BANK OF CANADA
BANQUE DU CANADA

Working Paper/Document de travail
2008-27

Are Bygones not Bygones? Modeling Price Level Targeting with an Escape Clause and Lessons from the Gold Standard

by Paul R. Masson and Malik D. Shukayev

www.bank-banque-canada.ca

Bank of Canada Working Paper 2008-27

August 2008

Are Bygones not Bygones? Modeling Price Level Targeting with an Escape Clause and Lessons from the Gold Standard

by

Paul R. Masson[1] and Malik D. Shukayev[2]

[1] Special Adviser
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
pmasson@bankofcanada.ca

[2] Research Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
mshukayev@bankofcanada.ca

ISSN 1701-9397

Acknowledgements

We would like to thank Robert Amano, Michael Bordo, Oleksiy Kryvtsov, David Laidler, Raphael Solomon, and Alexander Ueberfeldt for helpful comments.

Abstract

Like the gold standard, price level targeting (PT) involves not letting past deviations of inflation be bygones; both regimes return the price level (or price of gold) to its target. The experience of suspension of the gold standard in World War I, resumption in the 1920s (for some countries at a different parity), and final abandonment is reviewed. It suggests that PT would likely operate with an escape clause that allowed rebasing of the price target in the face of large output declines. Using a calibrated general equilibrium model, we show that such an escape clause can produce multiple equilibria. For some parameterizations, there is a low credibility equilibrium (with high expectation of a reset) associated with high output volatility and frequent resets. These problems reduce the expectational advantage of PT over inflation targeting.

JEL classification: E31, E52
Bank classification: Credibility; Monetary policy framework

Résumé

Tout comme on le faisait avec le prix de l'or sous le régime de l'étalon-or, la poursuite d'une cible de niveau des prix implique que l'on corrige les déviations passées en ramenant le niveau des prix à la cible. La suspension de l'étalon-or durant la Première Guerre mondiale, son rétablissement dans les années 1920 (sur la base d'une nouvelle parité pour certains pays) et son abandon définitif donnent à penser qu'un régime prenant pour cible le niveau des prix comporterait probablement une clause dérogatoire autorisant une redéfinition de la cible en cas de baisse marquée de la production. Au moyen d'un modèle d'équilibre général étalonné, les auteurs montrent qu'une telle clause peut donner lieu à de multiples équilibres. Dans certains paramétrages, l'un des équilibres obtenus se caractérise par une politique monétaire peu crédible (on s'attend fortement à ce que la cible soit révisée), une volatilité élevée de la production et des révisions fréquentes de la cible. La supériorité de ce type de régime sur un régime de cibles d'inflation se trouve ainsi réduite, car elle est liée au rôle joué par les attentes.

Classification JEL : E31, E52
Classification de la Banque : Crédibilité; Cadre de la politique monétaire

1 Introduction

Unlike inflation targeting (IT), price level targeting[1] (PT), does not let bygones be bygones. Shocks to supply or demand that are permanent cannot be allowed to have permanent effects on the price level, but have to be reversed by the central bank. This has been identified as an advantage of PT, because it produces an extra stabilizing effect on inflation [25, 26]. A shock leading to temporarily higher inflation than target will induce the expectation that inflation will be below the target in the future, since its price level effects will have to be reversed. This will have the effect of moderating inflation in the short-term. Under IT, in contrast, a positive inflation shock would only induce an expectation of an eventual decline back to the target rate for inflation.

However, the PT regime is more constraining by the very fact that even temporary inflation shocks will continue to affect monetary policy until they are completely reversed. As a result of this continuing effect, it seems likely that there may be circumstances in which the regime might be temporarily suspended, or even abandoned. What might those circumstances be? Here the experience under the gold standard may provide some guidance. The peg to gold was suspended in several earlier wars and at the outset of WWI. In the course of the 1920s, most of the major developed countries returned to the gold standard, in many cases at the prewar parity, but in others–such as France and Belgium–at a depreciated rate. Finally, the world abandoned the gold standard during the Great Depression[2].

The above reasoning suggests that modelling PT as a permanent and immutable regime, with a target price chosen once and for all, may not be realistic. Because PT embodies the requirement to offset past shocks, it may be more difficult to accommodate other objectives within the regime. Therefore, it may be more important to consider the possibility the regime would be temporarily, or even permanently, abandoned, or the price target reset. This might involve explicit escape clauses. In some countries, for instance, inflation targeting is operated subject to "caveats," so that targets do not have to be met in the case of large oil price or international financial shocks (as in South Africa). In others, e.g. the UK, the Governor can explain to the government the reasons why the inflation target was not met, implicitly acknowledging that unforeseen circumstances may make it impossible or undesirable to do so. Such mechanisms may be more necessary with a price level target, because it does not allow bygones to be bygones.

Modeling imperfect regime credibility as involving explicit or implicit escape clauses became popular in the context of the European Monetary System crises of 1992-93 [21]. In the EMS, changes of exchange rate parities were allowed, but discouraged. The escape clause model was based on the idea that a desirable monetary rule should have the flexibility to respond differently to large shocks [12]. When applied to the EMS, the model included a reputational cost from abandoning the regime, over and above the costs of deviating from inflation and output or employment targets. Thus, in normal times, monetary policy would ensure that the exchange rate remained within its target band. However, large positive shocks to unemployment, as occurred in many

[1]This is assumed here to include targeting an upward sloping path for the price level.

[2]Bordo and Kydland [4] also argue that the pre-1914 gold standard operated as a contingent rule under which the authorities could abandon the fixed price for gold during an emergency (such as war).

European countries in the early 1990s, gave an incentive for the authorities to abandon the peg in order to stimulate demand. An important insight from these models was that the public's expectation that a devaluation would occur exacerbated the tradeoff for the authorities, making a devaluation more likely. Thus, as Obstfeld showed, there could be self-fulfilling expectations of devaluation and indeed jumps between equilibria, depending on an exogenous change in sentiment [21].

The implication of operating PT with an escape clause is that the stabilizing effect of the price level target may not be so strong, since at least for a big shock there might well be some doubt as to whether the central bank would in fact reverse the price level effects. Thus, expectations of inflation would have to take into account that the central bank might suspend the price level target, and if only temporarily, whether it would go back to the same price level path eventually or rather adjust its level to make some or all of the effect of the past shocks bygones.

The interwar experience of the gold standard may also have some relevance to the possible costs of going back to an unchanged price path, as well as illustrating the possibility of adjusting the target level. If part of a credible commitment, returning prices to a pre-announced path should have involved small output costs. However, the experience of Britain in resuming the gold standard seems to suggest otherwise. Though the return to the prewar parity had been widely expected, the long delay that intervened and a debate about the parity undoubtedly affected expectations. France, in contrast, did not need to engineer deflation because it did not go back at the pre-war parity. France's GDP by 1929 had risen 50 percent above its 1920 level, while Britain's, only 7 percent.

In this paper, we first review briefly the experience with the gold standard in this light. Then we discuss in the context of PT how to model escape clauses that incorporate the possibility of resetting the price target in the face of large shocks. The expectation that this may occur introduces the possibility that a strict price target may be imperfectly credible, dampening some of the advantages of PT over IT (as shown by [16] when credibility is exogenous). A model is presented where the central bank has an option to reset the targeted price path to its latest level in the face of large negative shocks to output. Since output is an endogenous variable, the probability of resetting the target depends on monetary policy and private expectations, and varies over the business cycle. Thus, the model endogenizes credibility. The implications of such an escape clause for PT are as follows: for a range of parameter values multiple equilibria are possible, with different levels of PT credibility. Lower credibility equilibria have a higher unconditional probability of price target resets, raising the possibility of additional instability in inflation and output. Thus, just like in Obstfeld [21], the public's expectation that a price target reset would occur worsens the inflation-output tradeoff faced by the Central Bank, making a price target reset more likely. Expectations of price resets are thus self-fulfilling and jumps between equilibria are a possibility.

