Speculative Attacks, Private Signals and Intertemporal Trade-offs*

Nikola A. Tarashev†

December 12, 2008

Abstract

Confronted with a speculative attack on its currency peg, an authority weighs the short-term benefit of giving in and fine tuning the economy against the long-term benefit of credibility-enhancing resistance. In turn, speculators with heterogeneous beliefs face strategic uncertainty that peaks at the time of the attack, when the fate of the peg is unclear, and then declines, as the economy settles in a stable currency regime. In this environment, a *less* conservative authority – i.e. one that would stabilize less the exchange rate if the peg were abandoned – may be *more* likely to withstand an attack on the peg. This result, which strengthens as speculators' risk aversion declines, casts doubt on the conventional wisdom that greater conservatism enhances welfare.

JEL Classification Numbers: D82, D84, F31

Keywords: Global games of regime change, Strategic uncertainty, Coordination, Currency crises

---

*I thank Piti Disyatat, Pierre-Olivier Gourinchas, John Moore, Hyun Shin, Kostas Tsatsaronis and seminar participants at the BIS, Cambridge University and Humboldt University for useful comments and suggestions. All remaining errors and omissions are mine.

†Bank for International Settlements, Centralbahnplatz 2, CH-4002 Basel, Switzerland. E-mail: nikola.tarashev@bis.org. The views expressed in this paper are those of the author and do not necessarily reflect those of the BIS.

Introduction

The global games literature has shown that small departures from the representative-agent paradigm can alter drastically the link between economic fundamentals and market behavior.[1] In a specific application of this insight, Morris and Shin (1998) were the first to introduce heterogeneous information in a standard second-generation model of currency crises[2] in order to explain abrupt and intense speculative attacks as the *unique* outcome of a small deterioration of fundamentals. In studying the robustness of the equilibrium uniqueness result, Vives (2005), Hellwig et al (2006), Tarashev (2007) and others have found that it hinges on the presence of sufficient strategic uncertainty, defined as individual players' uncertainty about aggregate behavior.[3] Even when each player's private information is extremely precise, strategic uncertainty can be high and preclude the market from coordinating on different equilibria for the same fundamentals.

Building on these results, this paper analyzes the impact of *time varying* strategic uncertainty on the intertemporal problem of a central authority that governs an exchange-rate peg.[4] Given that an attack on the peg is followed by a stable currency regime (whose type depends on the attack's success) strategic uncertainty declines over time. A seemingly surprising result ensues: a *less* conservative authority – i.e. one that is less inclined to stabilize the exchange rate once the peg is abandoned – is *more* likely to withstand an attack on the peg. Furthermore, confronted by a lower probability of such an attack, a less conservative authority may deliver higher social welfare.

The global games model of this paper exploits two key aspects of Kydland and Prescott (1977) and Barro and Gordon (1983). First, predictable monetary policy actions entail inflation-related costs in equilibrium but no output-related gains. Second, albeit desirable, a peg is sustainable under discretionary monetary policy only if the gains from pegging extend beyond the current period. The second aspect prompts the assumption that a preservation of the peg provides the economy with the option to join a currency union, which buttresses the long-term credibility of the peg by institutionalizing the authority's commitment to it. By contrast, reneging on the peg eliminates this option and results in a managed float, which is a suboptimal currency regime in

[1] Carlsson and van Damme (1993) is often considered to be the pioneering paper in the global games literature. This literature has been reviewed by Morris and Shin (2003) and Vives (2004).

[2] Obstfeld (1994) provides an introduction to the second-generation approach to currency crises. For a comprehensive analysis of this approach and further references, refer to Obstfeld and Rogoff (1996).

[3] See also Corsetti et al (2004), who study the role of a big player in foreign exchange markets, Rochet and Vives (2004) and Goldstein and Pauzner (2005), who employ global games for the analysis of bank runs, and Goldstein (2005), who considers contagion between currency and banking crises.

[4] Dasgupta (2007) and Angeletos et al (2006) have also studied time-varying strategic uncertainty but have abstracted from its impact on the optimization problem of a central authority.

the adopted model.[5]

In this setting, the exchange rate depends on the authority's trade-off between the short-term benefit of abandoning the peg in order to fine tune output and the long-term benefit of joining the currency union. Considered one at a time, each of these benefits is higher for a lower degree of the authority's conservatism, which is captured, in the spirit of Rogoff (1985), by the importance attributed to exchange-rate stabilization. In the short term, given any behavior of the private sector, a less conservative authority enjoys, by definition, a greater benefit of reneging on the peg. This short-term benefit is raised further by the fact that a less conservative authority experiences more intense attacks, which, unless accommodated, would lead to greater output-related costs. That said, the less conservative is the authority the less capable it is to manage a float and, consequently, the more it stands to gain in the long term from joining a currency union.[6]

Thus, key in such a setting is the *relative* impact of conservatism on the authority's short-term and long-term benefits. A representative-agent version of the model, which gives rise to multiple equilibria, implies that lower conservatism raises the short-term benefit of accommodating an attack by more than the long-term benefit of joining a currency union. In turn, this confirms the conventional wisdom that a less conservative authority is more vulnerable to speculative attacks and, thus, delivers lower welfare. However, this conventional wisdom is shown to hinge on the representative speculator being equally certain of market outcomes, irrespective of whether this speculator attacks the peg in the short run or operates under a managed float in the long run.

Departing from the representative-agent paradigm by introducing even infinitesimal noise in market players' private signals leads to substantial *time variation* in *strategic uncertainty*, which may reverse the welfare implications of the authority's conservatism. Strategic uncertainty, which delivers equilibrium uniqueness, peaks in the short term because only then is the currency regime unstable. By impairing the coordination capacity of private agents, short-term strategic uncertainty *dampens* the sensitivity of

[5] Such a setup, albeit stylized, reflects important features of strict exchange rate regimes. In September 1992, the credibility-related benefits of preserving a peg underpinned the refusal of several European countries to participate in a coordinated *one-time* realignment vis-à-vis the Deutschemark. Eichengreen (2000) explains this refusal by arguing that each of the European pegs was the repository of anti-inflationary credibility and to abandon it would have been a heavy blow to confidence with long lasting consequences. In this respect, the 1994 devaluation of the Mexican peso provides a case in point. After this devaluation, the central bank tried but could not establish a new parity vis-à-vis the US dollar and was forced to float the peso (Obstfeld and Rogoff (1995)). At present, euro-area accession countries are required to demonstrate their resolve to stabilize the domestic exchange rate, which is viewed as supporting the reputation of incumbent members of the currency union.

[6] Note that traditional second-generation models of currency crises – similar to the one in Obstfeld and Rogoff (1996) – assume that the long-term benefit of pegging is exogenous and, thus, independent of the authority's conservatism. As illustrated by Section 5.1 below, this assumption drives a wedge between the traditional second-generation models and the model developed in this paper.

a speculative attack to the degree of the authority's conservatism. In the long term, irrespective of whether the attack has succeeded or not, the regime (a managed float or a currency union) is stable and is, thus, common knowledge. As a result, strategic uncertainty is considerably lower in the long term and has *limited impact* on long-term market outcomes, in general, and on their sensitivity to the authority's conservatism, in particular. If strategic uncertainty declines sufficiently over time, lower conservatism raises the authority's short-term benefit of fine-tuning output by less than its long-term benefit of preserving the peg. This explains why a *less* conservative authority may resist *more* to an attack on the peg.[7]

In the presence of strategic uncertainty, the authority's conservatism has two opposite effects on expected welfare. On the one hand, a less conservative authority may raise welfare by resisting more to an attack on the peg, which, built into speculators' beliefs, depresses the likelihood that such a costly attack materializes. On the other hand, lower conservatism gives rise to more intense speculative attacks, whose welfare-damaging impact might increase in expectation even when the probability of their materializing declines.

That said, there is a region of the parameter space on which the first effect dominates and, thus, lower conservatism raises welfare. Importantly, this region is larger when speculators' aversion to downside payoff risk is lower. The reason is that, by depressing the likelihood of an attack on the peg in the short term, lower risk aversion amplifies the impact of declining strategic uncertainty on the authority's intertemporal trade-off.

This paper adds to recent insights from the global games literature, which highlight how strategic uncertainty deepens the policy analysis of currency crises. Such insights have been developed by Gimaraes and Morris (2007) in a one-period model that incorporates risk aversion as well as wealth and portfolio distribution effects. Against this background, the contribution of the present paper is to underscore the impact of time-varying strategic uncertainty on economic trade-offs across multiple periods.

The rest of the paper is organized as follows. The general model and its key implications are presented in Sections 1 and 2, respectively. Then, Section 3 derives the equilibrium and analyzes welfare in a representative-agent version of this model. In turn, Section 4 conducts similar analysis in the context of private signals and strategic uncertainty. Finally, Section 5 digs deeper into how market players' strategic uncertainty and risk aversion affect policy analysis.

[7] If the authority represents both the central bank and the fiscal government, this result can be interpreted as follows. The stronger are fiscal pressures on the exchange rate, the stronger are the central bank's incentives to neutralize such pressures by joining a currency union. This echoes a key idea of Jeanne and Svensson (2007) who use the central banks' drive towards independence from the fiscal government in order to design a credible commitment to an optimal escape from a liquidity trap.

1 The model

A small open economy evolves over three periods: $t \in \{0, 1, 2\}$. In each of these periods, the foreign price level is normalized to unity and there is purchasing power parity. Thus, the domestic price equals the exchange rate, which is the domestic-currency price of the foreign currency. The exchange rate in period 0 is fixed exogenously.

