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Economic theory and central bank independence

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Economic Theory and Central Bank Independence

Institute for Monetary and Financial Stability
GOETHE UNIVERSITY FRANKFURT

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Economic Theory and Central Bank Independence

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Paper for the conference on Central Bank Independence:
Theoretical Foundations and Empirical Evidence
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1. Introduction: The problem of dynamic inconsistency

During the last decades, central bank independence proved to be the bedrock of credible and effective monetary policy. Both past and recent history provides plenty of evidence of disastrous outcomes with high inflation and economic stagnation, when central banks – lacking independence – were put under strong political influence. Game theoretic modeling provides valuable insights into the crucial role of independence. In a fiat money economy (with costs for producing additional pieces of paper money being close to zero) a commitment for price stability is key. In the absence of binding rules, it would not be dynamically consistent to stick to the promise to implement price stability.

The model by Barro Gordon Model (1982) is the work horse model for game theoretic analysis. It builds on the seminal work of Kydland Prescott (1977) on dynamic inconsistency. The starting point of Barro Gordon is a short run Phillips curve, causing a trade-off between stabilizing inflation and stabilizing output. If there are structural distortions in the economy, the promise to stick to some target rate π^* not credible: There is an incentive to stimulate economy by raising π above target rate of inflation π^* to raise output.

Private agents anticipate this incentive; they raise expected inflation π^e ex ante. So the optimal policy is not dynamic consistent (in game theoretic terms: not subgame perfect). This leads to an inflation bias: Inflation being too high ($\pi > \pi^*$), without any gain in output and employment. So ex post, discretionary policy ends up in an inferior outcome.

The abstract model stresses the importance of binding rules (of commitment), of the credibility of the legal framework for monetary policy. The need for commitment has already been stressed more than 2700 years ago in the Odyssey, composed by the Greek poet Homer: Odysseus ordered his crew to tie him up to the mast, preventing him to succumb to the seductive song of the Sirens. How relevant is the inflation bias today? Alan Blinder from Princeton university, who was Vice chairman of Fed 1994 to 1996, once remarked: "*During my time at the Fed, I never met colleagues suffering from incentives to inflate. The FOMC members were always concerned about the potential inflationary consequences of pushing unemployment below the natural rate.*" (Blinder 1999). Obviously, the rules for monetary policy designed at the Fed succeeded already in the 1990's in overcoming the problem of dynamic inconsistency.

2. Applications

The game theoretic analysis of time inconsistency provides insights for many different aspect of central banking. The paper focuses on the following 4 applications:

a. The Phillips curve trade-off. As argued by Barro/Gordon (1982), the trade-off may lead to an inflation bias which may be present independent of political pressure (as emphasized in the public choice literature). It may arise even if the policy maker tries to implement the welfare maximizing outcome. Delegation of monetary policy to a conservative central banker as suggested by Rogoff (1988) has become a popular commitment mechanism,

b. Using game theoretic tools, the opposite bias – a deflation bias – arises when the central bank hits the effective lower bound on interest rates (see Woodford /Eggertsson 2003)

c. In the presence of high public debt, political pressure to use the printing press (to inflate away public debt) again raises a commitment problem: the importance of monetary dominance to counteract fiscal pressures.

d. Finally, the paper briefly touches on lender of last resort activities during systemic crises. In a systemic crisis, the risk of contagious bank runs may impose enormous damage to the economy. This calls for the provision of unlimited liquidity by the central bank. But anticipating that central banks provide liquidity during systemic crises will encourage banks to take more risk and even to gamble for resurrection. Since a commitment not to provide liquidity is simply not credible during crisis (with costs being too high), again a problem of dynamic consistency arises.

3. The Barro Gordon Model

Robert Barro and David Gordon (1982) set up a simple setting to analyze strategic interactions in monetary policy. They focus on incentives for policy-makers to implement price stability in an economy with an upward sloping short-run Phillips curve between inflation π and output y. Given the expected rate of inflation π^e, an increase in inflation can stimulate the economy above the market outcome y_n according to the relation $\pi - \pi^e = \alpha (y - y_n)$ with y_n as the natural rate of output.

