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Breaking the spell with credit-easing: Self-confirming credit crises in competitive search economies[☆]

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ABSTRACT

In *self-confirming* crises lenders charge high interest rates wrongly believing that lower rates would generate losses. In a directed-search economy, misperceptions can persist because there is no equilibrium evidence that can confute it, preventing constrained-efficiency. A policy maker with the same beliefs as lenders will find it optimal to offer a contingent subsidy to induce lower market rates. As lenders price assets in response to this policy, new information may disprove misperceptions and restore efficiency. New micro-evidence suggests that the 2009 TALF intervention in the market of newly generated ABS was an example of the optimal policy in our model.

> The only way to argue that the subsidy is small is to claim that there is very little chance that assets purchased under the scheme will lose as much as 15 percent of their purchase price. *Given what's happened over the past 2 years, is that a reasonable assertion?* (Paul Krugman, The New York Times, on 23 March 2009; our emphasis.)

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1. Introduction

When the whole ABS market collapsed at the end of 2007, the Fed decided to step in by launching a hitherto untried policy: the Term Asset-Backed Securities Lending Facility (TALF). Under this policy the Federal Reserve Bank provided buyers of newly generated ABS with a subsidy contingent on ex-post realized losses, with the backing of the US Treasury. At that time, the move exposed the Fed to tough criticism. It was not easy to explain why the Fed should take risks that the private sector did not want to take. Even more difficult was defending the provision of a subsidy to the unpopular crowd of financial intermediaries. Krugman's quote is representative of the mood at that time.

Nevertheless, the introduction of TALF in the ABS market coincided with a rapid recovery of transactions. Even more surprisingly, the recovery occurred without any subsidy actually being dispensed![1] In retrospect, this can be seen as a proof that the counterpart risk *perceived* by investors in that market was indeed excessive. But what lessons should we draw from this experience? Was it "good luck" or "good policy"?

In this paper we develop a theory of credit crises and optimal policies that encompasses policy experiences like the TALF, without being specific to them. We model the credit market as a competitive search economy where lenders offer fixed interest rate loans to borrowers, who apply for loans to finance their – possibly risky – projects. The basic mechanism is simple: a borrower can implement a riskless project at a fixed cost, or a risky project without cost. Only with sufficiently low interest rates would borrowers pay the fixed cost and implement the safe project; however, their action is not observable. Lenders then may overestimate counterpart risk, believing that fixed costs are higher than they actually are, and only offer high interest rate loans. Given that only high interest rates are offered, only risky projects are implemented, and default rates are high.

Thus, credit crises can emerge in the form of a high-interest-high-risk equilibrium in which observables do not reveal whether or not defaults are high because interest rates are *too* high. In such a case, lenders, just as any external observer, may have correct beliefs about equilibrium outcomes, but be wrong about the never-observed counterfactual in which low interest rates induce borrowers to adopt safe projects. Of course, lenders could individually set lower interest rates, however, given their (mis)beliefs, they do not have incentives to do that. In such cases, lenders self-confirm the crises in which tight credit conditions induce high risk, and high risk induces tight credit conditions. This sustained lenders' miss-perception characterizes the non rational-expectations *self-confirming* equilibrium.

Directed search economies, as the one we model, would normally achieve the constrained-efficient allocation. This is *locally* true in our economy, in the sense that lenders will incur losses if they deviate from the equilibrium with a small variation of their offered interest rates, i.e. the Hosios condition holds locally. However, the equilibrium is not constrained-efficient since a larger reduction of interest rates could result in borrowers unlocking a higher social surplus by choosing safe projects.

In this context we study the problem of an authority supposing it holds the same (mis)beliefs as lenders and evaluates overall welfare. We show that in the absence of any fiscal power the authority's preferred interest rate on the market is the *laissez-faire* interest rate, that is, even if the authority could affect the market rate it would not do that. On the contrary, if the authority can implement zero-sum transfers, it would optimally subsidize lender's potential losses by taxing borrowers inducing a large reduction of the market interest rate as lenders compete for loans. More precisely, the subsidy acts as an implicit tax in the form of lower matching rates to those lenders who still offer high interest rates. As a by-product, the policy unveals the adoption policy of borrowers at low rates. Thus, with the policy in place (mis)beliefs can no longer be equilibrium beliefs, efficiency is then restored so that no subsidy is actually needed.

TALF resembles the optimal policy in our model once we interpret lenders as ABS investors and borrowers as ABS issuers. In line with our theory, the success of TALF could be explained by its ability to generate information about non-observed counterfactuals. In particular, the introduction of TALF, by mechanically lowering market rates, created incentives to issue less - rather than more - risky ABS, unveiling unexpected market profitability at low rates.

To test our hypothesis, we have collected micro data relative to issuance and realized payment losses on the second largest ABS market - that of Auto loan ABS from 2007 to 2012. Auto loan has many advantages in terms of publicity of transaction data, which other ABS sectors lack.

The data on ABS generated from the beginning of 2007 until the day before the introduction of TALF (two years, exactly the time horizon in Krugman's quote) show that on average – across issuers and time – higher risk premia factored-in interest rates were leading smaller losses on asset payoffs. Thus, according to market information in the absence of TALF, it was rational for investors to ask higher rates. This can explain the surge of rates in ABS markets before TALF, and the fears that the effect of an artificial reduction of rates through a subsidy could have resulted in enormous losses for the Fed.

However, two years of data generated after the introduction of the TALF exhibit an inverse relation: on average lower risk premia were leading smaller losses. This finding contradicts what could have been predicted by simply extrapolating from the available pre-TALF information. It is consistent with TALF producing new public information regarding the state of the ABS market, and once investors got evidence of this effect, subsidies were not needed any longer.