2 Experience with gold standard abandonment and resumption

It is useful to consider the reasons for the suspension and abandonment of the gold standard, and to assess whether they are relevant for understanding how a price level target might work. In the Appendix, more detailed analysis is given of the period around the time of gold standard suspension[3] at the outbreak of World War I, its resumption during the mid-1920s, and its ultimate abandonment during the early 1930s. Here, we just summarize the main conclusions.

During wartime, gold stocks (or foreign exchange reserves) can be essential to the war effort since they allow purchasing abroad needed supplies of fuel, materials, or munitions. Mercantilism becomes a rational policy because other mechanisms for international adjustment, such as free trade and capital mobility, may not operate as before. In contrast, price level targeting does not have any counterpart to the scarcity of gold that would make such a concern relevant.

However, a second, more general factor that led to the suspension of the gold standard was the judgement, given the international situation, that other objectives now made price stability much less important, so that at least for a time, the strong stabilizing role of gold on prices could be set aside. This is certainly consistent with the overriding objective of winning a war. Indeed, in many wars governments explicitly used money and short-term bond issuance as a source of war finance, and bidding away resources from consumer-goods sectors to the war industry was judged easier to do in a context of inflation, which facilitated the increase in the relative price of consumer goods.

The abandonment of the gold standard during the Great Depression (and its replacement after World War II by the more flexible Bretton Woods gold exchange standard) can also be explained by the focus on other objectives that had become overwhelmingly more important when compared to normal times. Given the depths of the decline in output and the calamitous rise in unemployment, it no longer seemed essential to provide an ironclad stabilizer for prices in the form of the gold standard. It is true that this period did not see serious inflation, but nevertheless abandoning the gold standard freed central banks to pursue other objectives. In particular, it allowed European central banks to provide monetary stimulus in an attempt to prevent a meltdown of the financial system, and in the United States and elsewhere, to stimulate employment.

3 Escape clause models of price level targeting

It seems intuitive that big shocks—major cataclysms like wars or a major depression—require different policy responses. How can we square this idea, and the stylized facts

[3] Britain also imposed restrictions on the convertibility of the pound into gold in 1797, at the time of its war with France, and only resumed convertibility of specie (at the pre-war parity) in 1821 [11]. Bordo and Bayoumi [3] consider the return to gold by the United States in 1879, after the Civil War, and compare it to Britain's resumption in 1925, concluding that external factors played a role in producing different outcomes.

mentioned above, with the models that we use to evaluate policy regimes, in particular IT and PT? In the standard linear-quadratic framework, where preferences are quadratic and behavioral equations linear, the optimal feedback response to a given shock (its coefficient in a reaction function) is always the same, whatever the shock's size. That is, optimal feedback rules are also linear. This is not consistent with the stories told above, in which large shocks induce different responses compared to small shocks. Major shocks mean the essential abandonment of other objectives and a discrete change in behavior. What can explain the difference?

First, the convenient assumption of quadratic preferences may be wrong. If welfare costs rise faster than the quadratic as variables deviate increasingly from their targets, then linear feedback rules would no longer be optimal. If welfare costs approached infinity as unemployment rose above a certain level, for instance, then other objectives like price stability would receive a zero weight at that point, justifying the complete neglect of the latter and the abandonment of a gold standard or a price level targeting regime. While there are mathematical formulations that have such a property, they are usually not used in analytical work because they are not so tractable. An alternative would be to introduce costs that only kick in discretely, if the policy is changed or if an endogenous variable goes outside a particular range. The escape clause models applied to the EMS have this feature. As a result, the objective function guiding the central bank is non-quadratic. A similar setup could be used to model PT.

The second assumption, that the economy is described by linear equations or approximations, may also be problematic. In the case of a war, for instance, defeat could involve the virtual destruction of the economy and making the currency worthless. Thus, the effect of policy would have to be modeled in a complicated nonlinear way that reflected the discrete effect of success or failure and the potential for dire outcomes from the latter. Clearly, the marginal impact of a particular policy variable would not be linear.

The complicated feedbacks between macroeconomic variables and financial stability also introduce potential nonlinearities. Major negative shocks to economic activity or to inflation risk pushing the economy into a financial crisis where bankruptcies lead to a shutdown of credit markets and an upward spike in risk aversion. Financial crises, in turn, imply that the real economy functions differently. Modeling these linkages is difficult and would add significant technical and computational complexity to DSGE models, which explains why such linkages are not so far embodied in most DSGE models. If they were, they might provide another reason for responding differently depending on the size of shocks, or even changing the policy regime. A severe shock to the financial system might explain why a price level target might temporarily be suspended in order to provide monetary stimulus, even in the face of inflationary pressures.

In what follows, we introduce an escape clause into a model in which the central bank has been assigned a price level target, but abandons the price level path when the output gap falls below a particular threshold. Thus, we allow the CB's objective function to be non-quadratic. However, nonlinearities due to financial sector linkages are not addressed.

In particular, society is assumed to assign to the central bank a price level targeting rule, consistent with the results of [25, 26] that such a rule can give higher welfare and may approximate the first-best, commitment solution, by limiting the extent of the central bank's policy discretion. Here, we further assume that the CB still has the option of occasionally resetting the price target. One way would be to assume that a reset happens whenever the central bank's gain from ignoring past deviations of prices from target–letting bygones be bygones–exceeds the costs of its losing reputation. We take a simpler approach here. As was mentioned above, we assume that CB resets the price target path, whenever continuing with the old target would imply the output gap value falling below a certain threshold (but only if the target change helps to mitigate that output loss). We think of such a mechanical reset rule as an approximation to more elaborate trigger strategies. The limiting case where the target is reset each period is of course an IT regime.

3.1 A (somewhat) general framework

Two models have been used to analyze the potential benefits of PT: one based on a Lucas supply curve [25], and one based on the New Keynesian Phillips curve [26]. There are similarities in the two approaches, and in this section a general discussion of how to fit them into an escape clause framework is sketched. However, in our simulation exercises reported below we use a calibrated New Keynesian Phillips curve model.

It is first assumed as in [25, 26] that society's preferences concern the losses from variability of inflation around some constant target and the output gap, from a zero value.[4] Let

$$S = -\frac{1}{2}\sum_{i=0}^{\infty}\beta^i\left[(\pi_{t+i}-\pi^T)^2+\lambda y_{t+i}^2\right] \quad (1)$$

be the society's intertemporal welfare function; this is usually justified on the basis of a second-order approximation to the true welfare function. It is assumed that the central bank cannot precommit, but must operate under discretion. Society could simply delegate to the central bank the job of maximizing S (on a discretionary basis), which would imply certain paths for output $\{y_t^*\}$ and inflation $\{\pi_t^*\}$. This is IT. In the light of results [25, 26], this is dominated by a monetary policy regime in which Central Bank targets the price level to be stationary around a deterministic path given by

$$p_t^T = \pi^T + p_{t-1}^T.$$

It would be preferable then (absent credibility issues) to assign the central bank the job of maximizing a function M that depends on deviations of the price level from the target price path (as well as deviations of the output gap from zero)

$$M = -\frac{1}{2}\sum_{i=0}^{\infty}\beta^i\left[(p_{t+i}-p_t^T)^2+\tilde{\lambda} y_{t+i}^2\right], \quad (2)$$

where $\tilde{\lambda}$ is chosen optimally by society when assigning the objective function to the CB. This gives paths for output $\{\tilde{y}_t\}$ and inflation $\{\tilde{\pi}_t\}$ under PT. When society's objective function S is evaluated alternatively for the IT or PT outcomes (both of them assumed