3.1 Inflation Bias

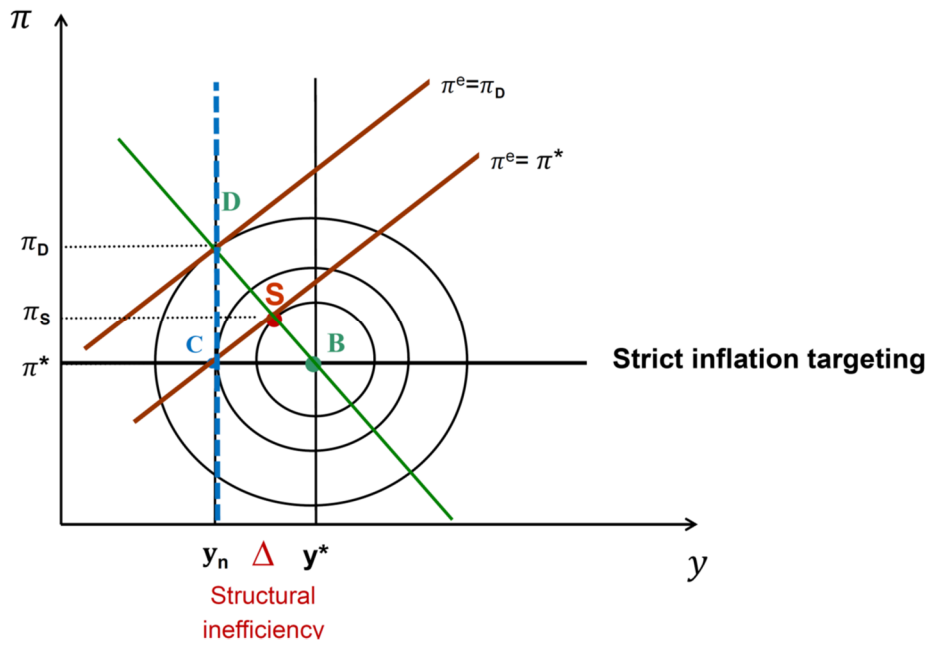
Barro/Gordon showed that even if the policy-maker is interested in maximizing social welfare, he will have an incentive to stimulate whenever the economy suffers from structural distortions, that is when the natural rate of output is below the efficient output level $y_n < y^*$. They model the following 3 stage game between a policy maker and private agents:

At stage 1, the policy-maker announces some policy rule. It can be characterized as intended response of the inflation rate π (η, ε, u) to shocks hitting the economy or alternatively as an interest rate rule (Taylor rule) i(η, ε, u) reacting to shocks. Shocks affect demand (η), supply (ε) and mark-ups (u).

At stage 2, private agents form their price expectations and arrange nominal contracts. They set their prices and wages, as well as interest rates for nominal bonds. The contracts are based on the expectations about the prevailing rate of inflation.

After contracts have been arranged, shocks η, ε, u occur, disturbing the economy.

Finally, at stage 3, the policy-maker – observing the shocks η, ε, u – responds (ex post) with some interest rate policy i(η, ε, u) in order to implement inflation π (η, ε, u) and the corresponding output y (η, ε, u).



π^*: target rate of inflation; y_n natural rate of output; y* efficient output; $\Delta=y^*-y_n$ structural distortion

Figure 1 Discretionary outcome in the Barro/Gordon model

Figure 1 illustrates why the promise at stage 1 to implement price stability on average ($E(\pi)= \pi^*$) is not dynamic consistent. The figure gives graphical representations of the loss function of the representative agent: She dislikes deviations from the bliss point B (with inflation at target π^* and output at efficient output y^* ($\pi = \pi^*$; $y = y^*$)). Circles represent indifference (or iso-loss) curves for the representative agent. The further away from the bliss point, the higher the losses. Agents are assumed to be risk averse, captured by a quadratic loss function. The parameter θ_i characterizes the relative weight for price stability relative to output stability. As drawn in figure 1, the relative weight is $\theta_i=1$.

Due to structural inefficiencies, the market outcome is below the efficient level: $y_n < y^*$ with the parameter $\Delta=y^*–y_n$ representing the degree of structural inefficiency. On average, the economy can reach only the natural rate y_n. So the vertical dotted blue line represents the effective policy constraint for the policy maker. Given that constraint, point C (with $\pi = \pi^*$ and $y=y_n$) yields the best outcome – called the commitment solution C.

But that solution is not credible, being not time consistent. Once private agents have formed inflation expectation π^e at stage 2, the trade-off for the policy maker changes. With $\pi^e= \pi^*$, there is now an upward sloping short-run Phillips curve crossing C. The ex post policy constraint in stage 3 is characterized by the Phillips curve (the red line). Facing that new constraint (given the expected rate of inflation π^e), the policy-maker can now achieve a better outcome than C. The best outcome to reach would be point S. So whenever the economy suffers from structural distortions, there will be an incentive to stimulate the economy in stage 3, in order to stimulate y above y_n by raising π above the target rate π^*.

But at stage 2, private agents will already anticipate this incentive. It is not rational for them to trust the promise to reach price stability. Instead, they raise their expected rate of inflation above target ($\pi^e > \pi^*$), shifting the short-run Phillips curve upwards. They will raise π^e until it pays no longer to stimulate the economy further above y_n. This holds for the discretionary outcome D. So in the end, the economy ends up worse without any gain: The average inflation rate realized π^D exceeds π^*, but nevertheless output stays at y_n. The economy is suffering from an inflation bias $\pi^D-\pi^*$.