[1] On 30 September 2010, the Fed announced that more than 60% of the TALF loans had been repaid in full, with interest, ahead of their legal maturity dates. The Fed finally announced that "as of May 2011, there has not been a single credit loss. Also, as of May 2011, TALF loans have earned billions in interest income for the US taxpayer". Source: http://www.newyorkfed.org/education/talf101.html

Relation to the literature

This paper belongs to a broad research agenda on financial crises and related policy interventions. The sources of a credit crisis identified by the literature are several, including: i) tighter constraints, as in Gertler and Karadi (2011) and Correia et al. (2014); ii) deterioration of collateral value, as in Gorton and Ordoñez (2014), Gorton and Ordoñez (2016b); iii) coordination failures, as in models of self-fulfilling credit crises (Bebchuk and Goldstein (2011)) or debt crises (Cole and Kehoe (2000) and Ayres et al. (2018)), and iv) pervasive 'adverse selection,' as in Chari et al. (2014) and Tirole (2012), or 'moral hazard', as in Farhi and Tirole (2012). By contrast, in our model there are no general equilibrium externalities that can create multiple equilibria, and no contractual problems – of moral hazard or adverse selection. However, buyers may (mis)believe that they are correctly pricing assets[2]

The optimal policy can correct this friction by producing new information. In this respect, our work also relates to an interesting literature that focuses on the production of public information for trading and related policies, as for example Kim et al. (2012), Bond and Goldstein (2015), Chamley and Gale (1994) and Caplin and Leahy (1998). Gorton and Ordoñez (2016a) is related to our work, in that public interventions induce agents to weight less public information (e.g. observed interest and default rates), which would have otherwise prolonged the crises. A first difference is that our story pertains to primary – rather than secondary – markets, as the policy works though a change of the underlying riskiness of the asset at origination, and does not affect the liquidity value of legacy assets; moreover we emphasize the role of the public policy in providing more information – not less – to the agents. We share this insight with Caplin et al. (2015). It is worth underlining however that producing new information is a by-product of our policy. The policy maker in fact implements the policy to correct an estimated inefficient return for the lenders, that prevents the market from sustaining the constrained efficient allocation, not to learn.

The growing literature on directed search – pioneered by Peters (1984), developed by Moen (1997), Eeckhout and Kircher (2010), Menzio and Shi (2010) and Guerrieri et al. (2010) among others, and reviewed by Wright et al. (2017) – emphasizes the constrained efficiency of directed search, provided that the menu of contracts is large enough.[3] To the best of our knowledge, this is the first paper showing the possibility of the particular inefficiency described above, as well as a policy instrument that, by implementing the 'Hosios condition', recovers constrained efficiency. Nevertheless, in directed search models the set of contracts may not be large enough as to avoid constrained inefficiency even in REE models; in this case, a version of our policy instrument would implement constrained efficiency by actually providing subsidies in equilibrium. In sum, the optimal policy we describe can change the equilibrium matching probabilities, and, therefore, its range of application is wider than the Self-Confirming Equilibrium (SCE) model discussed here.

The possibility of SCE in models with atomistic agents is also an original contribution of this paper. Self-Confirming Equilibria were introduced into Game Theory by Fudenberg and Levine (1993), and have two distinct properties[4] First, agents are subjectively rational and have correct beliefs about equilibrium outcomes but may have misspecified beliefs about never-realized states of the economy. Second, individual actions can potentially produce the observables that correct these misperceptions but, given beliefs, there are no incentives to deviate[5] In Macroeconomics, Sargent (2001), Sargent et al. (2006) and Primiceri (2006) have used the concept of SCE by modelling the learning problem of a major actor (the Fed) who has the power to affect aggregate observables and hence to trap itself in an SCE. In this paper, by contrast, we characterize a SCE in a directed search and matching competitive environment, where individual (atomistic) agents cannot affect equilibrium outcomes, but can affect the individual actions of borrowers who apply to their loans. In this context, the power that a public actor has of affecting market outcomes (matching probabilities) helps the market to exit a privately-sustained inefficient SCE.

Finally, our paper relates to a more empirical literature on TALF, whose discussion is postponed to Section 4.

2. Self-Confirming crises in competitive markets

This section introduces Self-Confirming equilibria in a simple competitive search model of the credit market. We make simple assumptions to emphasize the key elements of our model and briefly discuss their generalisation at the end of this section. In the Online Appendix B, we provide a tight interpretation of the model in terms of the market for *newly generated* ABS.

[2] Indeed, in our model there is no asymmetric information about equilibrium outcomes, but only about out-of-equilibrium behaviour.

[3] Some of these papers emphasize the possibility that submarkets can be belief dependent even if beliefs are not observed. This happens in our model as well: actual matching probabilities reflect correct beliefs of borrowers. However, in our equilibrium definition, lenders' beliefs may be possibly misspecified, which then requires that matching probabilities are not directly observable.

[4] Weaker forms of Self-Confirming Equilibria were discussed in Hahn (1977) and labeled as Conjectuaral Equilibria. Also, Battigalli (1987) provides a specific case of Self-Confirming Equilibrium.

[5] It should be noted that in the macro literature the term SCE sometimes only accounts for the first property (i.e. the definition of SCE) but not for the second – inherent to games and macro models where the government is a large player; see Sargent et al. (2009) for an example and Battigalli et al. (2021) for a SCE framework encompassing game theory and this class of macro models.

2.1. A simple search model of the credit market

Borrowers, lenders and credit contracts

There is a continuum of borrowers and lenders. A borrower needs one unit of liquidity to implement a project that matures in one period. Projects can be of two types, safe (s) and risky (r). A risky project yields $1+y$ where $y>0$ with probability α and 1 otherwise. A safe project yields $1+y$ without risk but requires an implementation cost k.

Let us denote by $\omega \equiv \{\alpha, k\}$ the two coefficients characterizing the set of projects available to borrowers. A credit contract is one in which the lender lends one unit of liquidity to the borrower in exchange for $1+R$ to be paid when the project matures. Borrowers' liability is limited.