[4]Introducing a target greater than the natural rate introduces a suboptimal inflation bias under inflation targeting, but otherwise does not enter the analysis.

to be perfectly credible and eternal), labelled by S^* or $\tilde{S}$, respectively, then it can be shown ([25, 26]) that

$$E\tilde{S} > ES^*$$

However, Kryvtsov et al. [16] and Yetman [28] show that under imperfect credibility, in the sense of a non-zero probability of abandonment of PT in favour of IT, the advantages of PT over IT may disappear. Let us refer to the output and price paths under imperfectly credible PT as $\{\tilde{y}_t(\rho_t^e)\}$ and $\{\tilde{\pi}_t(\rho_t^e)\}$, respectively, where ρ_t^e is the private sector's assessment of the likelihood in period t that the PT will be abandoned next period. Using a similar notation for the resulting welfare for society under imperfectly credible PT, it can be shown that at least for some parameter values

$$E_{t-1}\tilde{S}(\rho_t^e) < E_{t-1}S^*. \tag{3}$$

This inequality would in turn justify the imperfect credibility of PT, so that $\rho = \rho^e$ could be a fixed point that was equal to both the subjective and actual probability of abandoning the regime. However, one would have to specify the circumstances under which the central bank would abandon the price level target, and what the fallback regime would be.

3.2 Delegation of Monetary Policy and Escape Clauses

The dominance of PT over IT when there is complete credibility depends on the inability of the government or the central bank to precommit to the optimal policy; that it, they operate under discretion. However, Rogoff [23] proposed a partial solution to this problem, namely for society (or the government) to delegate a different rule or objective function to the central bank than society's true objective function. Thus, a more conservative central banker (in the sense of a lower λ in equation 1 above), helps to correct the inflation bias in the context of a Barro-Gordon model [2]. A more conservative central banker both produces lower mean inflation but also provides less stabilization, i.e. responds less to output shocks. On balance, this improves welfare, but as shown by Flood and Isard [12] and Lohmann [17], a preferable policy would be a contingent rule that kept inflation near zero except when output movements were large, since in these circumstances the need for stabilization is greater. Such a rule can be termed a "rule with escape clause"; the escape clause introduces a non-linearity that produces an improvement relative to linear rules.

Assignment to a central banker of a weight differing from society's raises the issue of whether society has the incentive to override the delegation and fire the conservative central banker. This is the argument of McCallum [18], who claims that delegation simply displaces the time inconsistency of the standard Barro-Gordon model, but doesn't change it. Alternatively, society may impose explicit costs on the central banker if she deviates from the assigned policy (such as embodied in Walsh contracts), but Jensen [15] argues that society (i.e., the government) must also incur large costs to change the terms of the contract with the central bank, otherwise it will have the incentive to change them and time inconsistency re-emerges[5]. Moreover, such costs cannot be arbitrarily chosen by society, but rather must correspond to some structural feature of the economy. Reputation costs can be quantified in terms of repeated games; indeed, Barro and Gordon [2] show that a sufficiently high discount factor is sufficient to support the optimal policy in a simple version of their model.

In the current context, the problem with discretion is not the inflation bias, but rather the fact that the commitment solution, like PT but not IT, does not let inflation bygones be bygones (see [26], Table 1). But the advantage of PT comes through expectations reflecting that feedback, and imperfect credibility dampens the expectations channel. We have argued, on the basis of gold standard experience, that letting bygones be bygones will sometimes be strongly preferred by society. We would argue further that society would in some circumstances over-ride its delegation and incur the associated costs (of reputation or otherwise). However, we will not attempt to model the delegation process nor the costs that society might incur in revoking the delegation. Instead, we will assume that the central banker, knowing that in some circumstance she will be overriden, internalizes society's desire to suspend price level targeting when output losses become great.

3.3 Rebasing the price target

The above might suggest the following: society could change the delegation rule if its welfare would be improved by asking the central bank to maximize an IT-based objective function directly. In this framework, expectations of an abandonment of PT would be based on the following probability:

$$\rho_t = \Pr_{t-1}\{\tilde{S}(\rho_t^e) < S^*\}$$

where the probability is calculated by integrating over the density function of a shock (or shocks). In principle, this allows calculating a fixed point for ρ_t. It is unclear however why the reversion to IT has to be permanent; why could not society decide in the future to reverse the assignment back to PT?

An alternative setup that is both more plausible and more general (since IT is subsumed within it) would involve not abandonment of the price targeting regime, but rather rebasing the price target so that past deviations are ignored. This resembles the gold standard experience in the interwar period, when some countries like France changed their gold parities when returning to gold after temporary suspension of the standard. Thus, a PT regime might involve occasionally allowing bygones to be bygones, if for the reasons argued above that reversing large shocks involves large welfare costs. In escape clause models of the EMS, this was captured by an additional term in the central bank's objective function that represented the reputation cost of abandoning the fixed exchange rate regime. However, in the current model, the central bank has no incentive to abandon the regime if it retains its objective function M. Instead, we assume that large enough output losses trigger an additional cost to the central bank, and if those costs are large enough, then they produce a resetting of the price path (letting bygones be bygones). Imperfect credibility of the price path under such

[5] Driffill and Rotondi [9] show that a slightly more general framework reduces the costs that society must incur to make the delegated monetary policy better than pure discretion.

PT would result from fears that the target itself would be changed to the lagged price level. Thus, the price target for period t would be

$$p_t^T = \delta_t p_{t-1} + (1 - \delta_t) p_{t-1}^T + \pi^T$$

where $\delta_t = 0$ or 1, if the price level is maintained or reset, respectively. In the special case where $\delta_t = 1$ for all t, the rule would be equivalent to IT. Optimal policy would result from maximizing M augmented by the costs of large output losses,

$$N = -\frac{1}{2} \sum_{i=0}^{\infty} \beta^i \left[(p_{t+i} - p_t^T)^2 + \tilde{\lambda} y_{t+i}^2 + C(y_t) \right] \tag{4}$$

where $C(y_t) = 0$, if $y_t > \underline{Y}$, and $C(y_t) = C > 0$, if $y_t \leq \underline{Y}$. Note that these costs $C(y_t)$ are also assumed now to be part of society's welfare function -they cannot be chosen arbitrarily but are true welfare losses due to additional costs from large output declines that are not captured in the second-order approximation. The central bank would compare the expected value of its objective function from the two cases. Writing the maximized values as $N(\rho_t|\delta_t = 0)$ and $N(\rho_t|\delta_t = 1)$ and noting that $\rho_t = E_{t-1}(\delta_t)$, then

$$\rho_t = \Pr_{t-1}\{N(\rho_t^e|\delta_t = 1) > N(\rho_t^e|\delta_t = 0)\} \tag{5}$$

This equation is similar to that used in escape clause models of pegged exchange rates, where a fixed reputation cost gives the central bank the incentive to maintain the regime in the face of small shocks, but to deviate in the face of larger ones. However, the additional cost here is induced by large output losses, which the central bank can partially offset by suspending PT and resetting the price target. If the cost C is large enough, this objective function produces a resetting of the price target whenever $y_t \leq \underline{Y}$.