In the absence of shocks, a mechanic rule could easily solve the commitment problem. By imposing a strict inflation target π^*, binding the policy maker would prevent him from raising output and force him to strictly implement the target rate $\pi = \pi^*$. But such a strict rule would also prevent him from responding to shocks. Risk averse agents, however, also prefer to stabilize shocks. With high uncertainty about the nature and persistence of shocks, a strong pre-commitment is likely to end up being costly (leaving no flexibility to react to shocks).

3.2 Design of central bank institutions

Applying game theoretic methods from optimal mechanism design, the Barro/Gordon model can be used to design rules for monetary policy aiming to implement a credible yet flexible commitment solution.

Essentially, this is a mechanism design or principal agent problem: Society (a group of heterogeneous agents) is interested in price stability, but also in dampening price and output fluctuations. Each agent *i* puts a different relative weight θ_i to price stability relative to output stability. In a democracy, society elects a government as policy maker. Following insights from public choice theory, the median voter with weight θ_m will be elected. In the presence of asymmetric information, the theory of mechanism design suggests that the policy maker (as the principal) should delegate monetary policy to an independent agent.

Several mechanisms have been proposed. The best known mechanism has been suggested by Ken Rogoff (1982). He argues that policy should be delegated to a central banker who is more conservative than the median voter. He should put a larger weight on price stability $\theta_{CB} > \theta_m$. Rogoff's proposal provides a theoretical foundation for a monetary policy design following the role model of the German Bundesbank. Carl Walsh (1995) suggested an alternative route. Using principal agent theory, he derives the so-called "optimal central bank contract." He shows that this contract mimics flexible inflation targeting as done in New Zealand and the United Kingdom since the 1990's. As more general insight from mechanism design theory, essential for the delegation mechanism is to give the central bank instrument independence (rather than goal independence) to pursue the policy it sees as appropriate to implement the task. Furthermore, accountability of the central bank is a crucial element to cope with problems of asymmetric information. Detailed reports and transparent communication to the public resp. the median voter are key conditions for providing democratic support for the independent agency.

3.2.1. Rogoff: Delegation to a conservative central banker

Ken Rogoff (1982) suggested an insightful proposal how to solve the trade-off between inflation bias and stabilisation bias inherent in the Barro/Gordon model. Consider a population with heterogeneous agents, each attaching some specific relative weight (θ_i) to price stability. In a democracy, the median voter θ_m is elected. Rogoff showed that the median voter θ_m should not run monetary policy himself. Instead, he should delegate policy to a central banker with a stronger weight θ_{CB} on price stability than himself. The intuition is simple: The lower the weight θ, the stronger will be the inflation bias. The inflation bias is decreasing in θ: The average rate of inflation is $E(\pi(\theta))= \frac{\Delta}{\theta}$. By delegating policy to a more conservative type, this bias will be smaller. Since the inflation bias is increasing in structural inefficiency Δ, the larger Δ, the higher the weight θ_{CB} should be.

On the other hand, shocks will be stabilized more in line with preferences of the median voter, the closer aligned are both weights. The larger the weight θ_{CB}, the smaller the response to shocks, imposing welfare losses (sub-optimal stabilization of shocks). These costs are increasing in the variance σ_u of shocks. Obviously, there is a trade-off: The more conservative the central banker, the lower the inflation bias, but the stronger distortions from sub-optimal stabilization.

The median voter delegates monetary policy to the type with weigth θ_{CB} which minimizes expected losses from his point of view (using his own weight θ_m), anticipating the policy a central banker with weight θ_{CB} is carrying out. With quadratic loss function, expected losses can be characterized by (for details see Cao/Illing 2019, p 180):

$$\underset{\theta_{CB}}{Min}\ E(L_{CB}) = \frac{1}{2}E\left(-\Delta - \frac{\theta_{CB}}{1+\theta_{CB}}u\right)^2 + \frac{1}{2}\theta_m\ E\left(\frac{1}{\theta_{CB}}\Delta + \frac{1}{1+\theta_{CB}}u\right)^2$$

The optimal type θ_{CB} appointed as central banker as viewed from median voter θ_m is characterized by solving the first order condition, giving the implicit function:

$$\frac{\theta_{CB}-\theta_m}{\theta_m}\left[\frac{1}{1+1/\theta_{CB}}\right]^3 = \frac{\Delta^2}{\sigma_u^2} > 0$$

Monetary policy should be delegated to a central banker being more conservative than the median voter! But $\theta_{CB} < \infty$ unless there are no shocks (volatility being extremely low $\sigma_u^2 \to 0$) or structural distortions are very large ($\Delta \to \infty$). So in principle, it will not be optimal to appoint an "*inflation nutte*r" — someone caring only about price stability, not at all being concerned about output fluctuations.