The economy is populated by a continuum of workers, a continuum of entrepreneurs and a central authority. Both the workers and the entrepreneurs are of measure one on aggregate; each worker is paired with a single entrepreneur and vice versa. In addition, the economy is overseen by a benevolent dictator who maximizes the expected value of social welfare.

The stochastic shocks to the economy stem exclusively from exogenous fundamentals, z_t, which follow an autoregressive process:

$$\begin{aligned} z_t &= (1-\psi)\,\mu + \psi z_{t-1} + \eta_t \\ \psi &\in [0,1]\,,\ z_0 = \mu < 0 \\ \eta_t &\sim iid\ N\left(0, \sigma^2\right) \text{ for } t \in \{1,2\} \end{aligned} \tag{1}$$

where μ is sufficiently below 0 to imply that positive realizations of z_t occur with such a small probability that it is safe to ignore them in deriving the equilibrium. As seen below, this biases the incentives of the authority towards devaluing the currency.[8]

1.1 Entrepreneurs[9]

At the beginning of periods $t \in \{1, 2\}$, each entrepreneur i takes her worker's wage $W_{i,t-1}$ (which is set one period in advance) and the domestic price S_t as given, observes the fundamentals z_t and employs the amount of labor $N_{i,t}$ that maximizes her profits. Profits equal the difference between revenues $S_t\,(\exp(z_t))^{\gamma}\,N_{i,t}^{1-\gamma}$, where $\gamma \in (0, 1)$, and labor costs $W_{i,t-1}N_{i,t}$. A first-order condition implies that the entrepreneur employs

$$N_{i,t} = \left[(1-\gamma)\,\frac{S_t}{W_{i,t-1}}\right]^{\frac{1}{\gamma}} \exp(z_t) \tag{2}$$

Using (2) to substitute for $N_{i,t}$ in $(\exp(z_t))^{\gamma}\,N_{i,t}^{1-\gamma}$, taking logs and setting $(1-\gamma)/\gamma =$

[8] Symmetrically, $z_t > 0$ introduces a bias towards exchange rate revaluations. Although such a bias is also empirically relevant, considering it in the model of this paper would burden the exposition without enriching the insights of the analysis.

[9] Sections 1.1 to 1.4 follow closely Rogoff (1985).

1 delivers the following production function:[10]

$$y_{i,t} = \bar{y} - (w_{i,t-1} - s_t) + z_t \tag{3}$$

where $s_t \equiv \log(S_t/S_{t-1})$ is the devaluation rate, $w_{i,t-1} - s_t \equiv \log(W_{i,t-1}/S_{t-1}) - \log(S_t/S_{t-1})$ is (the log of) the period-t real wage of worker i, and $\bar{y} \equiv \log(1-\gamma)$.

1.2 Workers

At the end of periods $t-1 \in \{0,1\}$, worker i takes the current exchange rate S_{t-1} as given and sets his wage for period t. This determines $w_{i,t-1}$, which, with slight abuse of terminology, is henceforth referred to as "the wage of worker i". Given $w_{i,t-1}$, worker i agrees to supply in period t as much labour as entrepreneur i demands.

Worker i sets $w_{i,t-1}$ so that his expectation of his (log) real wage equal zero:

$$w_{i,t-1} = E^i_{t-1}(s_t) \tag{4}$$

As illustrated in Rogoff (1985), such a wage-setting rule arises if the worker minimizes the expected deviation between his date-t employment level and an "ideal" employment level, attained when employment and wages are negotiated simultaneously.

The wage-setting rule (4) induces each worker to align his action with the market, which is known as "strategic complementarity". Since, as seen below, the equilibrium devaluation rate s_t increases in the aggregate wage bill $w_{t-1} = \int w_{i,t-1}di$, the rule in (4) implies that each worker will demand a higher wage if he believes that w_{t-1} is higher.

1.3 Central Authority

The authority administers the exchange rate regime in periods $t \in \{1,2\}$. At date 1, the authority observes the wage bill w_0 and the current fundamentals z_1 and sets the devaluation rate s_1 that minimizes the intertemporal loss $L^A(s_1; w_0, z_1)$. This loss increases as the aggregate output or the devaluation rate deviate from the respective targets, $\bar{y}$ and 0:

$$\begin{aligned} L^A(s_1; w_0, z_1) &= l^A(z_1, s_1, w_0) + \beta E_1\left[l^A(z_2, s_2, w_1)\right] \\ l^A(z_t, s_t, w_0) &\equiv (y_t - \bar{y})^2 + \chi^A s_t^2 \\ &= [(s_t - w_{t-1}) + z_t]^2 + \chi^A s_t^2 \end{aligned} \tag{5}$$

[10]Relaxing the assumption $(1-\gamma)/\gamma = 1$ generalizes equation (3) to $y_{i,t} = \bar{y} - (1-\gamma)(w_{i,t-1} - s_t)/\gamma + z_t$. Continuing the analysis with this more general production function would have burdened the exposition without altering qualitatively any of the conclusions.

where the discount factor and aggregate output are denoted by β and $y_t \equiv \int y_{i,t} di$, respectively, and the last equality follows from (3). Further, the authority's conservatism – i.e. the importance that the authority attributes to a stable exchange-rate, as opposed to output – is captured by $\chi^A > 0$.

As explained in Section 1.5 below, the country may be in one of two regimes in period 2. One possibility is a currency union, in which the authority is obliged to set $s_2 = 0$. The other possibility is a flexible exchange rate regime, in which the authority has full control over s_2 and uses it to minimize $l^A(z_2, s_2, w_1)$ for a given wage bill, w_1, and fundamentals, z_2.

1.4 Social Welfare

Expected social welfare decreases in the following expected loss:

$$E_0(L) = E_0[l(z_1, s_1, w_0) + \beta l(z_2, s_2, w_1)] \tag{6}$$

$$l(z_t, s_t, w_{t-1}) \equiv [(s_t - w_{t-1}) + z_t]^2 + \chi s_t^2 \tag{7}$$

The parameter $\chi > 0$ denotes the relative weight that the society places on exchange-rate stabilization. The analysis below remains unchanged for *any* positive value of χ and allows explicitly for social preferences that differ from the authority's: i.e. $\chi \neq \chi^A$.

1.5 The Benevolent Dictator in Two Variations of the Model

At the beginning of period 0, i.e. before any other player has acted, the dictator sets the authority's conservatism parameter χ^A to a level that minimizes the expected social loss $E_0(L)$. Once set, the value of χ^A is fixed for $t = \{1, 2\}$, which reflects the notion that the design of an authority incorporates considerations for the entire foreseeable future. More importantly, interpreted as the identity of the authority, χ^A needs to remain constant over time if the authority is to face intertemporal trade-offs.

In addition, the dictator has the option to place the country in a currency union in period 2 if and only if the peg is preserved in period 1.[11] The dictator exercises this option, before workers set w_1, if the expected future loss, $E_1[l(s_2; w_1, z_2)]$, is lower under a currency union.

[11] In principle, the option to join a currency union could be recovered after a devaulation if the authority demonstrates subsequently its renewed resolve to stabilise the exchange rate. The three-period model of this paper implicitly assumes that subsequent recovery of the currency-union option is such a distant possibility that it influences immaterially decisions in the short term.

1.6 Information Structure

The economic players are divided in two groups according to their information sets. The first group comprises private entrepreneurs, the authority and the benevolent dictator, who act knowing the *current* value of z_t.[12] Admittedly, the authority is likely to have noisy information about the fundamentals that determine entrepreneurs' employment decisions and, thus, output. That said, a wedge between the authority's and the entrepreneurs' information sets would add little insight about the role of workers' strategic uncertainty, which this paper focuses on. In addition, the assumption that the authority observes z_t directly is without loss of generality from the point of view of the workers. As implied by (4), workers are concerned exclusively with forecasting the devaluation rate, which depends solely on the authority's perceptions, be they accurate or not.

The second group comprises the workers, who act on possibly noisier information about the fundamentals. Namely, worker i bases $w_{i,t-1}$ on the following private signal:

$$x_{t-1}^i = z_t + \varepsilon_{t-1}^i \ , \ \varepsilon_{t-1}^i \sim N\left(0, \sigma_\varepsilon^2\right), \ \sigma_\varepsilon^2 \geq 0 \tag{8}$$

where ε_{t-1}^i are independent across i and serially uncorrelated.

This paper considers two information structures. Specifically, either the information sets are identical across all players – i.e. $\sigma_\varepsilon^2 = 0$ – or there is infinitesimal noise in workers' private information – i.e. σ_ε^2 is positive but extremely close to 0.

2 Generic Implications of the Model

This section reports implications of the model that are relevant irrespective of the information structure in place. The underlying sequence of events is summarized in Figure 1, where the first (second) action stated in parentheses is relevant only when $s_1 = 0$ ($s_1 = SDR_1$).

Expression (5) leads to the so-called *shadow* devaluation rate (SDR_t), which equals the value of s_t that minimizes the period-t loss of the authority:

$$SDR_t = \frac{1}{1+\chi^A}\left(w_{t-1} - z_t\right) \tag{9}$$

Let workers' aggregate belief be that the exchange rate is devalued, i.e. $s_t = SDR_t$, with probability π and the peg is preserved, i.e. $s_t = 0$, with probability $(1-\pi)$.

[12] Since they need not form expectations about a future period, entrepreneurs face no uncertainty.