3.4 Implications for policy

Whether (5) has an equilibrium (or several) with non-zero values of ρ_t depends on the equations of the model, the parameters, the values of the state variables, and the distribution of the shock that the central bank is assumed to react to. To be concrete, we will call this shock e_t, and assume that it corresponds to a positive inflation shock in the NKPC or a negative output shock in the Lucas supply curve, so that larger e_t increases the probability of abandonment. There is thus some critical value $e(\rho_t^e)$ at which the central bank chooses to do so.

$$\rho_t = \Pr_{t-1}\{e_t > e(\rho_t^e)\} \tag{6}$$

It is to be expected furthermore that greater values for ρ_t^e increase $N(\rho_t^e|\delta_t = 1) - N(\rho_t^e|\delta_t = 0)$, so $e'(\rho_t^e) < 0$. Thus, plotting the RHS of equation (6) in (ρ_t^e,ρ_t) space gives an upward sloping curve. In this case, greater doubts about the permanence of the price level target increase the likelihood that the current shock will be greater than some critical value and the price target will be rebased. Conversely, lower ρ_t^e is self-validating, since it makes it less likely that the target price path will be abandoned. In a rational expectations equilibrium, $\rho_t = \rho_t^e$.

A positive derivative of the RHS with respect to ρ_t^e with a slope greater than unity is a necessary condition for multiple equilibria for ρ_t, since it must intersect the 45 degree ray from below. However, this is not sufficient. As shown in [14], the possibility of multiple equilibria depends on the position and slope of the cumulative distribution function for e_t. The case of multiple equilibria then opens the door to self-fulfilling crises: if private agents doubt that the central bank will continue with its price level targeting regime, then they may make it more costly for the bank to do so, thus bringing about an abandonment of the regime. Conversely, if confidence is high, it will be easy for the central bank to continue with price level targeting, since expectations of a return to the price level path will make it unnecessary to surprise the market in order to achieve it (thus lowering output).

4 New-Keynesian model of PT with price-target rebasing

In this section we present a New-Keynesian model of a PT regime, in which the CB has to reset the target whenever the output gap falls below some fixed cut-off level, but only if the fall in output could be mitigated by resetting.[6] As described above, this type of reset rule could be justified by some non-quadratic losses or financial markets disruptions associated with large output declines. However, we do not formally rationalize the escape clause, but simply explore the possible consequences of having it in place. With that focus in mind, we entirely abstract from evaluating society's loss function, and compare policy outcomes by looking at the implied volatilities of inflation and output gap.

The model environment is taken from Clarida, Gali, Gertler [7] and Vestin [26]. There are four types of agents in the economy: infinitely lived households, final good producers, intermediate good producers, and a central bank.

The representative household maximizes lifetime expected utility subject to a budget constraint. The first-order conditions of the household's problem give rise to the following (log-linearized) Euler equation:

$$y_t = -\gamma \left[i_t - \mathbf{E}_t \pi_{t+1} \right] + \mathbf{E}_t y_{t+1} + g_t. \tag{7}$$

In (7) y_t is the output gap, defined as the log deviation of actual output from the potential (flexible-price) output, i_t denotes the nominal interest rate, π_{t+1} is the period $t+1$ log deviation of the inflation rate from its average level π, and g_t is a shock to the real interest rate.

A competitive final good producer aggregates a variety of intermediate goods into the final good. A monopolistically competitive intermediate good producer faces a

[6] One can think of this simple trigger strategy as the optimal, time-consistent behavior of the central bank with the loss function (4), in which the cost $C(y_t)$ gets very large, whenever $y_t \leq \underline{Y}$. A version of the New-Keynesian model with smaller values of $C(y_t)$, but where the CB is allowed to compare the benefits of resetting and not resetting the target, gives very similar results. We chose to present a simpler model for ease of exposition and for its analytical convenience.

dynamic problem in which output prices are set to maximize the expected stream of future dividends subject to the demand conditions and Calvo-type timing restriction on price adjustments. The log-linearized first-order conditions lead to the standard New-Keynesian Phillips Curve relation:

$$\pi_t = \beta E_t [\pi_{t+1}] + \kappa y_t + e_t, \tag{8}$$

where β is the discount factor of the households, and $e_t = \varphi e_{t-1} + \varepsilon_t$ is a cost-push shock with normally distributed innovations, $\varepsilon_t \sim N(0, \sigma^2)$.

Given constraints (7) and (8), the central bank sets the nominal interest rate i_t to meet its policy objectives. However, as in [7] we can split the problem of the central bank into two parts. First, the central bank chooses the values of the current output gap, y_t, and the current inflation rate, π_t, that satisfy the Phillips curve constraint (8). Second, it sets the interest rate, i_t, to satisfy the constraint (7) with the chosen value of the output gap, y_t. This dissection of the problem allows us to ignore the constraint (7) altogether and assume that the central bank can directly set the output gap, y_t. It also implies that we can further ignore the interest rate shocks, g_t.

Vestin defines inflation targeting in this environment as the optimal monetary policy under discretion, with the central bank's period loss function specified as[7]

$$L_t^0 \equiv \frac{1}{2}\left(\pi_t^2 + \lambda^{IT} y_t^2\right), \tag{9}$$

where λ^{IT} is the weight on the output gap.

Similarly, price-level targeting is the optimal monetary policy under discretion with the central bank's period loss function given by

$$L_t^1 \equiv \frac{1}{2}\left(\left(p_t - p_t^T\right)^2 + \lambda^{PT} y_t^2\right), \tag{10}$$

where p_t is the period t (log-)price level, p_t^T is the (log-)price-level target, and λ^{PT} is the corresponding weight on the output gap. The resulting PT policy implies the following dynamics

$$\begin{aligned} \left(p_t - p_t^T\right) &= a^{PT}\left(p_{t-1} - p_{t-1}^T\right) + b^{PT} e_t \\ \pi_t &= \left(a^{PT} - 1\right)\left(p_{t-1} - p_{t-1}^T\right) + b^{PT} e_t \\ y_t &= -c^{PT}\left(p_{t-1} - p_{t-1}^T\right) - d^{PT} e_t \end{aligned} \tag{11}$$

where a^{PT}, b^{PT} , c^{PT} and d^{IT} are strictly positive, and $a^{PT} \in (0, 1)$ makes price level stationary around the target.

Under both policy regimes, output weights λ^{IT} and λ^{PT} are chosen to maximize social welfare

$$-\frac{1}{2}\mathbf{E}\sum_{t=0}^{\infty} \beta^t \left(\pi_t^2 + \lambda y_t^2\right). \tag{12}$$

[7]In what follows we assume without loss of generality that the targeted rate of inflation π^T is zero, under both IT and PT. Under PT (without escape clauses) this assumption implies that the price target p_t^T is simply a constant p^T, so $p_t^T = p^T, \forall t$.

Vestin's contribution was to show that the PT regime attains higher social welfare by making inflation expectations change in a way that has a stabilizing effect on the economy.

In modeling PT with an escape clause we assume that CB sets its policy in a way that preserves the dynamics of the price level in (11), but resets the price target to be equal to the actual price level, $p_t^T = p_{t-1}$, whenever the output gap falls below certain lower bound value $\underline{Y} < 0$, provided the price target change mitigates the fall in the output gap.