3.2.2) Flexible inflation targeting

The trade-off between stabilizing inflation and stabilizing output illustrates the need for rules that are credible but not mechanical. Rogoff's model characterizes a popular mechanism (delegation to a more conservative central banker) to cope with the challenge posed by the problem of dynamic consistency. It can be seen as modelling the policy design of the German Bundesbank. Modern mechanism design suggests also alternative solutions with quite different designs. Carl Walsh (1995) applied principal agent theory to characterize the so-called "optimal central bank contract." This linear contract exhibits features which are similar to flexible inflation targeting. The optimal contract allows for flexible responses to real shocks and at the same time avoids the inflation bias. Transparency and accountability are crucial elements of such a contract, in order to establish legitimacy and public support. Such arrangements, stating explicit inflation targets in a contract between central bank and government, have been introduced first in New Zealand (with the Reserve Bank of New Zealand Act 1989),

followed soon by Canada 1991 and by the United Kingdom 1992. Other countries adapted similar arrangements not much later.

During the last decades, monetary policy has been delegated to independent central banks in many countries –either in line with the Bundesbank design or with the design of optimal contracts as in New Zealand. Central bank independence played a substantial role in the so-called great moderation. From mid-1980s till 2008, nearly all OECD countries experienced first a period of steadily declining inflation and then enjoyed later low and stable rates. At the same time, there was also a significant decline in macroeconomic volatility (see red lines in figure 2).

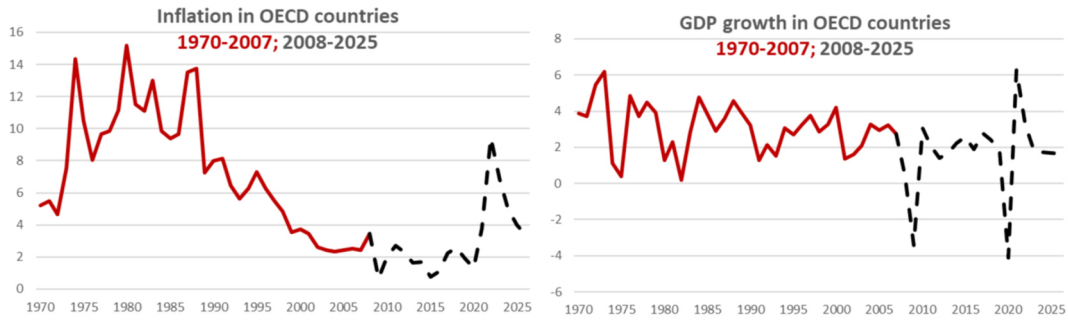


Figure 2 The great moderation in OECD countries, followed by the financial crisis

Data: OECD Data Explorer (Economic Outlook)

3.3 Challenges after great moderation

The financial crisis 2007/2008 ended the calm period of great moderation abruptly (see dotted black lines in figure 2). Suddenly central banks were facing again old challenges considered to be problems of the past – such as the need to act as lender of last resort during systemic crises or to fight pressures from public debt being on steep upward trajectories. At the same time, when cutting their interest rates, they soon hit the effective lower bound and so faced the risk of deflation bias. All these challenges had to cope again with problems of dynamic consistency. Just as with the inflation bias, game theory can help to guide policy design in these cases as well.

4. Deflation bias at effective lower bound

After the collapse of the asset price boom in Japan in the late 1980s, many financial institutions failed. The Japanese economy fell into deflation. In September 1995, the Bank of Japan lowered its interest rates to 0,5%. But for quite some time, it was reluctant to lower it even further down to zero. Many observers warned that with declining inflation expectations and rising real interest rates, Japan was facing the risk a liquidity trap, followed by a long period of stagnation. Paul Krugman (1998) suggested the Bank of Japan should "*credibly promise to be irresponsible*" — to commit to higher inflation targets.

After the Japanese experience, many macro-economists and game theorists studied the challenge central banks are facing when they hit the zero or rather effective lower bound. Gauti Eggertsson and Michael Woodford (2003) outlined an optimal-control policy in a New Keynesian macro model when nominal interest rates are constrained by the effective lower bound. They showed that the optimal path requires a commitment to overshoot the target later, when the economy is back to normal. Central banks should pursue unconventional monetary policy: Inducing positive long run inflationary expectations helps to lower the effective real rate of interest already today and so dampen the shock.