The timing is as follows: the period begins with lenders making credit offers (i.e. R contracts) and borrowers applying for loans being offered; once the match is realised, ω is revealed only to the borrower, who chooses which project to implement; finally at the end of the period risky projects succeed (safe projects always do) or fail, and each borrower pays his lender back: $1+R$ if the project succeeds and 1 if it fails.

Formally, a project adoption is an action denoted by $\rho \in \{s, r\}$. The optimal adoption policy is given by

$$\rho^*(R,\omega) \equiv \arg\max_{\rho\in\{s,r\}}\{\pi^b(\rho;R,\omega)\}, \tag{1}$$

with

$$\pi^b(r;R,\omega) \equiv (y-R)\alpha, \tag{2}$$

$$\pi^b(s;R,\omega) \equiv y-R-k. \tag{3}$$

where $\pi^b(\rho;R,\omega)$ is the expected net return associated with the implementation of a project type ρ, given an interest rate R and a set of available projects characterized by $\omega \equiv \{\alpha, k\}$. The expected net return for a lender of a contract at an interest rate R, $\pi^l(R;\rho,\delta)$, is

$$\pi^l(R;r,\delta) \equiv \alpha R-\delta, \tag{4}$$

$$\pi^l(R;s,\delta) \equiv R-\delta, \tag{5}$$

depending on the type of project implemented by the borrower, where δ is the per-unit opportunity cost of liquidity[6]. Hence, the lender also bears the cost of risk, although does not observe the choice of technology.

The surplus generated by a contract, $\mathcal{S}(R,\rho) \equiv \pi^l(R;\rho)+\pi^b(\rho;R,\omega)$, is independent of R. In particular, a safe project yields higher surplus – i.e. $\mathcal{S}(R,s) > \mathcal{S}(R,r)$ – if and only if $k<(1-\alpha)y$, that is, the fixed cost is sufficiently small.

However the incentives for the borrower to adopt a particular project depends on R, which determines the splitting of the surplus between the two agents. Specifically, a borrower with ω will choose to implement a safe project if and only if the offered interest rate is sufficiently low, i.e. $R \le \bar{R}(\omega) \equiv y-k/(1-\alpha)$. On the other hand, for the lender to participate, the interest cannot be too low, it must satisfy $R \ge \delta$. Therefore, for a safe project to be financed it must be that $\delta \le R \le \bar{R}(\omega)$.

Our payoff structure is such that, when the risky project generates higher surplus, the safe project will never be adopted by the borrower as the lender will never offer $\bar{R}(\omega)<0$. On the contrary, when the safe project generates higher surplus, the borrower finds viable to adopt the risky project if the offered rate is sufficiently high, i.e. $R>\bar{R}(\omega)$.

Objective and subjective probability distributions

Borrowers and lenders can differ in their beliefs about project characteristics. Formally, we can think of the set of the available project as a random variable $\tilde{\omega}$ which is distributed on $\Omega \equiv \{(0,1),\mathbb{R}^+\}$ according to an *objective* density function $\phi(\tilde{\omega})$[7] In the specification above we implicitly assume that $\phi(\tilde{\omega})$ is a point mass on a particular realization ω. In spite of this assumption, which is made for ease of exposition, we refer to ϕ, as a general density function in our definitions.

We can then denote by $\beta(\tilde{\omega})$ the *subjective* density function of a lender, describing her beliefs about the probability that a borrower has access to a set of choices characterized by $\omega \in \Omega$. In particular, for a given R and δ, $E^\beta\left[\pi^l(R;\rho^*(R,\tilde{\omega}),\delta)\right]$ denotes the lender's expected profit evaluated with her β beliefs[8] Note that we allow for subjective density function $\beta(\tilde{\omega})$ to possibly - but not necessarily - differ from the objective density function, $\phi(\tilde{\omega})$. The definition of equilibrium will then impose restrictions on how subjective and objective density functions can differ.

According to our timing, at the beginning of the period, lenders, given their beliefs β, offer contracts; borrowers, given their beliefs ϕ, observe a contract offer R and decide whether to apply or not, once the match is established they observe the actual ω and make their technology adoption.

[6] Since δ remains remains fixed throughout our discussion we simplify notation by denoting $\pi^l(R;\cdot,\delta)$ as $\pi^l(R;\cdot)$.

[7] We use a tilde to denote a random variable, $\tilde{x}$, in contrast to one of its particular realizations, x.

[8] Formally, $E^\beta[(\cdot)] \equiv \int_\Omega(\cdot)\beta(\tilde{\omega})d\tilde{\omega}$ is a subjective expectation operator.

Finally, for the sake of saving in notation, we assume that the following consistency condition is satisfied: $E^{\beta}[E^{\phi}[(\cdot)]] = E^{\beta}[(\cdot)]$; that is, the subjective expectation of the objective mean is the subjective unconditional mean. Implicit in our notation is the assumption that lenders share the same subjective beliefs β. Both the consistency condition and the uniformity of beliefs assumption are made without loss of generality and, at some notational cost, can be relaxed. In particular, subjective densities can be heterogeneous: we discuss the relevance of this issue at the end of this section.

Matching in the credit market

We model the credit market as a *directed search competitive market* as introduced by Moen (1997) along the simplified variant described by Shi (2006). Although the frictional nature of the credit market is not essential to our mechanism, we introduce it to allow for continuous and differentiable pay-off functions in the context of price competition. Perfect price competition, which obtains as a limit case of competitive directed search, is not suited for out-of-equilibrium analysis as it generates everything-or-nothing pay-offs for marginal deviations from the equilibrium price.

