p 112)

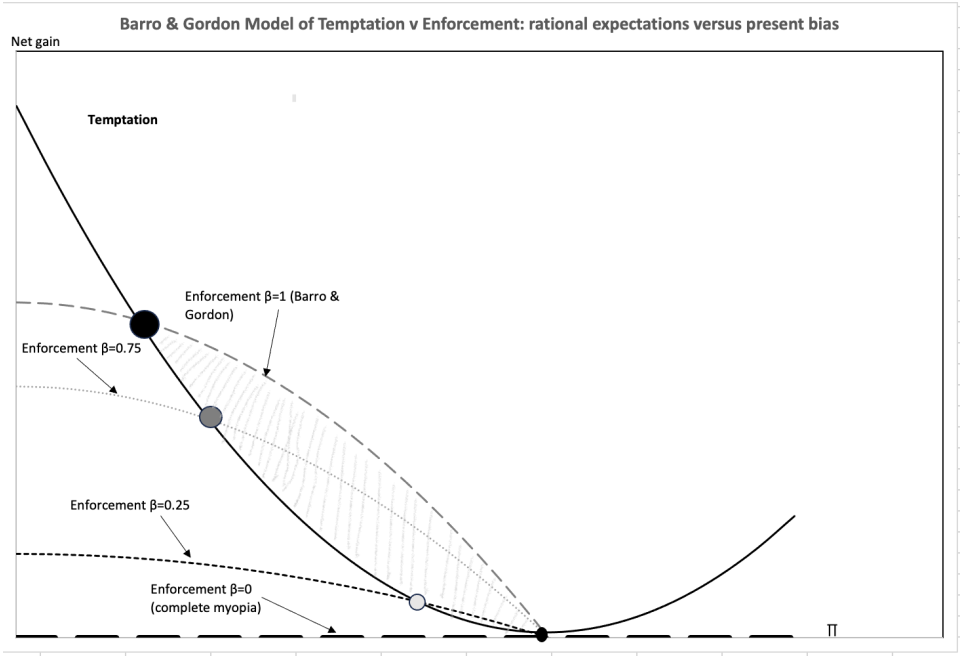

Figure 2: Temptation-Enforcement Model: exponential vs quasi-hyperbolic discounting

At the opposite end of the spectrum, for a rational expectations, time-consistent policy maker, $\beta = 1$ is a scenario consistent with a stable rate of time preference and exponential discount function. This scenario would also be consistent with a resolute policy-maker as per O'Donoghue and Rabin - who is aware of their present bias but makes a perfect pre-commitment.

Between these extremes, a rationally myopic policy-maker may have high discount rate so will never reach the extremes of a behaviourally myopic policy-maker. For the naïfs and sophisticates from the O'Donoghue and Rabin typology, their present bias parameter will be in the range $0 < \beta < 1$, with the former falling in the lower range of $0 < \beta < \overline{\beta}$, implying a weak commitment to any pre-commitment device; whereas the latter will be characterised $\overline{\beta} < \beta < 1$ and thus more strongly committed to any pre-commitment device.

Overall, Figure 2 captures a key insight from the hybrid model: the range of enforceable inflation targets, as depicted by the shaded area between the temptation and enforcement functions, will be decreasing in β, becoming vanishingly small when $\beta = 0$. This has policy implications for the rationale behind inflation targeting – based around insights that central bankers are disciplined by the fact that the costs of enforcement are balanced against their inflationary temptations. When a behavioural discount function is embedded into the enforcement function then the balancing power of enforcement is diluted - at the extreme it disappears altogether. This suggests that the value to a policy-maker of a good reputation will have less power once behavioural discounting is taken into account.[1] At the extreme, when present bias is overwhelming, then enforcement becomes toothless. With behavioural intra-personal time inconsistency, the reputational rationale for inflation targeting will be limited.

1. The final outcome may be further complicated by endogeneity of the discount rate. If inflation targeting is about getting central bankers/monetary policy-makers to worry more about reputation, then effectively this is incentivizsing a more far-sighted perspective, implying that it is decreasing their discount rate, implying that the discount rate is endogenously determined.

6 Policy Implications and Conclusions

Whether analysing the problem from a behavioural or rational expectations time inconsistency perspective, interactions between private agents and unreliable policy-makers deliver outcomes that are socially sub-optimal but in some way aligned with decision-makers' preferences - whether or not these are stable.

The rational expectations analyses of Barro, Gordon and others lead to the policy conclusion that inflation targeting by independent central banks will be a best-practice monetary-policy tool, incentivizing monetary policy-makers to commit to a transparent and credible target, thus anchoring private agents' inflationary expectations. This prescription is built on rational expectations assumption of a stable rate of time preference and discount rate.

However, once behavioural economic insights about shifts in boundedly rational agents' rates of time preference are embedded within the model, the policy prescription shifts because the structure of the dynamic strategic games between policy-makers and rational agents will shift when policy-makers are prone to present bias.

The institutional changes in the form of central bank reforms that were widely adopted across the OECD, including in the UK, USA, Canada and Australia - with New Zealand as a pioneer - were implemented to encourage more far-sighed monetary-policy making, as a means to navigate self-interested conflicts between rational agents and policy-makers. Within a rational expectations framework, delegation to independent policy-makers, removed from political pressures but incentivized to build a reputation for controlling inflation, can help to reduce problems created by time-inconsistency.

In capturing the impacts of such present bias, the model introduced in this paper takes basic insights about time inconsistency from the behavioural and rational expectations literature to capture dynamic strategic interactions between policymakers and private (rational) agents in the macroeconomy.

Relaxing the assumption of rational expectations to embed present bias has implications in terms of the discounting of future consequences from current policy choices, leading to interactions between the behavioural economics concept of intra-temporal time-inconsistency in preferences and the rational expectations concept of institutional time-inconsistency in expectations and outcomes. Thus this paper provides a behavioural economics alternative to the rational expectations policy prescription of inflation targeting and central bank independence. Specifically, present bias in the context of time inconsistency, changes the constraints faced by monetary policy-makers in achieving their inflation targets. The inflation bias associated with institutional time inconsistency, as originally outlined by Kydland and Prescott 1977, will be magnified in the context of behavioural present bias, and intra-personal time inconsistency will magnify institutional time inconsistency. The reputation benefits highlighted in the Barro and Gordon model will be dampened (and, at the limit, will disappear) when present bias is embedded within policy-makers' reaction functions.

Whilst well-designed institutions can play a role in mitigating time-inconsistency problems generated within a rational expectations framework, if present bias magnifies the problem, then pre-commitment mechanisms put in place to discipline monetary policy-makers (for example, inflation targeting) will need to be re-thought and extended.

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