Figure 3 illustrates the optimal policy in a simple example, assuming that a severe time preference shock hits the economy just for one period (period 1), and then returns back to normal the next period. At the time when the time preference shock hits, the natural real rate gets negative. In order to avoid a contraction, the real interest rate would need to be cut more than the expected rate of inflation, bringing the real market rate in line with the natural rate. But with the short-term nominal rate being constrained by the zero lower bound, the central bank cannot dampen the demand shock this way. The economy is hit by deflation, causing a high real market rate of interest. Both output and inflation fall below target (see the dashed lines in the upper part of figure 3). With no more shocks in period 2 and the nominal rate back to normal, the real rate also gets be back to its natural rate from that period on.

During period 1 the central bank has very limited options for short-term interest rate policy. Rates cannot be cut more than down to the lower bound (here assumed to be zero). But the central bank can try to cut long-term rates instead. According to optimal-control policy, the central bank should commit to keeping the nominal rate low even in period 2 (outlined by the red line in the lower left part of figure 3). This commitment to overshoot the target later triggers a temporary stimulus. Once the economy returns back to normal in period 2, keeping the nominal rate low dampens the real rate. So a boom in output and inflation will be triggered at that time. Anticipating that already during the shock, expected rate of inflation rises in period 1 (see the red lines – the commitment path - in the upper parts of the figure).

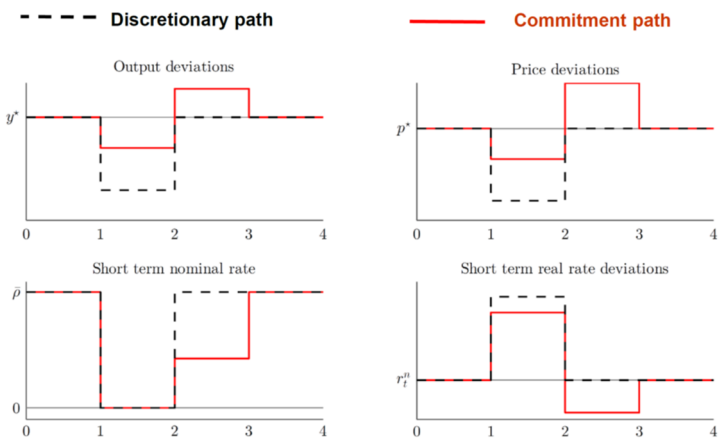


Figure 3: Commitment at the effective lower bound

The optimal-control policy, however, again suffers from a time-consistency problem, now being the reverse as the one outlined in section 3. Instead of an inflation bias, the central bank is now facing a deflation bias. It suffers from the following credibility problem: Later, at the time when the economy gets back to normal, there is no incentive anymore to stick to the promise to stimulate above normal. On the contrary, there is a strong incentive to renege on the promise to being irresponsible as soon as the shock is gone. Thus, the promised policy is not time consistent.

How to convince market participants that short-term rates will stay low for longer? Eggertsson/Woodford (2004) and others suggested central banks should use forward guidance (the promise to hold the policy rate low for longer) in order to alter the public's expectations of future central bank policies and so raise inflation expectations. Such a promise, however, might be just cheap talk, as pointed out by Otmar Issing (2014): "*There is a fundamental problem of forward guidance: It suffers from the same sort of time inconsistency malaise that it seeks to remedy.*"

Faced with the effective lower bound in the aftermath of the financial crisis, central banks adhered to the advice of optimal control policy during the 2010's. They extensively resorted to forward guidance to stimulate the economy. In order to overcome the time consistency problem, quantitative easing was used as commitment device. This is a rare example of theory preceding practice in economics: Macro-economists and game theorists studied the problem of deflation bias long before the Fed was forced to cut rates down to zero in fall 2009, with the ECB following in 2012. The ECB went even into negative territory from November 2014 till August 2022. During the 2010's, this policy indeed helped to stabilize the economy. The promise to hold interest rates low helped to lower risk premiums also for longer-term rates, keeping them low for a long time.

After the pandemic crisis 2020/2021, central banks again resorted to unconventional monetary policy. Some even adjusted their monetary policy strategy. The Fed adapted

so called “average inflation targeting,” signaling that it aims to achieve inflation above target for some time following periods when inflation has been running below target. In its strategy revision in summer 2021, the ECB also committed to avoid premature tightening. It promised to normalize interest rates only after net purchases under the asset purchase program have been ended and explicitly stated: “*That may also imply a transitory period in which inflation is moderately above target.*” The purpose of these commitments was to send a clear signal to financial markets that they can expect a steady recovery (raising rates not too early).