We normalize the mass of borrowers to one, whereas we allow free entry on the side of lenders. Each borrower can send an application for funds replying to an offer of credit posted by a lender. The search is *directed*, meaning that at a certain interest rate R there is a subset of applications $a(R)$ and offers $o(R)$ looking for a match at that specific R. The per-period flow of new lender-borrower matches in a (sub)market R is determined by a standard Cobb-Douglas matching function

$$x(a(R), o(R)) = Aa(R)^{\gamma} o(R)^{1-\gamma} \tag{6}$$

with $\gamma \in (0, 1)$.[9] The probability that an application for a loan at interest rate R is accepted is $p(R) \equiv x(a(R), o(R))/a(R)$ and the probability that a loan offered at R is finally contracted is $q(R) \equiv x(a(R), o(R))/o(R)$. As it is standard in the literature on directed search, we assume that all submarkets, in and out of equilibrium, are *active* so that matching probabilities, in and out of equilibrium, are well defined.

Borrowers send applications once lenders have posted their offers. A borrower sends an application to one posted contract R among the set of posted contracts H to maximize

$$J(R) \equiv p(R)E^{\phi}[\pi^{b}(\rho^{*}(R, \tilde{\omega}))]. \tag{7}$$

Competition among borrowers implies that $J(R)$ is equalized across the posted contracts, i.e. more profitable contracts are associated with lower probabilities of matching.

Lenders are first movers in the search: they choose whether or not to pay an entry cost c and, once in the market, at which interest rate R they post a contract. A posted R is a solution to the lender's problem:

$$\max_{R}[E^{\beta}[q(R)\pi^{l}(R; \rho^{*}(R, \tilde{\omega}))] - c], \tag{8}$$

subject to

$$E^{\beta}[p(R)\pi^{b}(\rho^{*}(R, \tilde{\omega}))] = \bar{J}, \tag{9}$$

and

$$q(R) = A^{\frac{1}{1-\gamma}} p(R)^{-\frac{\gamma}{1-\gamma}}, \tag{10}$$

where $\bar{J}$ is an arbitrary constant, which is determined in equilibrium. Note that (10) follows from (6). Lenders cannot individually affect the distribution of offers and applications – in particular $\bar{J}$, the expected utility granted to borrowers – but they understand the tradeoff between these two distributions given by (10) in each submarket. In fact, constraints (9) and (10) make sure that the individual lender takes the probability of matching in a submarket as given. However, they may misperceive the choices that borrowers make in every submarket. For this reason their subjective expectation operator includes the matching probabilities. Note that the competitive behavior of borrowers implies that (9) holds[10], which together with (10) and given $\bar{J}$, defines $q(R)$ at *any* R. On the side of the lenders, free entry guarantees competition, so that the mass of lenders posting a contract in the submarket R, namely $o(R)$, increases (resp. decreases) whenever $\mathrm{V}(R) > 0$ (resp. $\mathrm{V}(R) < 0$), where

$$\mathrm{V}(R) \equiv E^{\beta}[q(R)\pi^{l}(R; \rho^{*}(R))] - c, \tag{11}$$

is the value of posting a vacancy. Competition among lenders implies $\max_R V(R) = 0$, i.e. at the equilibrium lenders earn zero profits. Individual deviations from the equilibrium rate generates smooth losses as offers posted at marginally higher (resp. lower) rates will decrease (increase) volumes only marginally[11].

Finally note that, in order to solve (8), a lender needs to anticipate the reaction of the borrower $\rho^{*}(R, \tilde{\omega})$ to an offer R, to determine both the probability $q(R)$ that an offer R is accepted and the default risk associated with it. Hence, a lender bears two different risks: that a posted contract is not filled and that she wrongly evaluates a borrower's reaction to a credit offer.

[9] This assumption, which is standard in the literature, ensures a constant elasticity of matches to the fraction of vacancies and applicants, for each submarket R. In particular, the ratio $\theta(R) = a(R)/o(R)$ denotes the tightness of the submarket R. The tightness is a ratio representing the number of borrowers looking for a credit line *per-unit of vacancies.* Notice that the tightness is independent of the absolute number of vacancies open in a certain market.

[10] Note that in (9) we use the consistency condition: $E^{\beta}[E^{\phi}[(\cdot)]] = E^{\beta}[(\cdot)]$.

[11] On the contrary, under perfect price competition ($\gamma \to 1$), $V(R)$ would be discontinuous as volumes will be infinitely elastic to price offers.

2.2. Equilibria

Definition of an SSCE and an REE

Let us introduce now the definition of Strong Self-Confirming Equilibrium (SSCE) and relate it to the notion of Self-Confirming Equilibrium (SCE) and the one of Rational Expectation Equilibrium (REE).

Definition 1 (SSCE)**.** Given an objective density function $\phi(\tilde{\omega})$, a Strong Self-Confirming equilibrium (SSCE) is a set of posted contracts $\mathbb{R}^{ssce}$, a $\bar{J}$, and beliefs $\beta(\tilde{\omega})$ such that:

sc1) for each $R^* \in \mathbb{R}^{ssce}$, the maximizing value for the borrower $J(R^*) = \bar{J}$;
sc2) each $R^* \in \mathbb{R}^{ssce}$ solves the lender's problem (8)-(10), and free entry holds so that $V(R^*) = 0$;
sc3) for each $R^* \in \mathbb{R}^{ssce}$, there is an open neighborhood $\Im(R^*)$, such that $\forall R \in \Im(R^*)$:

$$E^{\beta}[q(R)\pi^{l}(R; \rho^*(R))] = E^{\phi}[q(R)\pi^{l}(R; \rho^*(R))]; \tag{12}$$

that is, lenders correctly anticipate borrowers' reactions locally around the realized equilibrium contracts.

The third condition (sc3) restricts lenders' beliefs $\beta(\tilde{\omega})$, regarding borrowers' actions to being correct in the in a neighbourhood of an equilibrium R^*.[12] Ours is a stronger restriction on beliefs than the one usually assumed within the notion of Self-Confirming Equilibrium (SCE), which does not contemplate any belief restriction out-of-equilibrium. In fact, in an SCE, condition (sc3) holds punctually for any R^* rather than for any $R \in \Im(R^*)$ – in particular, $\mathbb{R}^{ssce} \subset \mathbb{R}^{sce}$. While our definition of SSCE is new, it should be noted that (sc3) is the natural restriction when modelling self-confirming equilibria with actions being continuous variables: it shouldn't be the case that such equilibria are fragile to small first-order variations. This feature makes our notion of equilibrium trembling-hand robust and learnable; moreover, as we will see, it makes misbeliefs sustain a unique equilibrium outcome.