More precisely: let $\delta_t = 1$ if CB resets its target in period t and $\delta_t = 0$ otherwise. Further, let p_t^0, y_t^0, π_t^0 be the price level, output gap and inflation in period t, conditional on $\delta_t = 0$, while p_t^1, y_t^1, π_t^1 be the values of these variables in period t, conditional on $\delta_t = 1$. Then we can summarize the dynamics of the price-level target as follows

$$p_t^T = \delta_t p_{t-1} + (1-\delta_t) p_{t-1}^T,$$

where

$$\delta_t = \begin{cases} 1, & \text{if} \quad y_t^0 < \underline{Y} \quad \text{and} \quad y_t^0 < y_t^1 \\ 0, & \text{otherwise.} \end{cases}$$

The implied conditional inflation values are

$$\pi_t^0 = \left(a^{PT} - 1\right)\left(p_{t-1} - p_{t-1}^T\right) + b^{PT} e_t \tag{13}$$

$$\pi_t^1 = b^{PT} e_t, \tag{14}$$

while actual inflation in period t is

$$\pi_t = \delta_t \pi_t^1 + (1-\delta_t)\pi_t^0.$$

Forwarding this one period, and taking expectations we obtain expected future inflation

$$\begin{aligned} \mathbf{E}_t \pi_{t+1} &= \Pr\left(\delta_{t+1} = 1\right) \mathbf{E}_t \pi_{t+1}^1 + (1 - \Pr\left(\delta_{t+1} = 1\right)) \mathbf{E}_t \pi_{t+1}^0 \\ &= \rho_t b^{PT} \varphi e_t + (1-\rho_t)\left[\left(a^{PT} - 1\right)\left(p_t - p_t^T\right) + b^{PT} \varphi e_t\right] \\ &= b^{PT} \varphi e_t + (1-\rho_t)\left(a^{PT} - 1\right)\left(p_t - p_t^T\right), \end{aligned}$$

where $\rho_t = \Pr(\delta_{t+1} = 1)$ has subscript t because it is formed as of period t.

The dynamics of the output gap y_t are determined endogenously from the Phillips curve relation (8):

$$\begin{aligned} y_t &= \frac{1}{\kappa}\left(\pi_t - \beta \mathbf{E}_t\left[\pi_{t+1}\right] - e_t\right) \\ &= \frac{1}{\kappa}\left(\pi_t - \beta\left[b^{PT} \varphi e_t + (1-\rho_t)\left(a^{PT} - 1\right)\left(p_t - p_t^T\right)\right] - e_t\right). \end{aligned}$$

Note that if $\left(p_t - p_t^T\right) > 0$, then the output gap y_t is decreasing in ρ_t. This is the source of multiple equilibria in this economy: if $\left(p_t - p_t^T\right) > 0$ and private agents expect that CB is likely to reset its target next period (i.e. ρ_t is high), then y_t is low and CB is more likely to reset its target today. Thus private expectations of frequent price target changes make low output gap values more frequent, which leads to higher probability of price target resets. In other words, expectations of frequent target changes are self-fulfilling.

4.1 Parametrization and Simulation Results

As a benchmark set of preference parameters we use the values from Woodford ([27], Table 6.1)

$$\begin{aligned} \beta &= 0.99 \\ \lambda &= 0.048 \\ \kappa &= 0.024. \end{aligned}$$

We set the benchmark persistence of the cost push shocks at $\varphi = 0.48$, halfway between the estimates of Adam and Billi [1], $\varphi = 0$, and of Ireland [13], $\varphi = 0.96$ and carry out a sensitivity analysis later. We do the same for λ and κ. Finally, the standard deviation of the cost-push shocks is pinned down by the standard deviation of inflation in the model under inflation targeting:

$$st.dev.\,(\pi_t) = \frac{\lambda}{\kappa^2 + \lambda(1-\beta\varphi)} \frac{\sigma}{\sqrt{1-\varphi^2}}.$$

The standard deviation of quarterly CPI inflation rates in Canada during the inflation targeting period (from 1992:Q1 to 2007:Q2) was 0.4 percentage points. Hence the standard deviation of the cost-push shocks in the model is

$$\sigma = \frac{\kappa^2 + \lambda(1-\beta\varphi)}{\lambda} \sqrt{1-\varphi^2} \cdot 0.004.$$

With the parameters of the model set, we solve the model for various cutoff values of the output gap $\underline{Y}$. The solution procedure is a version of the Parameterized Expectations Algorithm (Marcet, Lorenzoni [**?**]). We start by guessing the expected future inflation as a function of the economy's state: $\mathbf{E}_t[\pi'] = f\left(p - p^T, e\right)$. For a grid of pairs $\left(p - p^T, e\right)$, we use the equations (13), (14) along with (8) to compute the implied conditional values of the inflation and of the output gap: y^0, π^0, y^1, π^1. With those conditional values computed, we can evaluate the conditional probability of price target reset $\rho\,(p, e)$, which lets us update the expected future inflation function. We iterate until convergence.

Naturally, if the trigger value of the output gap $\underline{Y}$ is very low, then the probability of target resetting must also be low. In particular, if $\underline{Y} = -\infty$, then no target resets will ever take place. We call such regime "PT without escape clauses". Conversely, if $\underline{Y}$ is very high, then escapes are very likely. This is not the full story though. Our results show that for an intermediate range of values of $\underline{Y}$, there are at least two stable equilibria with different unconditional probabilities of price target resets: $\mathbf{E}\left[\rho_t\right]$. We call the equilibrium with high (low) unconditional price target reset probability, a Low (High) credibility equilibrium.[8]

Table 1 summarizes simulation results for both the "Low credibility" (in the top half) and the "High credibility" (in the bottom half) equilibria, with the benchmark set of parameters.

[8] For some values of $\underline{Y}$ we found three stable equilibria, with high, medium, and low levels of PT policy credibility.

Table 1: Simulation Results

Cutoff output gap value, %	-8	-7	-6	-5	-4	-3	-2	-1
LOW CREDIBILITY EQUILIBRIUM								
Unconditional reset probability, %	0.0	0.1	0.1	0.4	1.3	4.3	6.0	15.4
St. Dev. of output gap relative to that w/o escapes	1.00	1.01	1.02	1.30	1.34	1.33	1.27	1.54
St. Dev. of inflation relative to that w/o escapes	1	1	1	1	1	1	1	0.99
HIGH CREDIBILITY EQUILIBRIUM								
Unconditional reset probability, %	0	0	0	0	0	0	5.4	12.3
St. Dev. of output gap relative to that w/o escapes	1	1	1	1	1	1	1.27	1.43
St. Dev. of inflation relative to that w/o escapes	1	1	1	1	1	1	1	0.99

The first row of the table shows the cutoff values of the output gap $\underline{Y}$ (the trigger values) expressed as a percent of potential output. For example the rightmost column, has $\underline{Y} = -1$, which means that quarterly output has to fall by at least one percent below its potential level before the CB can exercise its option of resetting the price target. Clearly, that is the least restrictive escape clause in the table. As we move to the left, escape clauses become more and more restrictive. When $\underline{Y} = -8$, the escape clause is so restrictive that the unconditional probability of price target changes becomes zero, since shocks of this magnitude are nearly impossible with our calibration. For this particular case the Low credibility case is the same as the High credibility one, because the escape clause is unlikely ever to be used. As a result, the (unconditional) volatilities of output gap and inflation are the same as the ones in the PT regime without an escape clause (i.e. $\underline{Y} = -\infty$). The second and third rows of Table 1 indicate this by reporting unit ratios of the standard deviations of the output gap and inflation relative to their counterparts under PT without escape clauses, for $\underline{Y} = -8$.