But unconventional monetary policy requires also a credible exit strategy. In 2021/2022, many observers heavily criticized central banks for letting inflation run far too high by keeping interest rates low for too long. Inflation in the Euro area was rising in 2021 up to 5% in December. After Russia’s attack on Ukraine, inflation kept rising during 2022, hitting a peak of more than 10% in October 2022. The ECB started tightening not before December 2021. At that time, it announced March 2022 as end date for the pandemic emergency purchase programme (PEPP). Net purchases under the general asset purchase programme (APP) were concluded in June 2022. The next month (July 2022), ECB raised interest rates (at that time being still negative) for the first time.

Obviously, with hindsight, the ECB should have started hiking rates much earlier. So was the commitment too strong? The experience casts doubt on the advice that a central bank should commit to a specific policy path in uncertain economic environments without clear escape clauses. Christine Lagarde (FT, Oct 27 2023) admitted: “*What we should have learned is that we cannot just rely only on textbook cases and pure models. We have to think with a broader horizon*.” Meanwhile, the ECB has decided to rely less on its forecasts and has scrapped its formal guidance on policy. Similarly, the Fed silently skipped its average inflation targeting.

Nevertheless, forward guidance certainly helped to prevent a depression after the financial crisis in 2008. QE was successful in decreasing the term premium on long-term government bonds. The key reason for reacting too slow in 2022 was that the ECB for quite some time underestimated the persistence of the inflation shock. Figure 4 presents the macroeconomic projections of the Eurosystem staff about HICP inflation in the euro area made for the quarters in the following two years.

The data in the left figure covers the period between June 2020 and June 2023. Even as inflation increased, the ECB staff persistently predicted that inflation would start decreasing over the next quarters. But only in the beginning of 2023 inflation did indeed start to decrease. So rather being a problem of too strong commitments to fight a deflation bias, the main reason for ECB’s late policy response in 2022 were prediction errors about the persistence of inflation. In particular, the dramatic rise in energy prices was underestimated. Wrong assumptions on energy prices account for three-quarters of ECB’s overall inflation forecasting errors in 2021. In contrast, in 2024 ECB staff projections have been impressively accurate (see the figure on the right).

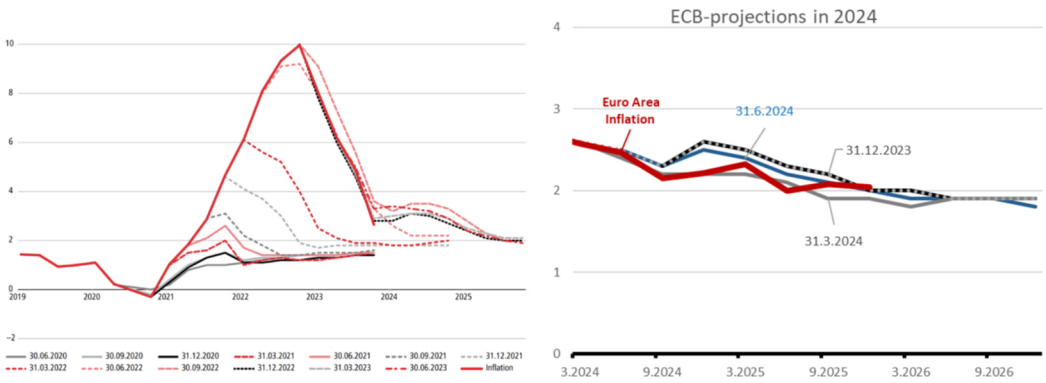


Figure 4: Forecasting errors of ECB staff projections

When inflation reached more than 10 % in October 2022, many critics warned that the slow response will take the economy back to a period of stagflation just like in the 1970s. They predicted that bringing inflation back to target would require dramatic increases in unemployment rates, just as during the stagflation in the 1970s. But obviously, credibility of central banks helped to prevent such a comeback. Expectations about long-term inflation rates did hardly increase during the time of rising prices. So – in contrast to the scenario analyzed in section 3, there was no upward-shift of the Phillips-curve.

5. Monetary vs. fiscal dominance

After the financial crisis and even more so after the pandemic, debt to GDP ratios increased dramatically in all OECD countries. In many countries, public debt still is on steep upward trajectories. With rising public debt, there is the risk that political pressure may force the central bank to inflate away public debt by "activating the printing press." The question how mechanisms should be designed to cut the link between public debt and central bank financing has been debated for a long time in economic theory.

One might expect that a simple policy design can easily solve the problem: Delegate the task of price stability to an independent central bank and assign to the treasury the task of fiscal policy: to implement a path of government spending and taxation in near and distant future required to achieve long term debt sustainability. Whenever such a regime with monetary authority being active and fiscal authority being passive is established, there may be no longer political pressure on the central bank.