The existence of a neighborhood is only a necessary requirement, our notion of equilibrium does not put bounds on the range of R for which lenders' beliefs are correct: a neighborhood around the equilibrium must exist but the range can be a large interval. This feature allows to accommodate non-degenerate beliefs or pay-off heterogeneity that we rule out here for convenience of exposition. We will discuss this issue at the end of this section.

A REE is a stronger notion than a SSCE, requiring that no agent holds wrong out-of-equilibrium beliefs. In the present model this is equivalent to imposing that lenders' beliefs about borrowers' payoffs are correct. In such a case the equilibrium contract is the one that objectively yields the highest reward with respect to every possible feasible contract.

Definition 2 (REE)**.** A rational expectation equilibrium (REE) is a Self-Confirming equilibrium such that, at any $R \in \Re$, (12) holds – that is, $R^* \in \mathbb{R}^{ree}$ if, and only if, lenders correctly anticipate borrowers' reactions to any possible contract.

Note that $\mathbb{R}^{ree} \subset \mathbb{R}^{ssce}$ since REE obtains from a tightening of condition (sc3) in the definition of an SSCE.

Equilibrium Characterization

We now provide a simple characterization of an equilibrium. Substituting (10) into constraint (9) and the latter into the objective (8) we can obtain equilibrium interest rates as a solution to:

$$R^* = \arg\max \left(A^{\frac{1}{1-\gamma}} \bar{J}^{-\frac{\gamma}{1-\gamma}} E^{\beta}[\pi^b(\rho^*(R,\omega))]^{\frac{\gamma}{1-\gamma}} E^{\beta}[\pi^l(R; \rho^*(R,\omega))] - c] \right).$$

If we define

$$\mu^{\beta}(R) \equiv E^{\beta}[\pi^b(\rho^*(R,\omega))]^{\frac{\gamma}{1-\gamma}} E^{\beta}[\pi^l(R; \rho^*(R))], \tag{13}$$

then, given two contracts posted respectively at R_1 and R_2, from the point of view of a single atomistic lender: $V(R_1) \geq V(R_2) \Leftrightarrow \mu^{\beta}(R_1) \geq \mu^{\beta}(R_2)$, for any profile of contracts offered by other lenders.

Note that the evaluation of R does not depend on $\bar{J}$, i.e. it does not depend on the level of utility granted to the other side of the market, which a single lender cannot affect. However, lenders partly internalize the welfare of borrowers, since contracts that provide better conditions for borrowers are more likely to be signed.[13] The objective function (13) provides a convenient characterization of equilibria:

Lemma 3. *For a given $\phi(\tilde{\omega})$ and $\beta(\tilde{\omega})$, a contract $R^* \in \mathbb{R}^{ssce}$ if there is an open neighborhood $\Im(R^*)$ of R^* such that $R^* \in \arg\max_{R \in \Im(R^*)} \mu^{\phi}(R)$ and $R^* \in \arg\max_{R \in \Re} \mu^{\beta}(R)$. Furthermore, $R^* \in \mathbb{R}^{ree}$ if $R^* \in \mathbb{R}^{ssce}$ and $R^* \in \arg\max_{R \in \Re} \mu^{\phi}(R)$.*

[12] In a dynamic interpretation of our model, where the above description of the economy corresponds to one, infinitely repeated, period, and $\{\tilde{\omega}_t\}$ is an i.i.d. process. The above definition naturally extends to that of a *stationary strongly self-confirming equilibrium*. The long-run frequency of subjective and objective distributions result in 'observationally equivalent' actions, consistently with Battigalli et al. (2021).

[13] In particular, with $\gamma = 0$, when all the surplus is extracted by lenders, $\mu(R) \equiv E^{\beta}[\pi^l(R; \rho^*(R))]$; that is, at the equilibrium only the interim payoff of lenders is maximized, as borrowers will always earn zero. With $\gamma = 1$ on the other hand, when the whole surplus is extracted by borrowers, $\mu(R) \equiv E^{\beta}[\pi^b(\rho^*(R,\omega))$; that is, only the interim payoff of borrowers is maximized as lenders will always earn nothing.

When R^* is *locally nonbinding* (i.e. $R^* > \delta$), then we can apply first-order conditions to obtain – possibly, local – maximands of $\mu^\beta(R)$, by solving:

$$\mu^\beta(R)\left(\frac{\gamma}{1-\gamma}\frac{1}{E^\beta[\pi^b(\rho^*(R,\omega))]}-\frac{1}{E^\beta[\pi^l(R;\rho^*(R,\omega))]}\right)=0. \quad (14)$$

Note that (14) is the famous Hosios condition (Hosios (1990)) – that is, R^* is such that the surplus is efficiently split: $\gamma E^\beta[\pi^l(R^*;\rho^*(R^*,\omega))]=(1-\gamma)E^\beta[\pi^b(\rho^*(R^*,\omega))]$. However, the distinction between SCCE and REE is important here since it means that in an SCCE the *local* Hosios condition is not a *global* efficiency property of the equilibrium.