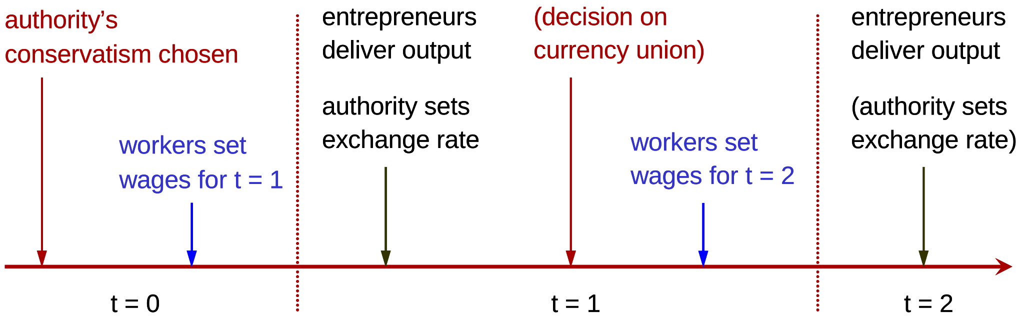

Figure 1: Sequence of events

Equations (4) and (9) then imply:

$$\begin{aligned} w_{t-1} &= \pi SDR_t, \\ SDR_t &= -\frac{1}{\chi^A + 1 - \pi} z_t \text{ and } w_t = -\frac{\pi}{\chi^A + 1 - \pi} z_t \end{aligned} \tag{10}$$

Henceforth, the value of the aggregate wage bill w_{t-1} will also be referred to as the intensity of workers' attack on the currency. This intensity decreases in the fundamentals z_t and the authority's conservatism χ^A but increases in workers' aggregate belief in the attack's success π.

On the basis of equations (10), expression (5) implies two generic outcomes for the authority's period-t loss, while expression (7) implies two similar outcomes from a social point of view. Introducing a superscript that identifies the action of the authority – peg or devaluation – these outcomes are:

$$l^{A,p}(z_t;\pi) = l^p(z_t;\pi) = \left(\frac{1+\chi^A}{1-\pi+\chi^A}\right)^2 z_t^2 \tag{11}$$

$$l^{A,d}(z_t;\pi) = \frac{\chi^A(1+\chi^A)}{(1-\pi+\chi^A)^2} z_t^2 \text{ and } l^d(z_t;\pi) = \frac{(\chi^A)^2+\chi}{(1-\pi+\chi^A)^2} z_t^2 \tag{12}$$

Several properties of the relationship between alternative loss outcomes have important implications for the behavior of the authority:

1. The net benefit of succumbing to an attack (equivalently, the net loss of pegging under an attack), $l^{A,p}(z_t;\pi) - l^{A,d}(z_t;\pi) > 0$, increases in the belief parameter π:

$$d\left(l^{A,p}(z_t;\pi) - l^{A,d}(z_t;\pi)\right)/d\pi > 0$$

This property illustrates the strategic complementarity between the aggregate action of workers and the action of the authority. Namely, the more strongly do workers believe that there will be a devaluation (i.e. the higher is π), the higher is the aggregate wage bill and, thus, the stronger are the incentives of the authority to validate workers' beliefs.

2. The net benefit of succumbing to an attack decreases in the authority's conservatism:

$$d\left(l^{A,p}\left(z_t;\pi\right)-l^{A,d}\left(z_t;\pi\right)\right)/d\chi^A<0$$

The logic behind this result is seen by referring to equations (5) and (10), which imply that a devaluation minimizes the overall (convex) loss of the authority by transforming part of the output-driven component into a devaluation-driven component. Property 2 arises because the size of the loss-reducing transformation decreases in the authority's conservatism, χ^A. The reason is twofold: (i) a larger χ^A makes the authority devalue by less for any size of the attack; (ii) this is incorporated in workers' action and their attack is weaker for a larger χ^A, which reduces further the devaluation rate that the authority finds optimal.

3. The authority and society prefer a credible peg to a perfectly anticipated devaluation:

$$l^{A,d}\left(z_t;\pi=1\right)-l^{A,p}\left(z_t;\pi=0\right)>0 \text{ and } l^{d}\left(z_t;\pi=1\right)-l^{p}\left(z_t;\pi=0\right)>0$$

This simply means that, being fully built into wages, a devaluation cannot influence output but leads to devaluation-related losses. Properties 1. and 3. illustrate the possibility for dynamic inconsistency in the authority's problem. Namely, the authority wishes to commit to a peg (property 3) but cannot do so if it is concerned solely with losses within the current period (property 1).[13]

4. The authority's net benefit of joining the currency union in period 2 (and avoiding a perfectly anticipated devaluation), decreases in the authority's conservatism:

$$d\left(l^{A,d}\left(z_2;\pi=1\right)-l^{A,p}\left(z_2;\pi=0\right)\right)/d\chi^A<0$$

This result extends property 3 and reflects the fact that, by (10), a more conservative authority attains a more stable exchange rate and, thus, has less to gain from fixing this rate in a currency union.

[13] This form of dynamic inconsistency is conceptually equivalent to that studied by the seminal contributions of Kydland and Prescott (1977) and Barro and Gordon (1983).

5. For a given belief in the attack's success, π, the authority's net benefit of succumbing to the attack in period 1 decreases faster in χ^A than the authority's net benefit of joining the currency union in period 2:

$$d\left(l^{A,p}(z_1;\pi) - l^{A,d}(z_1;\pi)\right)/d\chi^A < d\left(l^{A,d}(z_2;\pi) - l^{A,p}(z_2;\pi=0)\right)/d\chi^A$$

This property, which extends property 2 above, reflects the fact that, in comparison to devaluation-related losses, output-related losses from pegging are more sensitive to the size of the wage bill. In turn, the dependence of the wage bill on χ^A underpins the above inequality.

3 Common Knowledge

Let workers possess perfect foresight one period in advance – i.e. let $\sigma_\varepsilon^2 = 0$ in (8).[14]

Given this assumption, which implies common knowledge, properties 1 and 3 reveal fully the equilibrium in period 2. If the authority has control over the devaluation rate in that period, property 1 implies a perfectly anticipated devaluation. By contrast, the peg is fully credible if the country has joined the currency union. In turn, property 3 implies that the country joins the currency union as long as it is possible, i.e. recalling Section 1.5, as long as the peg survives in period 1.

In period 1, the strategic complementarity, illustrated by property 1, gives rise to two critical values of the fundamentals. The first, henceforth denoted by z^h, is the highest z_1 that supports a perfectly anticipated devaluation (in which case, $\pi = 1$). The second critical value, z^l, equals the lowest z_1 that supports a credible peg (i.e. $\pi = 0$).

These two critical values are determined by the *intertemporal* trade-off faced by the authority in period 1. Namely, at $z_1 = z^h$ and at $z_1 = z^l$, the authority is to be indifferent between (i) the current net benefit of devaluing in period 1 (see property 1) and (ii) the expected net benefit of joining the currency union in period 2 (property 3), which is enjoyed only after a peg in period 1:

$$l^{A,p}\left(z^h;\pi=1\right) - l^{A,d}\left(z^h;\pi=1\right) = \beta E_1\left(\begin{array}{c} l^{A,d}(z_2;\pi=1) \\ -l^{A,p}(z_2;\pi=0)\end{array}\middle| z_1 = z^h\right) \quad (13)$$

$$l^{A,p}\left(z^l;\pi=0\right) - l^{A,d}\left(z^l;\pi=0\right) = \beta E_1\left(\begin{array}{c} l^{A,d}(z_2;\pi=1) \\ -l^{A,p}(z_2;\pi=0)\end{array}\middle| z_1 = z^l\right) \quad (14)$$

[14] This information setting generalizes trivially under the assumption that workers, who hold all their information in common, observe a date-$(t-1)$ *public* signal about the fundamentals z_t. The equilibria in the two alternative settings converge as the noise in the public signal vanishes.

Finally, an equilibrium features one of two state-contingent loss sequences:[15]

$$\begin{array}{lll} \text{for } z_1 < z^l & : & \left\{ l^d (z_1; \pi = 1), l^d (z_2; \pi = 1) \right\} \\ \text{for } z_1 > z^h & : & \left\{ l^p (z_1; \pi = 0), l^p (z_2; \pi = 0) \right\} \\ \text{for } z_1 \in \left[z^l, z^h \right] & : & \text{multiple equilibria, either sequence is possible} \end{array} \tag{15}$$

When period-1 fundamentals are in the multiplicity region, an attack on the peg is triggered by "sunspots". By construction, sunspots are ad hoc variables that cannot be rationalized in economic terms and, thus, do not enrich the theoretical analysis.

Fortunately, a special feature of the modelled economy allows for abstracting from sunspots. Since this economy aspires to join a currency union, it should be quite likely that its fundamentals are sufficiently strong to support a peg in the absence of an attack: i.e. the event $z_1 > z^l$ should occur with a high probability. In order to streamline the exposition, this observation will henceforth be taken to an extreme and the impact of changes in z^l will be ignored. In turn, given that z^h is effectively the sole critical value of the fundamentals, the qualitative conclusions of the analysis remain the same for any positive probability with which sunspots may trigger an attack (see Appendix B).