Unfortunately, things are more complex. To ensure price stability, the central bank needs fiscal backing. The central bank can actively (independently) determine the time path of prices only if its policy actions trigger a validating response from fiscal

authorities. There is no automatic mechanism by which fiscal discipline can be compelled by a central bank that controls money growth. Since by nature such actions are subject to fiscal risks that have to be borne by the treasury (or rather, in the end, by the tax payer), there is a crucial need for fiscal backing. It requires credible medium-term fiscal adjustment— a credible path that stabilizes the debt/GDP ratio. Central bank actions and fiscal policy are linked via the intertemporal government wealth constraint. Obviously, since both tasks are interdependent, at least some times there are bound to be inherent conflicts. These conflicts are likely to be aggravated by distributional issues.

The intertemporal government wealth constraint helps to clarify the interdependence: Current debt must be covered by the present value of the future path of revenues, including both taxation and seignorage, minus spending. In real terms: As long as the real rate r exceeds the growth rate γ (r- γ >0), the real value of debt (the debt to GDP ratio) plus the present value of future government spending must be covered by the present value of future revenues (taxes and seignorage) (see chapter 3 in Cao/Illing (2019) for details).

$$b_0 = \frac{B_0}{P_0 \cdot Y_0} = \sum_{\tau=1}^{\infty} \left(\frac{1+\gamma}{1+r} \right)^{\tau} [\tau_\tau - g_\tau + \mu \cdot k_t]$$

Both B_0 and Y_0 are given: The initial level of nominal debt B_0 is given as result of promises made in the past; the level of current GDP Y_0 is given by the natural rate of output. In contrast, the current price level P_0 is a forward looking variable – it will be affected by expected future reactions of fiscal and monetary policy to shocks. Since real debt must be covered by the expected path of monetary and fiscal policy, there is a need to coordinate fiscal and monetary policy.

Consider an exogenous shock, pushing nominal debt up by ΔB. As response, one can think of quite different adjustment paths to the shock ΔB:

a. To ensure price stability, fiscal adjustment would be needed. That is, the treasury has to commit to fiscal consolidation. It needs to outline a credible plan how to raise a future primary surplus to cover the higher debt by increasing future taxes and/or cutting future spending $\Delta(\tau\text{-}g)$. This is the regime called **monetary dominance.**
b. Alternatively, there may be monetary adjustment. In that case, the central bank raises the rate of money growth, taking the path of government spending and taxes as given. It activates the printing press to generate future seignorage revenue $\Delta\mu \cdot k$. Of course, raising the rate of money growth increases the rate of inflation. This is the regime called **fiscal dominance** (see Sargent/Wallace (1975)).
c. Following the fiscal theory of the price level, the adjustment may occur via a drastic jump of the initial price level ΔP_0. Quite dramatic movements (resulting in hyperinflation) may be needed as adjustment of the price level in order to ensure that the intertemporal government wealth constraint still holds. In that case, the real value of nominal debt adjusts as buffer to dampen shocks. Leeper (1991) and Cochrane (2011) analyze this mechanism in detail.

d. Finally, there can be an explicit real default on government debt, imposing a haircut on debt holders. Even though the mechanisms behind c) and d) are fairly similar, the distributional impact and default costs may differ substantially between explicit and implicit default.

Since the current price level depends strongly on the expected future path of both monetary and fiscal policy, the link between public debt and price stability is delicate. Stability depends not just on current, but also on future actions. The challenge is that the future policy path is not uniquely determined. Switching between alternative adjustment paths cannot be ruled out. If capital markets expect a future regime shift, the costs imposed for sticking to the intended path may rise so much that it is no longer optimal to follow this path. So there may be indeterminacy with multiple, Pareto-ranked equilibria.

This illustrates the importance of a credible design of institutions. To establish price stability, monetary dominance is needed - a regime with monetary authority being active and fiscal authority being passive. Sargent/Wallace (1975) modelled the interaction between fiscal and monetary authority as a chicken game. They argued that – due the nature of the problem – the central bank is likely to be the chicken in this game. So fiscal rather than monetary dominance will be the natural outcome. But history proved this view to be far too pessimistic. From the 1990's on, even countries with high debt to GDP ratios succeeded in establishing regimes with low inflation rates. Take Brazil as example (left hand of figure 5). During the 1980's, increases in the debt to GDP ratio (the black dotted line) led to extremely high rates of (hyper-) inflation (the red line). But this link has been broken since 1995. Inflation stayed low (compared to the 1980's) despite debt rising again. Looking at the case of Japan (right hand of figure 5), there is no link at all between inflation (red line) and the debt to GDP ratio (black dotted line).