Equilibria

We use (14) to compute optimal interior contracts conditional on the adopted project being safe or risky:

$$\hat{R}_s(\omega)=(1-\gamma)(y-k)+\gamma\delta, \quad (15)$$

$$\hat{R}_r(\omega)=(1-\gamma)y+\gamma\delta\alpha^{-1}, \quad (16)$$

respectively. As we have seen, a safe project which is adopted must satisfy $\delta\le\hat{R}_s(\omega)\le\bar{R}(\omega)$, which constraints (16); therefore, let $R_s^*(\omega)\equiv\min\{\bar{R}(\omega),\hat{R}_s(\omega)\}$. Similarly, a risky project which is adopted must satisfy $\bar{R}(\omega)\le\hat{R}_r(\omega)\le y$, which constraints (15); so, let $R_r^*(\omega)=\min\{y,\hat{R}_r(\omega)\}$. In turn, since $\bar{R}(\omega)\equiv y-k/(1-\alpha)$, for a given k, the bounds on $\hat{R}_s(\omega)$ determine bounds on α: a lower bound $\underline{\alpha}(k)$, satisfying $\hat{R}_s(\underline{\alpha}(k),k)=\bar{R}(\underline{\alpha}(k),k)$, and an upper bound $\bar{\alpha}(k)$, given by $\bar{R}(\bar{\alpha}(k),k)=\delta$.[14] We can now fully characterize the sets of equilibria:

Proposition 4. *There exists a threshold $\hat{\alpha}(k)\in(\underline{\alpha}(k),\overline{\alpha}(k))$, decreasing in k, and subjective beliefs $\beta(\tilde{\omega})$ such that:*

(i) *if $\alpha<\hat{\alpha}(k)$ then $\mathbb{R}^{ree}=\{R_s^*(\omega)\}$ and $\mathbb{R}^{ssce}=\{R_s^*(\omega),R_r^*(\omega)\}$*
(ii) *if $\alpha>\hat{\alpha}(k)$ then $\mathbb{R}^{ree}=\mathbb{R}^{ssce}=\{R_r^*(\omega)\}$, and*
(iii) *only for $\alpha=\hat{\alpha}(k)$ $\mathbb{R}^{ree}=\mathbb{R}^{ssce}=\{R_s^*(\omega),R_r^*(\omega)\}$*
(iv) *if $R^*\in\mathbb{R}^{ssce}$ but $R^*\notin\mathbb{R}^{ree}$, then $R^*=\{R_r^*(\omega)\}$.*

Proof. See Appendix A. □

The proposition states that the set of REE is *generically unique* in Ω, while the set of SSCE is not; in particular, there exist two SSCE equilibria one of which is not REE. As (*iv*) states, the latter is characterized by excessive credit tightening and risk taking. Hence, in this model, misbeliefs can produce credit crises.

The conditions for the existence and uniqueness of risky SSCE that are not REE are intuitive. Evaluated with the objective distribution, the safe equilibrium must be, globally, a strictly dominant contract. In contrast, lenders with subjective beliefs must think that the adoption costs k (which they cannot infer from equilibrium outcomes) are too high; in other words, lenders must believe themselves to be in a global maximum of their value function while they are in a local one.[15] On the other hand, safe SSCE that are not REE do not exist. The only candidates could be along the contract frontier $\bar{R}$, but they are not since, by condition (12), SSCE requires lenders to have correct beliefs about borrowers' reaction in at least a neighborhood of $\bar{R}$.

2.3. Self-Confirming crises

We are ready now to use our simple model to describe how an economy can slide from the REE into a risky SSCE that is not a REE. We can think about a Self-Confirming crisis as determined by an exogenous increase in risk from $a=0.9$ to $b=0.55$, as is illustrated in Fig. 1. When the risk is low – i.e. $\alpha>\hat{\alpha}(k)$ – then the unique REE is the risky equilibrium $R_r^*(\omega)$ where borrowers only adopt risky projects. In this equilibrium, lenders also observe low default rates $1-a$.

When risk increases up to a sufficiently high level – i.e. $\alpha<\hat{\alpha}(k)$ – the REE requires that lenders switch to a low interest rate regime $R_s^*(\omega)$. However, in the logic of Self-Confirming equilibria, lenders do not observe any information about k and so they could well be pessimistic about the level of $\overline{R}(\omega)$, believing that there is no profitable $R<\overline{R}(\omega)$ that they can offer. As a consequence, lenders offer a high interest rate R_r^*. By doing that, no information about the reaction of borrowers to low interest rate is produced at this equilibrium and so misbeliefs cannot be confuted. Thus, instead of cutting interest rates to induce safe behavior, lenders may increase their interest rates self-confirming high default rates, which in turn justify high interest rates.

Fig. 2 illustrates the lender's maximization problem that lies behind the situation plotted in the previous figure. On the x-axis we measure R, i.e. the individual choice of a lender. On the y-axis we measure the expected pay-off of the individual

[14] Simple algebra shows that $\underline{\alpha}(k)=\frac{\gamma(y-k-\delta)}{\gamma(y-k-\delta)+k}$ and $\bar{\alpha}(k)=\frac{y-\delta-k}{y-\delta}$.

[15] As we discuss at the end of this section, the restrictions on subjective beliefs needed to sustain a Self-Confirming crisis are compatible with belief heterogeneity.

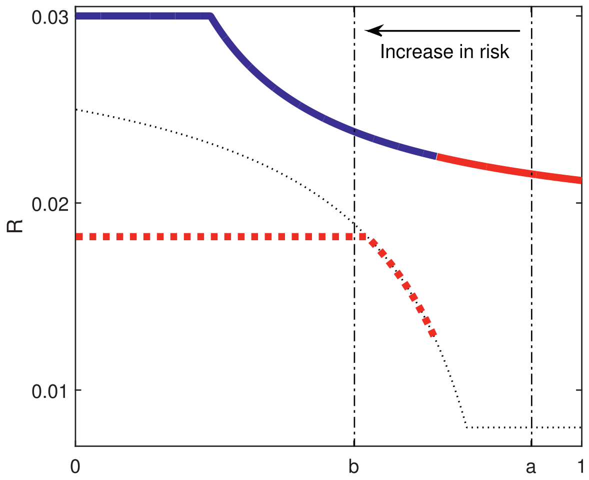

Fig. 1. **(i) Equilibria in the** (α, R) **space**, given $k = 0.005$. The thick solid line denotes R^*_r whereas the thick dotted denotes R^*_s. Red curves indicate $\mathbb{R}^{ree}$ and blue curves $\mathbb{R}^{ssce}$ not $\mathbb{R}^{ree}$. The thin dotted curve plots $\bar{R}$. Other parameters are: $y = 0.03, \delta = 0.008, \gamma = 0.4, c = 0.001, A = 0.1$. **(ii) Weaker fundamentals** (α going from a to b) **create room for a Self-Confirming crisis.**. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