3.1 Conservatism and Welfare under Common Knowledge

In the presence of common knowledge, the benevolent dictator maximizes social welfare by designing the authority to be as conservative as possible:

$$\frac{dE_0 \left[l (s_1; w_0, z_1) + \beta l (s_2; w_1, z_2) \right]}{d\chi^A} < 0 \tag{16}$$

A rise in the authority's conservatism improves welfare for two reasons. First, by (11), (12) and (15), one of the two possible sequences of equilibrium losses, i.e. $\left\{ l^d (z_1; \pi = 1), l^d (z_2; \pi = 1) \right\}$, decreases in χ^A, whereas the alternative, $\left\{ l^p (z_1; \pi = 0), l^p (z_2; \pi = 0) \right\}$, is insensitive to χ^A. Second, the latter sequence of losses, which delivers higher welfare by property 3 (Section 2), is more likely to materialize when χ^A is higher. This is because, by depressing the critical value of the fundamentals, greater conservatism lowers the probability of an attack on the peg:

[15] The critical values z^h and z^l are analyzed in Appendix A. This appendix also derives that $\chi^{CA} \leq \beta\psi^2 / \left(1 - \beta\psi^2\right)$ leads to such a high net benefit from joining the currency union that there is an equilibrium in which the peg survives for any value of the period-1 fundamentals (i.e. there is no finite z^l solving (14)). In order to abstract from this trivial case, the discussion in the main text assumes that $\chi^{CA} > \beta\psi^2 / \left(1 - \beta\psi^2\right)$. This assumption guarantees that z^l, z^h and z^* (which is derived in Section 4) are all finite.

$$\frac{dz^h}{d\chi^A} < 0 \tag{17}$$

The result in (17) is rooted in three of the generic properties of the model reported in Section 2. An increase in the authority's conservatism lowers both the period-1 net benefit of succumbing to an attack on the peg (property 2) and the period-2 net benefit of joining the currency union (property 4). However, given that workers' belief in the success of a viable attack on the peg, π, stays constant over time (see the equilibrium condition (13)), property 5 implies that the former effect of the authority's conservatism dominates. In turn, this implies that a more conservative authority is more likely to withstand an attack, which then leads to (17).

The magnitude, albeit not the sign, of $dz^h/d\chi^A$ is affected by the interaction of χ^A with other parameters. For example, smaller intertemporal discounting, i.e. a higher β, raises the ex ante net benefit of joining the currency union in period 2. Thus, given that the country joins the currency union if and only if the peg survives in period 1, a higher β strengthens the negative impact of a rise in χ^A on devaluation probability. In turn, if $z_1 = z^h$ and the critical value of the fundamentals is lower than the unconditional mean, i.e. $z^h < \mu$, a larger persistence parameter ψ raises the likelihood of weak period-2 fundamentals, z_2. By (11) and (12), this raises the ex ante net benefit of joining the currency union and, similarly to a higher β, entails a stronger negative impact of a rise in χ^A on devaluation probability. The opposite result holds if $\mu < z^h$. Formally:[16]

$$\frac{d^2 z^h}{d\chi^A d\beta} < 0 \text{ and } \left(\mu - z^h\right) \frac{d^2 z^h}{d\chi^A d\mu} < 0 \tag{18}$$

3.2 Generalizing the Welfare Result

Inequalities (16) and (17) describe the conventional wisdom that a more conservative authority is less vulnerable to attacks and, thus, delivers higher welfare.[17] Importantly, a sufficient condition for this welfare result – i.e. property 5 (Section 2) being relevant in equilibrium – does *not* require perfect foresight on the part of workers. Rather, property 5 requires that the level of workers' belief in the success of an equilibrium attack on the currency, π, be independent of whether the attack is staged in period 1 or 2.

A parsimonious way to allow for an arbitrary level of such time invariant uncertainty is to incorporate an ad hoc random factor, which can impose a peg regardless of what

[16] Expressions (17) and (18) are derived formally in Appendix A.

[17] For completeness, it should be noted that $dz^l/d\chi^{CA} > 0$ (see Appendix A). Thus, in light of the analysis in Section 3.1, abstracting from changes in z^l reinforces the conventional wisdom that a more conservative authority improves welfare.

the authority's optimization problem prescribes:

Proposition 1 [18] *Augment the model of Section 3 with an exogenous factor, which is triggered in periods* 1 *and* 2 *with probability* $(1-\tilde{\pi})$ *and, when triggered, forces the authority to peg. The welfare results (16) and (17) hold for any* $\tilde{\pi} \in (0,1]$.

4 Private Signals

Even small private noise in workers' signals about the fundamentals leads to *time varying strategic uncertainty*, which surfaces in equilibrium as a time varying *aggregate* belief about an attack's success. This renders property 5 (Section 2) irrelevant in equilibrium, violating a key condition of Proposition 1. The result is a possible *reversal* of the welfare implications derived above: i.e. by *raising* devaluation probability in the presence of private signals, *greater* conservatism of the authority may *lower* welfare.

This section derives this result by assuming that each worker sets $w_{t-1,i}$ on the basis of a noisy *private* signal about z_t: i.e. $\sigma_\varepsilon^2 > 0$ in expression (8). In order to solve for the equilibrium in closed form and highlight differences with the common-knowledge setting, the analysis is conducted in the limit $\sigma_\varepsilon^2 \to 0$.[19]

4.1 Unique Equilibrium

In period 2, it is common knowledge that either (i) the authority has discretion over the exchange rate and, by property 1, minimizes its loss via a devaluation or (ii) the country is in a currency union and the authority is forced to peg. The common knowledge about the currency regime leads to the same equilibrium losses as under common knowledge about the fundamentals: (i) $l^{A,d}(z_2;\pi=1)$ or (ii) $l^{A,p}(z_2;\pi=0)$, respectively.[20] Thus, by the argument in Section 3, the economy still joins the currency union in period 2 if and only if $s_1 = 0$ and the authority still enjoys the following period-2 net benefit of maintaining the peg in period 1: $l^{A,d}(z_2;\pi=1) - l^{A,p}(z_2;\pi=0) > 0$.

In a period-1 equilibrium, there is a critical value of the fundamentals, z^*, with the following properties: (i) workers expect the authority to devalue if and only if $z_1 < z^*$ and set their wages accordingly; (ii) given workers' wages, the authority finds it optimal

[18] Appendix B contains a proof of this proposition.

[19] Considering the limit $\sigma_\varepsilon \to 0$ is necessary in order to derive analytically tractable equilibrium conditions when the devaluation rate is endogenous and, as a result, depends on the fundamentals. The same point is made in Morris and Gimaraes (2003 and 2006).

[20] This is a direct consequence of the result that the wage bill w_1 equals the devaluation rate s_2 even in the presence of private signals. In turn, this result stems from the wage-setting rule (4) and the assumption that the noise in workers' private signals is infinitesimal.

to devalue if and only if $z_1 < z^*$. Using (4) and (10) and denoting an individual wage and the aggregate wage bill under strategic uncertainty by $w^{SU}\left(x_0^i; z^*\right)$ and $w^{SU}\left(z_1, z^*\right) = \int w^{SU}\left(x_0; z^*\right)\phi\left(x_0; z_1, \sigma_\varepsilon\right) dx_0$, respectively, it then follows that:[21]

$$w^{SU}\left(x_0^i; z^*\right) = \frac{1}{1+\chi^A}\int^{z^*}\left(w^{SU}\left(z_1; z^*\right) - z_1\right)\phi\left(z_1; x_0^i, \sigma_\varepsilon\right) dz_1 + \mathsf{o}_i\left(\sigma_\varepsilon^{-1}\right) \tag{19}$$

where $\lim_{\sigma_\varepsilon \to 0} \mathsf{o}_i\left(\sigma_\varepsilon^{-1}\right) = 0$.[22]

This translates into the following expression for the aggregate wage bill:[23]

$$w^{SU}\left(z_1; z^*\right) = \frac{1}{1+\chi^A}\int^{z^*}\left(w^{SU}\left(\zeta; z^*\right) - \zeta\right)\phi\left(\zeta; z_1, \sqrt{2\sigma_\varepsilon^2}\right) d\zeta \tag{20}$$

which simplifies to:

$$w^{SU}\left(z_1; z^*\right) = -\frac{z_1\Phi\left(z^*; z_1, \sqrt{2\sigma_\varepsilon^2}\right)}{\chi^A + \left(1 - \Phi\left(z^*; z_1, \sqrt{2\sigma_\varepsilon^2}\right)\right)} + \mathsf{o}\left(\sigma_\varepsilon^{-1}\right) \tag{21}$$

where $\lim_{\sigma_\varepsilon \to 0} \mathsf{o}\left(\sigma_\varepsilon^{-1}\right) = 0$. Equation (21) reveals that workers' heterogeneous beliefs are, in effect, aggregated in the devaluation probability perceived by the "average" worker, whose private signal happens to equal the actual value of the fundamentals: i.e. $\pi = \Phi\left(z^*; z_1, \sqrt{2\sigma_\varepsilon^2}\right)$.

This aggregate belief reflects workers' strategic uncertainty, which is underpinned by the noise in their private signals. Since small deviations of the fundamentals from the critical value are associated with large differences in the realized devaluation rate, strategic uncertainty peaks when the fundamentals are in a neighborhood of this value. As a specific implication, when $z_1 = z^*$, $\pi = 1/2$ and aggregate wage bill is $w^{SU}\left(z^*; z^*\right) = -\frac{z^*\frac{1}{2}}{\chi^A + \left(1-\frac{1}{2}\right)}$.