For $\underline{Y}$ between -7 and -3 percent, the High credibility equilibria still imply zero probability of price target resets, and the same volatilities of the output gap and inflation as under PT with no escapes. There are, however, also Low credibility equilibria, in which the target reset probability is positive, the volatility of inflation is nearly the same as under PT without escapes, but the volatility of the output gap is higher and is rapidly, albeit not always monotonically, increasing with $\underline{Y}$.

Finally, when $\underline{Y} = -2$, or -1 percent, the target reset probability is positive under both High and Low credibility equilibria. Furthermore, as before the volatility of inflation is barely affected, while the volatility of the output gap is substantially higher than under PT without escapes.

What is the intuition for these results? A credible PT has the advantage, relative to IT, of stabilizing the economy through an inflation expectation channel: an increase in the current price level relative to target implies that CB will have to lower future inflation to bring the price level back to target. Lower expected future inflation lowers the incentive to raise current prices, and stabilizes the economy by counteracting the current price increase.[9] Thus, changes in expected inflation induced by the current price change stabilize the economy even before CB has done anything to the current output gap (via changes in interest rates). This automatic stabilization mechanism is absent under IT. IT does not explicitly target any price level. Thus, the expected future inflation under IT is independent of the current price level, and there is no negative feedback effect of expected inflation on current price shocks. CB has to rely only on changes in the output gap to meet its stabilization objectives.

Turning back to the PT regime with escape clauses, the positive probability of a price target reset weakens the link between the deviation from the current price target and expected future inflation. This is precisely because CB has an option of ignoring the old price level target, and resetting the target so that monetary policy does not have to reverse past price shocks. The consequence of the weaker link between the current price and expected future inflation is that the automatic stabilization mechanism becomes less effective. This hurts in two ways: first, since PT loses some of its automatic stabilization benefits, CB has to rely more on costly changes in the output gap to meet its objectives. Second, because of heavier reliance on output gap manipulations, the variance of the output gap increases, making low output gap values and price target resets more likely. This further undermines CB's credibility and leads to self-fulfilling credibility problems for PT and to multiple equilibria. In other words, escape clauses may have a perverse effect on public expectations, leading to higher output volatility and a costlier PT regime. This of course raises the question why the CB's assigned objective function includes an escape clause: CB should optimally be told to stick to PT whatever happens. But if the costs of large output declines are borne by society, then this delegation would not be credible.

Another important result evident in Table 1 is that even small unconditional reset probabilities can lead to large increases in output gap volatility. For example, when $\underline{Y} = -5$ percent, the unconditional probability of price target resets is only 0.4 percent, but the volatility of the output gap is 30 percent higher than under PT without escapes. This is because the conditional target reset probability changes endogenously and becomes very high when the deviation of the price level from target increases. Low PT credibility in those periods leads to big fluctuations in the output gap, which contribute disproportionately to the increase in the overall output volatility.

The volatility of output gap is not always increasing in $\underline{Y}$, however. For example, Table 1 shows that in a Low credibility equilibrium with $\underline{Y} = -2$ percents, the standard deviation of output gap is lower than in a Low credibility equilibrium with $\underline{Y} = -4$ percents. This non-monotonic relationship arises because there are two opposing effects of having a less stringent escape clause. On the one hand, a less stringent escape clause makes price target resets more likely, which leads to higher volatility by destabilizing inflation expectations and the output gap. On the other hand, a less stringent escape

[9] This negative feedback mechanism works in the symmetric way for price decreases relative to target.

Table 2: Simulation Results for $\lambda = 0.5$

Cutoff output gap value, %	-4	-3	-2	-1
LOW CREDIBILITY EQUILIBRIUM				
Unconditional reset probability, %	0	0.1	0.6	2.8
St. Dev. of output gap relative to that w/o escapes	1.00	1.93	3.10	2.81
St. Dev. of inflation relative to that w/o escapes	1	1	0.99	0.99
HIGH CREDIBILITY EQUILIBRIUM				
Unconditional reset probability, %	0	0	0	0
St. Dev. of output gap relative to that w/o escapes	1	1	1	1
St. Dev. of inflation relative to that w/o escapes	1	1	1	1

clause lets the central bank act before the output gap becomes very low, thus reducing the magnitude of each output fall. The interaction of these two opposing effects results in a non-monotonic relationship between $\underline{Y}$ and output gap volatility. Thus, while lax escape clauses alleviate the magnitude of output declines, they also increase their frequency.

Finally, the results we presented in this section are not sensitive to the parameter values chosen. We conducted a thorough sensitivity analysis with respect to λ, κ and φ and found no remarkable differences[10] from the results in Table 1. A set of results that is of interest in its own right is one with a higher value of λ, i.e. a larger weight on output gap variability in the social loss function. Table 2 presents simulation results for $\lambda = 0.5$. As can be seen from a comparison of the top part of Table 2 with that of Table 1, a larger weight on output gap variability in the social loss function makes large output gap fluctuations less likely, thus reducing the unconditional reset probability. On the other hand, the effect of credibility on the output gap variability is much more pronounced: volatility of output gap increases quite rapidly as the unconditional target reset probability increases from 0 to 0.6 percent.

[10] We tried the following values of these parameters: $\lambda = \{0.024, 0.048, 0.096, 0.5\}$, $\kappa = \{0.012, 0.024, 0.048\}$, and $\varphi = \{0.0, 0.48, 0.8\}$. The standard deviation of the cost-push innovations, σ, was always recalibrated, as described above, to give the same volatility of inflation under IT as in the Canadian data.

5 Conclusions

The gold standard regime and price level targeting have similarities in that neither lets bygones be bygones, but each requires reversing deviations from a particular nominal price. The gold standard experience suggests that in some circumstances a PT regime might also be suspended or abandoned. While it is difficult to anticipate what those circumstances might be, nevertheless they would seem to be associated with major risks of an economic downturn or financial collapse. In our view, price level targeting is unlikely to be implemented without an explicit or implicit escape clause that allows bygones to be bygones under some circumstances. The model presented in this paper assumes that this is the case; in particular, large enough shocks provoke abandonment of strict PT and rebasing of the price target to ignore past deviations.

In addition, this possibility may be reflected in expectations, and thus hamper the credibility of a PT regime relative to a regime like IT.[11] The latter is less constraining because it allows bygones to be bygones, and hence temporary deviations from the inflation target do not have to be corrected later. Of course, it may be that in normal times the magnitude of downturns is not so great as to affect credibility. However, history suggests that one should not ignore the possibility that large fluctuations, either derived from financial crisis, war, or fiscal indiscipline, may lead to regime change. If PT is suspended only temporarily, the issue of the price level at which to resume PT has to be faced. The inter-war period suggests that even long-anticipated resumption at pre-war parities had substantial cost in Britain in 1926, though the experience of Sweden was less severe. In contrast, France, which went back on the gold standard only in 1928, at a much depreciated level for the franc, benefited from a boost to activity. Of course, a PT regime with frequent suspensions and resumptions at the prevailing price level would differ very little from inflation targeting.

References

[1] K. Adam and R. M. Billi. Optimal monetary policy under commitment with a zero bound on nominal interest rates. Research Working Paper RWP 05-07, Federal Reserve Bank of Kansas City, 2005.

[2] Robert Barro and David Gordon. Rules, Discretion, and Reputation in a Model of Monetary Policy. *Journal of Monetary Economics*, 12:101–121, July 1983.

[3] Tamim Bayoumi and Michael D Bordo. Getting pegged: Comparing the 1879 and 1925 gold resumptions. *Oxford Economic Papers*, 50(1):122–49, January 1998.

[4] Michael Bordo and Finn Kydland. The Gold Standard As a Rule: An Essay in Exploration. *Explorations in Economic History*, 32(4):423–464, October 1995.