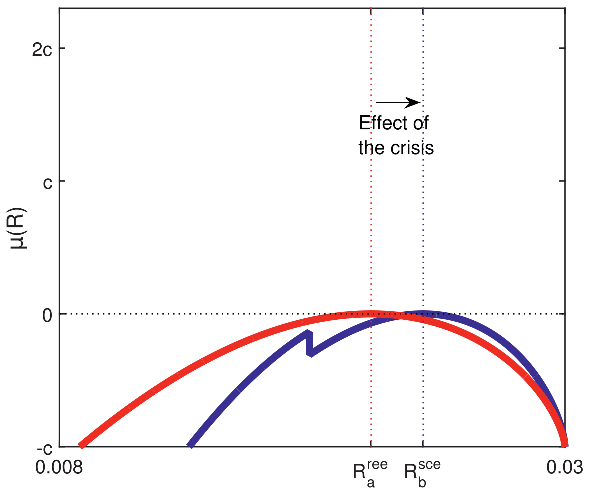

Fig. 2. **In a Self-Confirming crisis, an increase in risk implies higher interest rates.** The figure plots the lender-expected payoffs in the $(\mu^\beta(R), R)$ space whenever everybody else posts equilibrium contracts, in two situations: with $\alpha = a$ (red curve) and with $\alpha = b$ (blue curve). The optimal contract moves from R^{ree}_a to R^{sce}_b. Other parameters are: $y = 0.03, \gamma = 0.4, c = 0.001, A = 0.1$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

lender $\mu^\beta(R)$ *when all the other lenders post at the equilibrium* R. Thus the figure illustrates the individual (dis)incentive to deviate at a given equilibrium.

When risk is at a low level ($R = a$) the maximization problem of the lender is represented by the convex solid red curve. The maximal value for a level of risk a obtains at R^{ree}_a, which yields zero, as implied by the zero profit condition.

An exogenous increase in risk from a to b shapes the value function as the solid blue curve. The new curve, supported by subjective beliefs, peaks at $R^{ssce}_b > R^{ree}_a$, accounting for higher risk premia factored into interest rates.

A subjectively perceived lottery

In Fig. 2, along the blue curve, one can observe a non-smooth break. This results from the lender's *subjective* uncertainty about the borrower's reaction to lower interest rates. In this particular example, designed for the sake of clarity, we consider the case of a lender putting a low probability $p = .07$ on k being low, i.e. $k_L = 0.005$, and probability $(1 - p)$ on k being high, i.e. $k_H = 0.015$.

The example is such that a profitable low interest rate R_s exists only for low k, and lenders put too little probability on k being low. However, in an equilibrium where only a high interest rate R_r is offered, there is no evidence on the level of k and so misperception can persist.

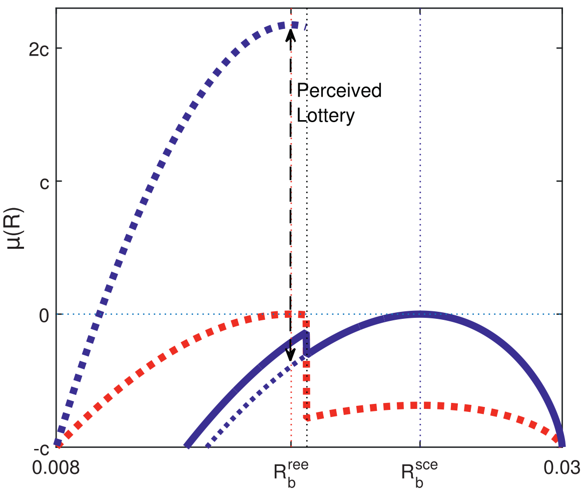

Fig. 3. At a Strong Self-Confirming Equilibrium, a lender perceives a out-of-equilibrium lottery with negative expected value. The figure plots individual expected values of contracts in the $(\mu^{\beta}(R), R)$ space whenever everybody else posts equilibrium contracts in the case where $\alpha = b$ – in thick blue $\mathbb{R}^{ssce}$ not $\mathbb{R}^{ree}$ and in dotted red $\mathbb{R}^{ree}$. The dotted blue curves correspond to borrowers' individual payoffs with $k = 0.005$ (higher curve) and $k = 0.015$ (lower curve) which are believed with probability 0.07 and 0.93 respectively. Other parameters are: $y = 0.03, \gamma = 0.4, c = 0.001, A = 0.1$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