Incorporated in the authority's intertemporal problem, this result leads to the analog of (13) under strategic uncertainty:

$$l^{A,p}\left(z^*; \pi = \frac{1}{2}\right) - l^{A,d}\left(z^*; \pi = \frac{1}{2}\right) = \beta E_1\left(\begin{array}{c} l^{A,d}\left(z_2; \pi = 1\right) \\ -l^{A,p}\left(z_2; \pi = 0\right) \end{array}\middle| z_1 = z^*\right) \tag{22}$$

Equilibrium condition (22) delivers a unique critical value z^*, which underpins the

[21] $\phi\left(\cdot, b, c\right)$ $\left(\Phi\left(\cdot, b, c\right)\right)$ stands for the PDF (CDF) of a normal variable with a mean b and variance c^2.

[22] Specifically, $\mathsf{o}_i\left(\sigma_\varepsilon^{-1}\right)$ incorporates knowledge of z_0 and the law of motion in (1). However, as $\sigma_\varepsilon \to 0$, the importance of this knowledge for forecasting z_1 vanishes.

[23] Equation (20) is derived in Appendix C, where ζ is introduced as an auxiliary variable of integration.

following state-contingent sequence of losses:

$$\begin{aligned} \text{for } z_1 &\leq z^* : \left\{ l^{A,d}(z_1; \pi = 1), l^{A,d}(z_2; \pi = 1) \right\} \\ \text{for } z_1 &> z^* : \left\{ l^{A,d}(z_1; \pi = 0), l^{A,d}(z_2; \pi = 0) \right\} \end{aligned}$$

and belongs to the interval associated with equilibrium multiplicity under common knowledge: $z^* \in (z^l, z^h)$.[24]

4.2 Conservatism and Welfare under Strategic Uncertainty

When there are private signals, changes in the authority's conservatism χ^A have two opposite effects on welfare. First, as explained below, the critical value of the fundamentals increases in the authority's conservatism: $dz^*/d\chi^A > 0$. When this effect is considered in isolation, a lower χ^A increases welfare by raising the likelihood that the economy will avoid a costly speculative attack in period 1 and will import credibility by joining the currency union in period 2. Second, (21) implies that if a speculative attack does occur, it is more intense – i.e. is manifested by a higher aggregate wage bill – when χ^A is lower. Ceteris paribus, this effect lowers welfare.

Proposition 2 states that the first (second) effect dominates when χ^A is low (high). Thus, if workers face strategic uncertainty and the dictator has to choose from among not very conservative authorities, it would appoint the least conservative authority possible. This is the opposite of what would be optimal under common knowledge.

Proposition 2 [25] *There exist* $\underline{\chi}^A$ *and* $\bar{\chi}^A$ *such that* $\bar{\chi}^A > \underline{\chi}^A > 0$ *and*

$$dE_0 \left[l(s_1; w_0, z_1) + \beta l(s_2; w_1, z_2) \right] / d\chi^A \begin{cases} > 0 & \text{for } \chi^A < \underline{\chi}^A \\ < 0 & \text{for } \chi^A > \bar{\chi}^A \end{cases}$$

The difference between Proposition 1, which is relevant under common knowledge, and Proposition 2, which arises under strategic uncertainty, is rooted in the fact that the impact of the authority's conservatism on the probability of devaluation differs across the two information structures. Namely, in contrast to the common-knowledge result in (17), a higher χ^A raises the probability of devaluation in the presence of private signals:

$$\frac{dz^*}{d\chi^A} > 0 \tag{23}$$

[24] The critical value z^* is analyzed formally in Appendix A.
[25] This proposition is proved in Appendix D.

This result follows directly from equation (22), which portrays the intertemporal trade-off faced by the authority when the period-1 fundamentals equal their critical value, i.e. when $z_1 = z^*$. In period 1, the fundamentals z_1 influence the authority's impact on the currency regime and, thus, private signals about z_1 create strategic uncertainty among workers about this regime. This uncertainty surfaces as a weak aggregate belief that an attack will succeed (i.e. $\pi = 1/2$). By contrast, there is no such uncertainty in period 2, when the authority cannot influence the currency regime (i.e. $\pi = 1$ ($= 0$) if an attack is (is not) viable). Since this decline of strategic uncertainty entails a rise in the intensity of attacks over time, a rise in χ^A plays a greater role in restraining period-2 than period-1 attacks. The flipside of this is that a higher χ^A decreases the period-2 net benefit of joining the currency union by more than it decreases the period-1 benefit of succumbing to an attack. As a result, a rise in χ^A lowers the authority's incentives to resist an attack on the peg in period 1, which, built into workers' expectations, gives rise to (23).

Just as under common knowledge, the magnitude, albeit not the sign, of $dz^*/d\chi^A$ depends on the interaction of χ^A with other parameters. For reasons that are analogous to those outlined at the end of Section 3.1, smaller intertemporal discounting, i.e. a higher β, strengthens the negative impact of a drop in χ^A on devaluation probability. Further greater persistence of the fundamentals, as captured by a larger ψ, has a similar impact if and only if $\mu > z^*$:[26]

$$\frac{d^2 z^*}{d\chi^A d\beta} > 0 \text{ and } (\mu - z^*)\,\frac{d^2 z^*}{d\chi^A d\mu} > 0 \tag{24}$$

5 Variations on the Model

Three variations on the model enhance the understanding of its implications. The first subsection below demonstrates that removing the intertemporal trade-offs from the authority's optimization problem may reverse the welfare implications obtained under strategic uncertainty. The second and third subsections show, respectively, that a rise in workers' strategic uncertainty in period 1 or a drop in their risk aversion increases the likelihood that a decline in the authority's conservatism improves welfare.

5.1 Ad hoc Cost of Devaluation

Models of currency crises often sharpen policy conclusions by biasing the authority's incentives against pegging. Such a bias – attained in the present paper via the parameter

[26] Expressions (23) and (24) are derived in Appendix A.

restrictions in (1) – makes it necessary to introduce a cost of devaluation (or revaluation) in order for the equilibrium to sustain a peg in at least some states of the economy. Traditional models of currency crises (see Obstfeld and Rogoff (1996)) assume an *ad hoc* cost of abandoning the peg. By contrast, in this paper, the cost of a devaluation in period 1 has been captured *endogenously* by the foregone net benefit of joining the currency union in period 2 (i.e., the right-hand sides of (13), (14) and (22)). This subsection demonstrates the key role of the endogenous cost of devaluation by deriving how the equilibrium changes when this cost is replaced by a constant.

Indeed, the equilibrium changes drastically under strategic uncertainty. If the cost of devaluing in period 1 is $C > 0$, condition (22) becomes:

$$l^{A,p}\left(z^*; \pi = \frac{1}{2}\right) - l^{A,d}\left(z^*; \pi = \frac{1}{2}\right) = C, \text{ which implies that}$$
$$z^* = -\left(1/2 + \chi^A\right)\sqrt{C/\left(1+\chi^A\right)} \text{ and, thus, } dz^*/d\chi^A < 0$$

Contrary to the case with an endogenous cost of devaluation, devaluation probability is now lower and, thus, welfare is unambiguously higher when the authority is more conservative. The reason for this reversal is rooted in the fact that the use of an exogenous cost C forces the model to abstract from the impact of time-varying strategic uncertainty on the authority's intertemporal trade-offs.

By contrast, since time varying strategic uncertainty does not enter the model under common knowledge, assuming an exogenous cost of devaluing in period 1 does not alter the welfare result in this information setting. Specifically, the critical value z^h becomes:

$$z^h = -\chi^A\sqrt{C/\left(1+\chi^A\right)} \text{ and, thus, } dz^h/d\chi^A < 0$$

Thus, greater conservatism still delivers higher welfare under common knowledge.[27]

5.2 Trade Union

This subsection modifies the model of Section 1 by assuming that a fraction, $(1-\alpha) \in [0,1]$, of the workers belong to a trade union. This trade union has perfect foresight one period in advance and sets unionized workers' wages so that they are (i) in line with the rule in (4); and (ii) at the highest level supported in equilibrium.[28] Under perfect

[27] Section 3.1 has explained why a change in χ^A that lowers the devaluation probability also raises welfare.

[28] Assuming that the trade union prefers to attack allows for abstracting from equilibrium multiplicity. Such an assumption is also an ad hoc mechanism for incorporating a finding of Corsetti et al (2004), who study currency crises when both small traders (the counterparts of workers in this paper) and a

common knowledge, such a trade union generates a critical value of the fundamentals that still equals z^h (see Section 3). When there are noisy private signals, however, the equilibrium changes since only non-unionized workers face strategic uncertainty.