[11] The IT regime could also be subject to an escape clause, in which case a proper comparison would compare PT and IT regimes, both having escape clauses. However, following the literature, we model IT as the optimal policy under discretion. The (Markov-perfect) optimality of IT makes escape clauses redundant in such regime. Moreover, the escape clause for PT relates solely to the issue of letting bygones be bygones, which IT does in any case.

[5] Michael D. Bordo. The gold standard, Bretton Woods and other monetary regimes: a historical appraisal. *Federal Reserve Bank of St. Louis Review*, March/April:123–191, 1993.

[6] Gustav Cassell. *The Downfall of the Gold Standard*. Oxford at the Clarendon Press, London, 1936.

[7] Richard Clarida, R. Gali, and M. Gertler. The Science of Monetary Policy. *Journal of Economic Literature*, 37:1661–1707, 1999.

[8] Marcello de Cecco. *Money and Empire: The International Gold Standard, 1890-1914*. Basil Blackwell, Oxford, 1974.

[9] John Driffill and Zeno Rotondi. Credibility of Optimal Monetary Delegation: Comment. *American Economic Review*, 96(4):1361–1366, September 2006.

[10] Barry Eichengreen. *Golden Fetters: The Gold Standard and the Great Depression, 1919-1939*. NBER Series on Long-Term Factors in Economic Development. Oxford University Press, New York and Oxford, 1992.

[11] Frank Whitson Fetter. *Development of British Monetary Orthodoxy, 1797-1875*. Harvard University Press, Cambridge, Massachusetts, 1965.

[12] Robert Flood and Peter Isard. Monetary Policy Strategies. *International Monetary Fund Staff Papers*, 36:612–632, 1989.

[13] P. N. Ireland. Technology Shocks in the New Keynesian Model. *The Review of Economics and Statistics*, 86(4):923–936, 2004.

[14] Olivier Jeanne. Are currency crises self-fulfilling? A test. *Journal of International Economics*, 43:263–286, 1997.

[15] Henrik Jensen. Credibility of Optimal Monetary Delegation. *American Economic Review*, 87(5):911–920, December 1997.

[16] Oleksiy Kryvtsov, Malik Shukayev, and Alexander Ueberfelt. Adopting Price-Level Targeting under Imperfect Credibility. Working Paper 2008-3, Bank of Canada, February 2008.

[17] Susanne Lohmann. Optimal Commitment in Monetary Policy: Credibility versus Flexibility. *American Economic Review*, 82(1):273–286, March 1992.

[18] Bennett T. McCallum. *Handbook of Macroeconomics*, volume 1, chapter 23. Issues in the design of monetary policy rules, pages 1483–1530. Elsevier, Amsterdam, 1999.

[19] B.R. Mitchell. *International Historical Statistics, Europe 1750-1993*. Macmillan Reference Limited, Stockton Press, New York, 4th edition, 1998.

[20] D.E. Moggridge. The Return to Gold, 1925: The Formulation of Economic Policy and its Critics. Occasional Papers 19, University of Cambridge, Department of Applied Economics, Cambridge University Press, UK, 1969.

[21] Maurice Obstfeld. Models of currency crises with self-fulfilling features. *European Economic Review*, 40:1037–1048, 1996.

[22] Alessandro Prati. Poincare's stabilization: Stopping a run on government debt. *Journal of Monetary Economics*, 27:213–239, 1991.

[23] Kenneth Rogoff. The Optimal Degree of Commitment to an Intermediate Monetary Target. *Quarterly Journal of Economics*, 100:1169–89, November 1985.

[24] Pierre Sicsic. Was the Franc Poincare deliberately undervalued? *Explorations in Economic History*, 29:69–92, 1992.

[25] Lars E.O. Svensson. Price-Level Targeting versus Inflation Targeting: A Free Lunch? *Journal of Money, Credit, and Banking*, 31(3):277–295, August 1999.

[26] David Vestin. Price-level versus inflation targeting. *Journal of Monetary Economics*, 53:1361–1376, 2006.

[27] Michael Woodford. *Interest and Prices: Foundations of a Theory of Monetary Policy.* Princeton University Press, 2003.

[28] James Yetman. The credibility of the monetary policy "free lunch". *Journal of Macroeconomics*, 27:434–451, 2005.

A Appendix: Gold Standard Experience in the 20th Century

A.1 Why was the gold standard suspended in World War I?

There is a consensus of authorities on the gold standard that it was much less automatic than usually thought, or than as described in Hume's price-specie flow mechanism [5, 6, 8, 10]. In fact, central banks used their powers at times to prevent gold from flowing, such as raising interest rates to offset potential loss of gold due to current account deficits. In addition, countries imposed varying restrictions on the domestic and international convertibility of their paper currencies into gold, some allowing one but not the other form of convertibility. They also varied in the extent that they issued paper currencies (and backed them by gold); minted gold or silver coins at times, but suspended new coinage at others; and at times took measures to concentrate gold reserves within the central bank (if they had one, which was not the case for the United States until 1913).

So instead of the abrupt abandonment of gold's role at the center of the international monetary system at the time of the outbreak of war in 1914, there was an increase in various controls and restrictions on the textbook operation of the gold standard. Countries' currencies were still in principle linked to gold, but there were restrictions on convertibility and patriotic appeals to furnish gold to the central bank, where it could be used for the war effort. The transport of gold was restricted because of dangers to shipping, so the specie flow mechanism worked even less smoothly. However, payments for international transactions did require transfer of gold, or at least claims to gold, and the United States, a large holder of gold and a non-belligerent until 1917, did ship some gold to Europe. The United States never officially suspended the gold standard until the 1930s, and Britain was the country next to the United States where the fewest modifications to the gold standard were imposed during the war. Neutral countries such as Sweden and the Netherlands, which tended to attract gold bullion inflows, refused to mint gold or to buy foreign gold coins, fearing the inflationary impact on their money supplies [10, p. 71].

The war was typically not financed by taxation, however, and governments borrowed heavily, either through issuing paper money or borrowing short-term, increasing the liquidity of their banking systems to facilitate floating public debt. The war was expected to be short-lived, and the enemy expected to pay off debts and retire the notes that had been issued by the victors to finance it, leading governments to choose not to raise taxation [10, p. 75]. Government debt rose by a factor of 10 in Germany and the United States, relative to 1914 levels, and by a multiple of 4 in Britain and 2 in France. Thus, the threat to the gold standard became most evident after the war, when patriotic appeals and war-time restrictions could no longer keep the lid on inflation nor ensure that short-term debts would be rolled over. Eichengreen argues "[the] overhang of debts greatly complicated postwar problems of monetary management. Never had governments sought to maintain convertibility while shouldering such a heavy debt burden." [10, p. 81]. When the United States, which was still linked to gold and had supported the value of the currencies of its allies, Britain and France, terminated its interventions in March 1919, the two currencies abruptly depreciated.

This, and the sharp postwar boom led to great increases in the price of gold in domestic currencies and signalled the effects of gold standard suspension and the challenges of reestablishing pre-war parities.

In sum, the link to gold was abandoned progressively, and it could be argued that it was the fiscal effects of the war, increasing the fiat money outstanding and creating a large public debt that had to be serviced, that caused the extended suspension of the system. Nevertheless, far from being automatic, the pre-war system required continuing intervention and cooperation among central banks, and already this cooperation before the war had been severely strained, suggesting that the breakdown of the system may have been inevitable [8]. Others, however, have pointed to the gold standard rule of maintaining free convertibility at a fixed price of gold as a commitment mechanism that helped to ensure the gold standard's longevity, in contrast to the post-World-War-II Bretton Woods system [5].