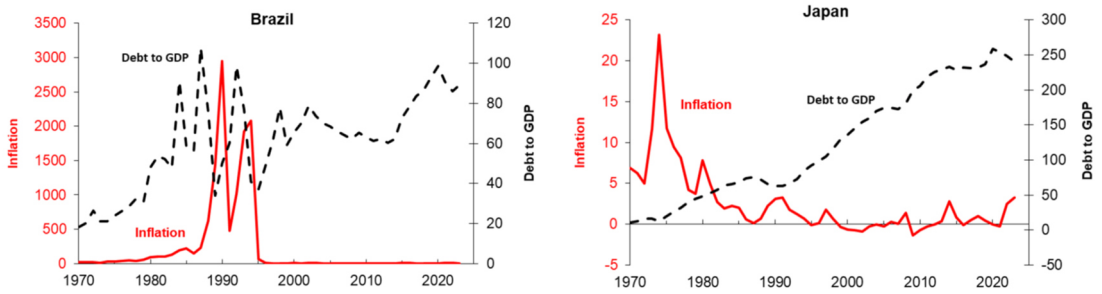


Figure 5: Inflation and Debt to GDP — Brazil and Japan

Data: World Bank

Evidently, changes in mechanism design can help to strengthen the monetary authority. Key is to make sure it stays fiscal policy's job to satisfy the intertemporal wealth constraint. Fiscal backing requires credible medium-term fiscal adjustment— a credible path that stabilizes debt/GDP in the medium to long-run. Clearly, monetary dominance is not just about debt ratios and paths. It is also about building institutions and laws that protect central bank independence. The challenge is, of course, that such rules might change in the future again, once public support for independence gets lost.

6. Liquidity provision during systemic crises

In a systemic crisis, the risk of panics, bank runs and of cascading liquidations is likely to impose enormous damage to the economy. This calls for the provision of unlimited liquidity by the central bank as lender of last resort. But anticipating that central banks provide liquidity during systemic crises will encourage banks to take more risk and even to gamble for resurrection. Since a commitment not to provide liquidity is simply not credible during crisis (with costs being too high), again a problem of dynamic consistency arises.

Cao/Illing (2011) analyze how lender of last resort policy should be designed in the presence of this time consistency problem. They model pure liquidity risk with banks taking endogenous exposure to systemic risk and show that indeed public provision of liquidity encourages risk taking (investment in more illiquid assets). For some range of parameter values, this improves investors payoff - as long liquidity provision would be targeted purely to prudent banks. But during a crisis, it is hardly feasible to distinguish between support for prudent and non- prudent banks.

Non- prudent banks (such as shadow banks during the build-up of the financial crisis before 2007/2009) have an incentive to free ride on the liquidity provided by prudent banks in good states. Such free-riding results in excessively low liquidity in bad states. In view of the high social costs involved, a commitment not to support free riders ("non-prudent banks") is not credible in a systemic crisis. Anticipating this, the provision of liquidity increases free riding incentives. In the end, non-prudent banks will drive out prudent banks whenever there is unconditional liquidity supply. So again, central banks face a serious problem of dynamic consistency.

Cao/Illing (2011) show that the optimal mechanism design to cope with this problem is to force all banks to act prudent ex ante so that a crisis arising becomes a low probability event. But once a systemic crisis arises, the best response is to provide unlimited liquidity. Costs not to do so would impose enormous damage. The optimal second best design is to impose ex ante macro-prudential supervision of financial institutions, requiring them to hold sufficient liquidity ratios. As shown in Cao/Illing

(2011), the mix of ex ante liquidity regulation and ex post lender of last resort policy can implement second best outcome. Such an arrangement strictly dominates both equity requirements and narrow banking.

The model captures the role of shadow-banks during the financial crisis 2007/2008. But the insights also apply to the regulation of the stable-coin industry: A run on stable-coins could also trigger a fire sale of their reserve assets, which could adversely impact the functioning of markets for liquidity.

Clearly, the problem of dynamic consistency is also haunting the regulation of financial industry. After a systemic crisis, there is usually strong public support to impose measures for sensible regulation. But as soon as memories of crisis fade, it gets harder to resist calls for relaxing strong measures from pressure groups. It seems to be much harder to enforce independence of regulatory authorities compared to central banking. Evidently, accountability for price stability is easier to establish than accountability for prudent regulation.

7. Conclusion

Central banking activities are burdened with problems of dynamic consistency. Game theory has been successful in characterizing optimal design for central banking. It stresses the importance of rules, credibility and institutions.

Game theoretic tools contribute not only to understanding how to cope with problems of inflation bias. They also played an important role in finding strategies to fight problems of deflation bias when interest rates hit the effective lower bound. More generally, optimal-control strategies help to guide policy in uncertain times. They provide valuable insights in the importance of monetary dominance in the context of high public debt and in the design of lender of last resort policy during systemic crises.

Game theory analyzes central banking as a science, applying methods of mechanism design. But in practice, central banking is not just science, it is also an art. It cannot just rely purely on pure textbook models.

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