Under strategic uncertainty, the critical value of period-1 fundamentals, z^{**}, is such that: (i) there is a devaluation if and only if $z_1 < z^{**}$; (ii) the unionized workers get fully compensated in the event of a devaluation; (iii) the non-unionized workers set their wages on the belief that there is a devaluation if and only if $z_1 < z^{**}$. Paralleling the derivation of (21), the period-1 wage bill of the non-unionized workers is found to equal:[29]

$$w^{SU}\left(z_1, z^{**}\right) = -\frac{\alpha z_1 \Phi\left(z^{**}; z_1, \sqrt{2\sigma_\varepsilon^2}\right)}{\chi^A + \alpha\left(1 - \Phi\left(z^{**}; z_1, \sqrt{2\sigma_\varepsilon^2}\right)\right)} \tag{25}$$

while the wage bill of unionized workers and the devaluation rate are given by:

$$w^{TU}\left(z_1, z^{**}\right) = (1-\alpha)\, s\left(z_1, z^{**}\right) = \begin{cases} -\frac{(1-\alpha) z_1}{\chi^A + \alpha\left(1 - \Phi\left(z^{**}; z_1, \sqrt{2\sigma_\varepsilon^2}\right)\right)} & \text{for} \quad z_1 \leq z^{**} \\ 0 & \qquad\quad z_1 > z^{**} \end{cases} \tag{26}$$

This leads to the following generalization of equilibrium condition (22):

$$\left(\begin{array}{c} l^{A,p}\left(z^{**}; \pi = 1 - \frac{\alpha}{2}\right) \\ -l^{A,d}\left(z^{**}; \pi = 1 - \frac{\alpha}{2}\right) \end{array}\right) = \beta E_1 \left(\begin{array}{c} l^{A,d}\left(z_2; \pi = 1\right) \\ -l^{A,p}\left(z_2; \pi = 0\right) \end{array} \middle| z_1 = z^{**}\right) \tag{27}$$

The right-hand side of this equation reflects the fact that the expected benefit of joining the currency union is not affected by the presence of a trade union. This is because there is no strategic uncertainty about the exchange-rate regime in period 2, which implies that the trade union's impact on the equilibrium wage bill vanishes as the precision of private signals increases (i.e. as $\sigma_\varepsilon \to 0$).

Since the trade union sets the highest possible wage rate, it is not surprising to find that the probability of a devaluation increases with the importance of the trade union in the economy. Formally, $dz^{**}/d\alpha < 0$ and, thus, $z^{**} > z^*$ because the latter value was obtained, in Section 4.1, for $\alpha = 1$.

Finally, a higher α – i.e. smaller importance of the trade union and greater strategic uncertainty – raises welfare and leads to a wider range of values of χ^A, for which a decline in this parameter raises welfare:[30]

large trader (the counterpart of the trade union) act on the basis of private signals. An implication of this setting is that the sheer presence of the large trader raises the likelihood of a speculative attack.

[29] In line with Section 4, the measure of non-unionized workers receiving the private signal x_{t-1} equals $\alpha\phi\left(x_{t-1}, z_t, \sigma_\varepsilon\right) dx_{t-1}$.

[30] Proposition 3, the inequality $dz^{**}/d\alpha < 0$ and the statements in (29) are proved in Appendix E.

Proposition 3 *The expected loss* $E_0\left[l\left(s_1;w_0,z_1\right)+\beta l\left(s_2;w_1,z_2\right)\right]$ *decreases as* α *increases. In addition, let*

$$dE_0\left[l\left(s_1;w_0,z_1\right)+\beta l\left(s_2;w_1,z_2\right)\right]/d\chi^A>0 \text{ if and only if } \chi^A\in\Upsilon\left(\alpha\right) \tag{28}$$

Then, $\alpha_1>\alpha_2$ *implies that* $\Upsilon\left(\alpha_1\right)\supset\Upsilon\left(\alpha_2\right)$.

This result is rooted in the fact that a rise in α strengthens the negative impact of a lower χ^A on devaluation probability:

$$\begin{aligned} dz^{**}/d\chi^A &> 0 \text{ if and only if } \chi^A<\chi^{**}\left(\alpha\right)=\frac{\alpha}{2\left(1-\alpha\right)} \\ d^2z^{**}/d\chi^A d\alpha &> 0 \text{ and } d\chi^{**}\left(\alpha\right)/d\alpha>0 \end{aligned} \tag{29}$$

5.3 Risk Aversion

This subsection considers a modification of the model of Section 4 that does not affect strategic uncertainty but lets workers have asymmetric preferences with respect to negative and positive deviations of their wage from the equilibrium exchange rate. In the light of Sections 1.1 and 1.2, this modification reflects, for example, the case in which underestimating the exchange rate – and working more than optimal at a low wage – hurts each worker more than overestimating the exchange rate by the same amount – and working less than optimal at a high wage. Of course, such asymmetric preferences affect the equilibrium *only* when workers face uncertainty, which, given the considered information structures, occurs only in the presence of noisy private signals.

When workers' private signals are noisy, risk aversion drives a wedge between the actual probability distribution of the fundamentals and the distribution used for setting wages. Modelling this wedge via a variance-preserving shift of the actual distribution, generalizes the wage setting rule (4) to:

$$w_{i,t-1}=E_t^{RN,i}\left(s_t\right)=\int s\left(z_t\right)\phi\left(z_t,x_i-\varphi\sqrt{\varepsilon},\sqrt{\varepsilon}\right)dz_t \tag{30}$$

where aversion to downside wage risk increases in φ. Equation (30) implies the following aggregate wage bill:

$$w^{SU}\left(z_1,z^{***}\right)=-\frac{z_1\Phi\left(z^{***};z_1-\varphi,\sqrt{2\sigma_\varepsilon^2}\right)}{\chi^A+\left(1-\Phi\left(z^{***};z_1-\varphi,\sqrt{2\sigma_\varepsilon^2}\right)\right)} \tag{31}$$

where z^{***} is the critical value of the fundamentals in the present setup. Thus, equilibrium condition (22) generalizes to:

$$\begin{pmatrix} l^{A,p}\left(z^{***};\pi=\Pr\left(\varphi\right)\right) \\ -l^{A,d}\left(z^{***};\pi=\Pr\left(\varphi\right)\right) \end{pmatrix} = \beta E_1 \left(\begin{array}{c} l^{A,d}\left(z_2;\pi=1\right) \\ -l^{A,p}\left(z_2;\pi=0\right) \end{array} \middle| z_1 = z^{***} \right) \tag{32}$$

where $\Pr\left(\varphi\right) \equiv \Phi\left(z^{***}; z^{***}-\varphi, \sqrt{2\sigma_{\varepsilon}^{2}}\right)$. Since greater aversion to downside wage risk leads to a stronger attack on the currency for any value of the fundamentals, it also leads to a greater devaluation probability: $dz^{***}/d\varphi > 0$ and $\left(z^{***}-z^{*}\right)\varphi \geq 0$.[31]

Similarly to greater strategic uncertainty in period 1, lower aversion to downside risk – i.e. a lower φ – raises welfare and leads to a wider range of values of χ^A, for which a decline in this parameter raises welfare:[32]

Proposition 4 *The expected loss* $E_0\left[l\left(s_1;w_0,z_1\right)+\beta l\left(s_2;w_1,z_2\right)\right]$ *decreases as* φ *decreases. In addition, let*

$$dE_0\left[l\left(s_1;w_0,z_1\right)+\beta l\left(s_2;w_1,z_2\right)\right]/d\chi^A > 0 \text{ if and only if } \chi^A \in \Upsilon\left(\varphi\right)$$

Then, $\varphi_1 < \varphi_2$ *implies that* $\Upsilon\left(\varphi_1\right) \supset \Upsilon\left(\varphi_2\right)$.

This result is rooted in the fact that a drop in φ strengthens the negative impact of a drop in χ^A on devaluation probability:

$$dz^{***}/d\chi^A > 0 \text{ for } \chi^A < \chi^{***}\left(\varphi\right) = \begin{cases} \frac{1-\Pr(\varphi)}{2\Pr(\varphi)-1} & \text{for } \varphi > 0 \\ \infty & \quad\;\; \varphi \leq 0 \end{cases} \tag{33}$$

$$d^2 z^{***}/d\chi^A d\varphi < 0 \text{ and } d\chi^{***}\left(\varphi\right)/d\varphi < 0 \text{ for } \varphi > 0$$

Conclusion

This paper has developed new policy insights on the basis of a global games model of speculative attacks. The model features a central authority, which administers an exchange-rate peg and faces a short-term benefit of a devaluation and a long-term benefit of perpetuating the peg. Time-varying strategic uncertainty among private market players is at the root of a seemingly surprising result that the probability of a speculative currency attack decreases and social welfare may increase if the authority

[31] As implied by (32), the expected period-2 benefit from joining the currency union is unaffected by the degree of risk tolerance. The reasons for this are the same as those brought up in the context of a trade union (see Section 5.2).

[32] Proposition 4, the inequality $dz^{***}/d\varphi > 0$ and the statements in (33) are proved via a direct application of the analysis in Appendix E.

is less inclined to stabilize the exchange rate once the peg has been abandoned. This result is stronger, the smaller is workers' aversion to downside wage risk.

Appendix A

This appendix analyzes the critical values z^l, z^h and z^* and derives the results reported in (17), (18), (23) and (24).

The equilibrium conditions (13), (14) and (22) can be rewritten in the following generic form, where $\hat{z}$ stands for either z^l, z^h or z^*:

$$\begin{gathered}\Theta\left(\hat{z};\chi^A\right)=c,\text{ where }\Theta\left(\hat{z};\chi^A\right)\equiv\left(f_{\hat{z}}\left(\chi^A\right)-\beta\psi^2\right)\hat{z}^2+b\hat{z} \\ b\equiv-2\beta\left(1-\psi\right)\psi\mu>0;\;\; c\equiv\beta\left(\sigma^2+\left(1-\psi\right)^2\mu^2\right)>0 \\ f_{z^h}\left(\chi^A\right)\equiv\left(1+\chi^A\right)/\chi^A;\;\; f_{z^l}\left(\chi^A\right)\equiv\chi^A/\left(1+\chi^A\right) \\ f_{z^*}\left(\chi^A\right)\equiv\chi^A\left(1+\chi^A\right)/\left(.5+\chi^A\right)^2\end{gathered} \tag{34}$$

Note first that, if $f_{\hat{z}}\left(\chi^A\right)<\beta\psi^2$, there is no finite negative equilibrium value of $\hat{z}$. This degenerate case is henceforth ruled out by assuming that $\chi^A>\beta\psi^2/\left(1-\beta\psi^2\right)$.