A.2 Interwar resumption

European countries waited until the middle of the decade of the 1920s before resuming convertibility at a fixed gold price, the price being the pre-war parity for some countries, but not for all. Prices had risen during and after the war, but declined sharply in 1920-21 as the world went into recession. Given the apparent downward flexibility of prices, and the widespread expectation of a return to pre-war parities, it is hard to understand purely on the basis of relative prices why resumption took so long. Cassell denies that for Britain deviations from purchasing power parities were so large as to justify the delay[6]. However, Moggridge [20] points to the weakness of sterling in 1924 relative to its pre-war parity against the US dollar of $4.86, and the concern that Britain's prices were out of line with those of the United States, as reasons explaining why the Chamberlain-Bradbury Committee was reluctant to recommend an immediate resumption[12]. Eichengreen explains the delay by the fiscal problems resulting from the war, mentioned above. Governments needed to refinance their war debts, and there was tremendous pressure not to increase interest rates, since doing so would have reduced the price of existing bonds as a result.

Britain temporized, so Sweden was the first European country to resume the gold standard, which it did at the prewar parity in April 1924. At this point, Sweden's prices were not out of line and until 1931 the country had no trouble maintaining the gold standard [6, p. 36]. Britain returned to gold at its pre-war parity in April, 1925, but British prices still needed to fall and Britain suffered deflation and stagnation for the rest of the decade.

France had more severe fiscal problems than Britain, and they led France to the verge of hyperinflation [22]. German reparations were expected to allow paying off wartime debt, but Germany's inability to do so, and the abortive French occupation of the Ruhr in 1923 led to accelerating inflation and a depreciating franc. Under the Poincaré government, France had stabilized its public finances with some difficulty by 1926, and it reassured bond investors by ruling out a capital levy [22]. When France

[12] Keynes, in his testimony, argued that the pre-war parity would imply an overvaluation of sterling against the dollar of 10-12 percent, but he thought that inflation in America would bring the two currencies into line if resumption was delayed.

officially resumed the gold standard in June, 1928, the value of the franc was only about 20 percent of its pre-war parity [6, p. 47]. While by this time resumption at the pre-war parity was probably not an option, it seems that the French authorities deliberately resisted a more appreciated rate, since Poincaré's stabilization had changed sentiment and the franc was now appreciating [24]. By this time, all of the world's major economies were back on the gold standard, but Germany and Belgium had also depreciated relative to pre-war parities.

The effects of gold standard resumption were varied. It is instructive to compare the experiences of Sweden, Britain and France; consumer price index and real GDP data are presented in Tables 3 and 4, taken from [19]. Sweden, of course had not faced the problems of war financing. It was able to reduce prices while at the same time experiencing rising output; resumption of the prewar parity in 1924 did not induce a recession. Britain and France both incurred substantial war debt, but differed in the parity at which they returned to gold. Britain experienced declines in output throughout the decade, while France, which had gained competitiveness that was consolidated by the parity at which it returned to gold, showed much stronger growth. Cassell had recommended to the 1922 International Economic Conference in Genoa that countries whose currencies had fallen very far from pre-war parities return to gold at a devalued exchange rate [6, p. 31]. Credibility problems leading to output declines when Britain returned to the gold standard may have resulted from doubts engendered by the delay in resuming the pre-war parity; at war's end, a rapid return to pre-war parities had been expected [10, p. 101]. However, in Britain, unlike in France or Belgium, there had never been any consideration by the authorities of a parity different from the pre-war parity, and the Cunliffe Committee's 1918 commitment to gold standard restoration was official policy of successive British governments, whatever their political stripe [20].

A.3 Final abandonment

Starting late in 1929, the world tipped into depression, exacerbated by increasing protectionism and caused or worsened by contractionary monetary policies. Cassell, for instance, argues that the fundamental problem was that the gold surplus countries, notably the United States and France, did not allow their money supplies to increase (as the automatic operation of the classical gold standard would dictate), while the deficit countries were forced into severe contraction. The net effect, according to Cassell, is that the world went into a deflationary period destructive of economic activity [6, chapter III].

Falling price levels should have allowed monetary stimulus to come into play through more-or-less automatic mechanisms, such as real balance effects. This seemed to have been occurring by early 1931; however, the situation deteriorated markedly thereafter. Onset of severe financial crisis led countries which remained on the gold standard to abandon it, in a desperate attempt to stave off catastrophe [10, chapter 9]. The Credit-Anstalt crisis in Austria spread to Hungary, Germany, Britain, and Sweden in 1931. Faced with the prospect of total collapse of their banking systems, the above countries all left the gold standard in the course of the year[13]. The abandonment by Britain

[13] An interesting sidelight is Cassell's recommendation to the Swedish government that they should replace the gold standard with the objective of maintaining the internal purchasing power of the

was followed by a large depreciation of sterling against the US dollar. Faced with weak exports and gold outflows as a result of devaluations in other countries, the United States was itself forced to suspend gold convertibility. On April 19, 1933, President Roosevelt took the country off gold in order to achieve reflation of the economy.

Many authors have underlined that the gold standard system had problems that limited its usefulness as an international monetary regime [6, 8, 10]. The overall price level was hostage to the global supply, which was insufficient to allow stable prices. Central banks reacted perversely to changes in their gold reserves. But the commitment mechanism and discipline it embodied were widely valued at the time, and are still considered to have contributed to international stability [5]. The abandonment of the gold standard did not occur because central banks and treasuries had constructed a better monetary system, though there were numerous inter-war conferences on the subject. Instead, the fall of the gold standard was due the severity of the shock of the Great Depression and the context of financial crisis that required more flexibility of monetary policy than the gold standard allowed. Faced with catastrophic prospects and as a last resort, the monetary authorities freed themselves to use what instruments they had to stimulate the economy, despite the loss of reputation involved in going back on previous commitments.

Swedish krona against commodities [6, p. 66]–that is, a price level target. Cassell also made the case for such a regime in front of the Conservative Party Finance Committee of the British House of Commons in May, 1932, when he described how a commodity price target could operate [6, pp. 85-86].

Table 3: Consumer Prices, 1919-1937

	France	**Sweeden**	**U.Kingdom**
1919	44	154	131
1920	61	159	152
1921	53	143	138
1922	51	115	112
1923	57	105	106
1924	65	103	107
1925	69	104	107
1926	90	102	105
1927	94	101	102
1928	94	101	101
1929	100	100	100
1930	101	97	96
1931	97	94	90
1932	88	92	88
1933	85	91	85
1934	82	91	86
1935	75	92	87
1936	80	93	90
1937	101	96	94

Source: Mitchell, *Historical Statistics, Europe 1750-1993*

Data rebased from original (1929 = 100)

Table 4: GDP, constant prices, 1920-1938

	France	**Sweeden**	**U.Kingdom**
1920	65	66	94
1921	62	68	88
1922	73	71	83
1923	77	75	86
1924	87	76	89
1925	87	83	91
1926	89	89	96
1927	88	93	92
1928	94	93	98
1929	100	100	100
1930	97	106	102
1931	91	98	102
1932	85	96	97
1933	91	98	97
1934	91	104	98
1935	88	110	105
1936	92	117	109
1937	97	119	113
1938	96	123	117

Source: Mitchell, *Historical Statistics, Europe 1750-1993*

Data rebased from original (1929 = 100)

Mistakes in UK figures for 1931-32 in Table J1 have been corrected, using data in other columns.