There are unique negative values of z^l, z^h and z^*. Tho see why, note that, as long as $\hat{z}<0$ and $f_{\hat{z}}\left(\chi^A\right)>\beta\psi^2$, $\Theta\left(\cdot;\chi^A\right)$ is convex and ranges from $+\infty$ to a minimum that is smaller than or equal to 0. Thus, since $c>0$, there is at least one solution of (34) in terms of $\hat{z}$. The solution is unique because the upward sloping portion of $\Theta\left(\cdot;\chi^A\right)$ ranges from $\left(b/2\right)^2/\left(\beta\psi^2-f_{\hat{z}}\left(\chi^A\right)\right)<0$ to 0 and is, thus entirely below c.

Since $\frac{d\Theta\left(z;\chi^A\right)}{dz}|_{z=\hat{z}}<0$ and $f_{z^h}\left(\chi^A\right)>f_{z^*}\left(\chi^A\right)>f_{z^l}\left(\chi^A\right)>0$, then $z^h>z^*>z^l$.

Likewise, $df_{z^h}\left(\chi^A\right)/d\chi^A<0$, $df_{z^*}\left(\chi^A\right)/d\chi^A>0$ and $df_{z^l}\left(\chi^A\right)/d\chi^A>0$ lead, respectively, to (17), (23) and $dz^l/d\chi^A>0$.

Expressions (18) and (24) are derived by first calculating $d\hat{z}/d\chi^A$ on the basis of (34) and then differentiating further with respect to β and ψ, keeping in mind that:

$$\begin{aligned}\frac{d\hat{z}}{d\beta} &= \frac{f\left(\chi^A\right)\hat{z}^3}{2\beta^2\left(\left(1-\psi\right)^2\mu^2+\psi\left(1-\psi\right)\mu\hat{z}+\sigma^2\right)}<0 \\ \left(\hat{z}-\mu\right)\frac{d\hat{z}}{d\psi} &= \frac{\left(\hat{z}-\mu\right)^2\left(\left(1-\psi\right)\mu+\psi\hat{z}\right)\hat{z}}{\left(\left(1-\psi\right)^2\mu^2+\psi\left(1-\psi\right)\mu\hat{z}+\sigma^2\right)}>0\end{aligned}$$

Appendix B

Proposition 1 *Augment the model of Section 3 with an exogenous factor, which is triggered in periods* 1 *and* 2 *with probability* $(1-\tilde{\pi})$ *and, when triggered, forces the authority to peg. The welfare results (16) and (17) hold for any* $\tilde{\pi} \in (0,1]$.

Proof. Given a $\tilde{\pi} \in (0,1]$ and a value of the fundamentals, a currency union is preferred to a managed float. This is because, by (11) and (12):

$$\left(\begin{array}{c} \tilde{\pi} l^{d}\left(z_t; \pi=\tilde{\pi}\right)+(1-\tilde{\pi}) l^{p}\left(z_t; \pi=\tilde{\pi}\right) \\ -l^{p}\left(z_t; \pi=0\right) \end{array} \right)=\frac{\tilde{\pi}}{\chi+1-\tilde{\pi}} z_t^2>0 \tag{35}$$

This implies that, in period 0, the benevolent dictator faces the following expected loss:

$$\begin{array}{c} E_0\left[l\left(s_1; w_0, z_1\right)+\beta l\left(s_2; w_1, z_2\right)\right]=(1+\beta) E\left[l^p\left(z_t; \pi=0\right)\right] \\ +\lambda \int^{\tilde{z}} \left(\begin{array}{c} \tilde{\pi} l^d\left(z_1; \pi=\tilde{\pi}\right)+(1-\tilde{\pi}) l^p\left(z_1; \pi=\tilde{\pi}\right) \\ -l^p\left(z_1; \pi=0\right) \end{array} \right) \phi\left(z_1, \mu, \sigma\right) d z_1 \\ +\lambda \beta \operatorname{Pr}_0\left(z_1<\tilde{z}\right) E_0\left[\begin{array}{c} \tilde{\pi} l^d\left(z_2; \pi=\tilde{\pi}\right)+(1-\tilde{\pi}) l^p\left(z_2; \pi=\tilde{\pi}\right) \\ -l^p\left(z_2; \pi=0\right) \end{array} \middle| z_1<\tilde{z} \right] \end{array} \tag{36}$$

where $\tilde{z}$ is the highest value of the fundamentals that is consistent with a peg under the generalization described in the proposition. In addition, $\lambda \in (0,1]$ equals the probability with which sunspots trigger an attack on the peg when $z_1 < \tilde{z}$.

Irrespective of the value of λ, (35) and (36) imply that the welfare result (16) holds for any $\tilde{\pi} \in (0,1]$ as long as so does (17), i.e. as long as $d\tilde{z}/d\chi^A < 0$. To prove the latter inequality, refer to the generalized version of (13):

$$\begin{aligned} \left(\begin{array}{c} l^{A,p}\left(\tilde{z}; \pi=\tilde{\pi}\right) \\ -l^{A,d}\left(\tilde{z}; \pi=\tilde{\pi}\right) \end{array} \right) &= \beta E_1 \left(\begin{array}{c} \tilde{\pi} l^{A,d}\left(z_2; \pi=\tilde{\pi}\right)+(1-\tilde{\pi}) l^{A,p}\left(z_2; \pi=\tilde{\pi}\right) \\ -l^{A,p}\left(z_2; \pi=0\right) \end{array} \middle| z_1=\tilde{z} \right) \\ \text{or } f_{\tilde{z}}\left(\chi^A\right) \tilde{z}^2 &= \beta\left(\left((1-\psi)\mu+\psi \tilde{z}\right)^2+\sigma^2\right) \\ \text{where } f_{\tilde{z}}\left(\chi^A\right) &\equiv \left(1+\chi^A\right) / \left(\pi\left(\chi^A+1-\pi\right)\right) \end{aligned}$$

Direct application of the analysis in Appendix A reveals that there is a unique $\tilde{z} < 0$ and $d\tilde{z}/d\chi^A < 0$ because $df_{\tilde{z}}\left(\chi^A\right)/d\chi^A < 0$. ■

Appendix C

To derive equation (20), note that aggregating the firm-specific wage in (19) across firms delivers the wage bill:

$$w^{SU}(z_1; z^*) = \frac{1}{1+\chi^A} \int \left[\int^{z^*} \left(w^{SU}(\zeta; z^*) - \zeta \right) \phi(\zeta; x_0, \sigma_\varepsilon) \, d\zeta \right] \phi(x_0; z_1, \sigma_\varepsilon) \, dx_0$$

Rewriting this expression on the basis of

$$\phi(\zeta; x_0, \sigma_\varepsilon) \phi(x_0; z_1, \sigma_\varepsilon) = \phi\left(x_0; \frac{\zeta + z_1}{2}, \sigma_\varepsilon / \sqrt{2} \right) \phi\left(\zeta; z_1, \sqrt{2\sigma_\varepsilon^2} \right)$$

and integrating out x_0 results in equation (20).

Appendix D

Proposition 2 *There exist* $\underline{\chi}^A$ *and* $\bar{\chi}^A$ *such that* $\bar{\chi}^A > \underline{\chi}^A > 0$ *and*

$$dE_0 \left[l(s_1; w_0, z_1) + \beta l(s_2; w_1, z_2) \right] / d\chi^A \begin{cases} > 0 & \text{for } \chi^A < \underline{\chi}^A \\ < 0 & \text{for } \chi^A > \bar{\chi}^A \end{cases}$$

Proof. There are six steps, which draw on (10), (11) and (12):

1. Given that $\sigma_\varepsilon \to 0$, the ex ante expected loss is

$$\begin{aligned} E_0 \left[l(s_1; w_0, z_1) + \beta l(s_2; w_1, z_2) \right] &= (1+\beta) E_0 \left[l^p(z_t; \pi = 0) \right] \\ + \int^{z^*(\chi^A)} &\left(l^d(z_1; \pi = 1) - l^p(z_1; \pi = 0) \right) \phi(z_1, \mu, \sigma) \, dz_1 \\ +\beta \Pr{}_0 \left(z_1 < z^*\left(\chi^A\right) \right) E_0 &\left[l^d(z_2; \pi = 1) - l^p(z_2; \pi = 0) \,|\, z_1 < z^*\left(\chi^A\right) \right] \end{aligned} \tag{37}$$

2. $dE_0 \left[l^p(z_t; \pi = 0) \right] / d\chi^A = 0$.

3. The second line of (37) equals $\frac{\chi}{(\chi^A)^2} \int^{z^*} z_1^2 \phi(z_1, \mu, \sigma) \, dz_1 \equiv \Omega\left(\chi^A\right)$. This implies $\Omega'\left(\chi^A\right) = \chi \left(\frac{z^*}{\chi^A} \right)^2 \phi(z^*, \mu, \sigma) \frac{dz^*}{d\chi^A} - \frac{2\chi}{(\chi^A)^3} \int^{z^*} z_1^2 \phi(z_1, \mu, \sigma) \, dz_1$. Characterizing the sign of $\Omega'\left(\chi^A\right)$ involves the following sub-steps:

   (a) By (34), $dz^*/d\chi^A > 1/\left(4\left(\chi^A\left(1+\chi^A\right) \right)^{3/2} \right)$. Thus, there exists $\chi_{11}^A > 0$ such that $dz^*/d\chi^A > 2/\chi^A$ for all $\chi^A < \chi_{11}^A$.

(b) Since $dz^*/d\chi^A > 0$, l'Hôpital's rule implies that there exists $\chi_{12}^A > 0$ such that $(z^*)^2 \phi(z^*, \mu, \sigma) > \int^{z^*} z_1^2 \phi(z_1, \mu, \sigma)\, dz_1$ for all $\chi^A < \chi_{12}^A$.

(c) Setting $\chi_1^A = \min\left\{\chi_{11}^A, \chi_{12}^A\right\}$ implies that $\Omega'\left(\chi^A\right) > 0$ for all $\chi^A < \chi_1^A$.

4. The third line of (37) equals $\frac{\beta\chi}{(\chi^A)^2}\int^{z^*}\left[\left((1-\psi)\mu + \psi z_1\right)^2 + \sigma^2\right]\phi(z_1, \mu, \sigma)\, dz_1 \equiv \Psi\left(\chi^A\right)$. Paralleling the analysis of $\Omega'\left(\chi^A\right)$ in step 3 reveals that there exists $\chi_2^A > 0$ such that $\Psi'\left(\chi^A\right) > 0$ for all $\chi^A < \chi_2^A$.

5. Set $\underline{\chi}^A = \min\left\{\chi_1^A, \chi_2^A\right\}$.

6. A symmetric argument derives $\bar{\chi}^A$.

■

Appendix E

Proposition 3 *The expected loss $E_0\left[l(s_1; w_0, z_1) + \beta l(s_2; w_1, z_2)\right]$ decreases as α increases (recall Section 5.2). In addition, let*

$$dE_0\left[l(s_1; w_0, z_1) + \beta l(s_2; w_1, z_2)\right]/d\chi^A > 0 \text{ if and only if } \chi^A \in \Upsilon(\alpha) \tag{38}$$

Then, $\alpha_1 > \alpha_2$ implies that $\Upsilon(\alpha_1) \supset \Upsilon(\alpha_2)$.

Proof. First, it is necessary to prove the statements in (29). Note that the equilibrium condition (27) is a variant of (34) with
$f_{\hat{z}}\left(\chi^A\right) \equiv f_{z^{**}}\left(\chi^A\right) = \chi^A\left(1+\chi^A\right)/\left(\chi^A + \alpha/2\right)^2$. By the argument in Appendix A, $dz^{**}\left(\chi^A, \alpha\right)/d\alpha < 0$, because $df_{z^{**}}\left(\chi^A\right)/d\alpha < 0$, and $dz^{**}/d\chi^A > 0$ for $\chi^A < \chi^{**}(\alpha) \equiv \alpha/2(1-\alpha)$. As a by-product, $d\chi^{**}(\alpha)/d\alpha > 0$. In addition, total differentiation of (27) leads to $d^2 z^{**}/d\chi^A d\alpha > 0$.

Second, in the presence of a trade union, i.e. for $\alpha \in [0, 1)$, the expected loss (37) generalizes to:

$$\begin{aligned} E_0\left[l(s_1; w_0, z_1) + \beta l(s_2; w_1, z_2)\right] &= (1+\beta) E_0\left[l^p(z_t; \pi = 0)\right] \\ &+ \int^{z^{**}(\chi^A, \alpha)}\left(l^d(z_1; \pi = 1) - l^p(z_1; \pi = 0)\right)\phi(z_1, \mu, \sigma)\, dz_1 \\ +\beta \Pr_0\left(z_1 < z^{**}\left(\chi^A, \alpha\right)\right) & E_0\left[l^d(z_2; \pi = 1) - l^p(z_2; \pi = 0)\,|z_1 < z^{**}\left(\chi^A, \alpha\right)\right] \end{aligned} \tag{39}$$

where α does not affect the losses $l^d(z_t; \pi = 1)$ and $l^p(z_t; \pi = 0)$, but affects the states in which either loss materializes, $z_1 < z^{**}(\chi^A, \alpha)$. Thus, a higher α raises welfare because $dz^{**}(\chi^A, \alpha)/d\alpha < 0$.

Fix α_1 and α_2, where $1 > \alpha_1 > \alpha_2 > 0$, and suppose that $\chi^A \in \Upsilon(\alpha_2)$. By Proposition 2, $\Upsilon(\alpha_2)$ is not empty. Since the net loss $l^d(z_t; \pi = 1) - l^p(z_t; \pi = 0) > 0$ does not depend on α, $d^2 z^{**}/d\chi^A d\alpha > 0$ implies that $\chi^A \in \Upsilon(\alpha_1)$ as well. Thus, $\Upsilon(\alpha_1) \supseteq \Upsilon(\alpha_2)$. Since net losses, $l^d(z_t; \pi = 1) - l^p(z_t; \pi = 0)$, and z^{**} are continuous and, for $\chi^{CA} \in \Upsilon(\alpha_1)$, monotonic in χ^A, $d^2 z^{**}/d\chi^A d\alpha > 0$ implies that there is a value of χ^A that belongs to $\Upsilon(\alpha_1)$ but not to $\Upsilon(\alpha_2)$. Thus, $\Upsilon(\alpha_1) \supset \Upsilon(\alpha_2)$. ■

References

Angeletos, George-Marios, Christian Hellwig and Alessandro Pavan (2006). *Dynamic Global Games of Regime Change: Learning, Multiplicity and Timing of Attacks*, working paper.

Barro, Robert and David Gordon, 1983, *A Positive Theory of Monetary Policy in a Natural-Rate Model*, Journal of Political Economy, XCI, 589-610.

Carlsson, H. and E. van-Damme, 1993, *Global Games and Equilibrium Selection*, Econometrica 61, 989-1018

Corsetti, Giancarlo, Amil Dasgupta, Stephen Morris and Hyun Song Shin, 2004, *Does One Soros Make a Difference? A Theory of Currency Crises with Large and Small Traders*, Review of Economic Studies, 71(1), 87-113.

Dasgupta, Amil (2007). "Coordination and Delay in Global Games." *Journal of Economic Theory*, 134, 195-225.

Eichengreen, Barry, 2000, *The EMS Crisis in Retrospect*, CEPR Working Paper 2704

Goldstein, Itay (2005). "Strategic Complementarities and the Twin Crises." *The Economic Journal*, 115, 368-390.

Goldstein, Itay and Ady Pauzner (2005). "Demand Deposit Contracts and the Probability of Bank Runs", *Journal of Finance*, vol. 60(3), 1293-1328.

Hellwig, Christian, Arijit Mukherji and Aleh Tsyvinski (2006). "Self-Fulfilling Currency Crises: The Role of Interest Rates." *American Economic Review*, 96(5).

Jeanne, Olivier and Lars E O Svensson (2007). "Credible Commitment to Optimal Escape from a Liquidity Trap: The Role of the Balance Sheet of an Independent Central Bank." *American Economic Review*, 97(1).

Krugman, Paul, 1996, *Are Currency Crisis Self-Fulfilling?*, NBER Macroeconomics

Annual, 345-378.

Kydland, Finn and Edward Prescott, 1977, *Rules Rather that Discretion: The Inconsistency of Optimal Plans*, Journal of Political Economy, LXXXV, 473-92.

Morris, Stephen and Bernardo Gimaraes (2007). *Risk and Wealth in a Model of Self-Fulfilling Currency Attacks*, Journal of Monetary Economics, 54.

Morris, Stephen and Bernardo Gimaraes (2003). *Risk and Wealth in a Model of Self-Fulfilling Currency Attacks*, Cowles Foundation Discussion Paper 1433.

Morris, Stephen and Hyun Song Shin (2003). "Global Games: Theory and Applications." In *Advances in Economics and Econometrics, the Eighth World Congress*, edited by Mathias Dewatripont, Lars Hansen and Stephen Turnovsky. Cambridge University Press.

Morris, Stephen and Hyun Song Shin, 1999, *A Theory of the Onset of Currency Attacks,* in The Asian Crisis: Causes, Contagion and Consequences; Agenor, Miller, Vines and Weber eds., Cambridge: Cambridge University Press, 230-264.

Morris, Stephen and Hyun Song Shin, 1998, *Unique Equilibrium in a Model of Self-Fulfilling Currency Attacks,* American economic Review, June 1998, vol. 88, No. 3, 587-597.

Obstfeld, Maurice, 1994, *The logic of currency crises*, Cahiers économiques et monétaires 43, 189-213.

Obstfeld, Morris and Kenneth Rogoff, 1996, *Foundations of International Macroeconomics*, MIT Press.

Obstfeld, Maurice and Kenneth Rogoff, July 1995, *The Mirage of Fixed Exchange Rates*, NBER Working Paper #5191.

Rochet, Jean Charles and Xavier Vives (2004). "Coordination Failures and the Lender of Last Resort: Was Bagehot Right After All?" *Journal of the European Economic Association*, 2, 1116-1147.

Rogoff, Kenneth, 1985, *The Optimal Degree of Commitment to an Intermediate Monetary Target*, Quarterly Journal of Economics, 100, 1169-1189.

Vives, Xavier (2005). "Complementarities and Games: New Developments." *Journal of Economic Literature*, XLIII, 437-479.

Tarashev, Nikola (2007). "Speculative Attacks and the Information Role of the Interest Rate", *Journal of the European Economic Association*, 5(1).