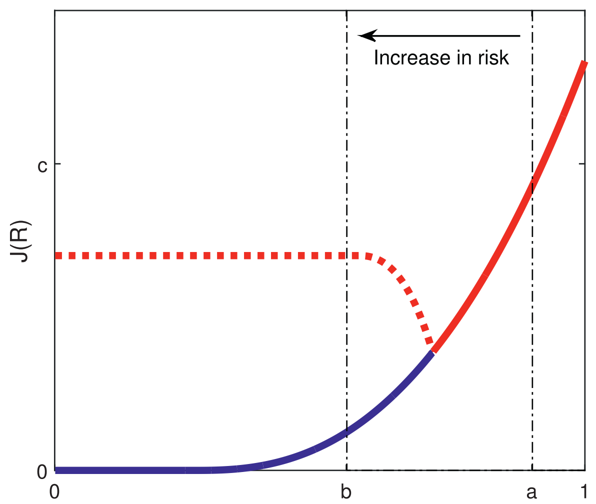

Fig. 4. Social welfare in a self-confirming crisis. Social welfare, i.e. $J(R^{*})$, is represented in the $(J(R), \alpha)$ space. The thick solid line denotes $J(R_r^{*})$ whereas the thick dotted line denotes $J(R_s^{*})$. Red curves indicate $\mathbb{R}^{ree}$ whereas the blue curve indicates $\mathbb{R}^{ssce}$ not $\mathbb{R}^{ree}$. Other parameters are: $y = 0.03, \delta = 0.008, k = 0.005, \gamma = 0.4, c = 0.001, A = 0.1$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Fig. 3 illustrates the possible perceived lottery of the lender. The lower and higher dotted blue lines denote the lender's payoff in the case where k is high and low, respectively. Although a lender may understand that R_b^{ree} entails the strictly dominant action in case of a low k, this state is believed too unlikely to induce an individual deviation. A misbelief of this type is a necessary condition for R_b^{ssce} to be an equilibrium.

Social welfare

Fig. 4 plots social welfare, measured in terms of cost-per-vacancy c, as a function of α. Colours are used to distinguish the REE from the other SSCE, as in Figure 1. Note that since lenders run at zero expected profits, the social welfare coincides with the expected profits of borrowers $J(R)$

Social welfare is increasing in α (and so decreasing in R_r) when the economy is on a risky equilibrium, whereas it is insensitive to risk at a REE where borrowers adopt safe projects (i.e. in the interior of the 'safe adoption set' in Fig. 1). Social welfare is instead decreasing in α when $\alpha \geq \underline{\alpha}(k)$ and the safe technology is being implemented – i.e. the safe equilibrium arises as a corner solution: $R_s^{*}(\omega) = \overline{R}(\omega)$. This occurs because for values of α higher than $\underline{\alpha}$ borrowers implements safe technology only for rates lower than the one ensuring the Hosios condition; this departure, which increases with risk, decreases welfare generated by the adoption of safe projects, up to the point in which adopting risky projects becomes socially optimal. The effect of a Self-Confirming crisis triggered by an increase in fundamental risk is a dramatic fall in social welfare along the blue line. The drop would have been much lower at the unique REE.

2.4. Robusteness: some remarks on our modeling choices

We have made some simplifying assumptions to streamline our presentation. We comment on their generality here.

First, the model with two technologies and one-price contract is extremely simple, but the results do not rely on this simplicity. One can allow for continuous project types or introduce more complicated contract spaces dealing with adverse selection and moral hazard (absent in our model), without necessarily preventing self-confirming crises. Our main result strictly requires two features that are condensed in our equilibrium characterization: i) the individual payoff function $V(R)$, which accounts for the actual best response of the borrower, has a local maximum that is not global, ii) at that local maximum there is no market evidence that can confute the local nature of that maximum. We have assumed the minimal set of assumptions to satisfy these conditions, but clearly one can still do the same adopting more sophisticated settings.

Similarly, for the sake of simplicity, we have assumed homogeneity of beliefs. Again, our results do not rely on this assumption. To see this, consider Fig. 3, where all agents play R_b^{sce} and all expect R_b^{ree} to yield the same negative pay-off. In fact, what is strictly needed for a self-confirming crises to exist is that all agents offer interest rates above the rate threshold $\bar{R}(\omega)$, and consistently, that none is entertaining beliefs that offers below $\bar{R}(\omega)$ are worth being played – not that beliefs are literally the same. In addition, as shown by Battigalli et al. (2015), risk aversion or ambiguity can substantially expand the set of beliefs that sustain a self-confirming crisis.

Furthermore, one may wonder if pay-off heterogeneity could undo the results. Analogously to beliefs heterogeneity, there is a large range in which differences in pay-offs is harmless. Out of that range, heterogeneity can have a bite, but one has to carefully consider all the implications of it. If, on the one hand, heterogeneity may generate richer market information, on the other, it may slow down learning. When considering large heterogeneity, it is hard to maintain that agents can perfectly disentangle all the forces behind market outcomes and control for them in their inference. Because of uncertainty on heterogeneous primitives, learning about market outcomes can take considerable time before producing useful information and make suboptimal equilibria even more persistent.

Finally, could a lender have incentives to potentially experiment, risking losses? First of all, note that experimentation must be large to provide information; for example, in the context of Fig. 3, lenders should experiment with rates below $\bar{R}(\omega)$. Since large deviations can be costly, potential gains must be large for an agent to have an incentive to experiment. However, competition is likely to reduce such incentives. In our model lenders earn zero profits in *any* equilibrium, no matter whether it is a REE or a SSCE (this is true also at the unique REE, as plotted in Fig. 3 with a dotted red curve). Therefore, at the SCE, the ex-ante value of individual experimentation is determined by the perceived cost of a one-shot *large* deviation from equilibrium. As in a model of R&D, lenders could not prevent others from observing the outcome of their deviation and eventually capture their potential gains. One can extend the one-shot gain by relaxing perfect competition, for example, by having other lenders learning with some lags or considering segmented markets. However, as already said, such gains should be large enough to overcome the perceived costs of large experimentations. In addition, heterogeneity in learning or in varieties would increase the cost of experimentation by dilating learning times.

3. Credit easing as an optimal policy

In this section we study optimal policy and its implementation as a *Ramsey* plan. We assume that policy makers' beliefs must be the same as those of lenders, meaning also that they have to comply with the restriction (12) at the resulting equilibrium. We first show that, absent any policy instrument, the socially most preferred equilibrium is the same as that induced by the market. Next, we look at the case where the policy maker can operate contingent transfers from borrowers to lenders. By implementing contingent transfers, the policy maker can induce a superior allocation as a market outcome. In particular, the policy ensures a globally optimal splitting of the surplus so that it restores the ability of the economy to sustain a constrained efficient allocation. We show that this last case is incompatible with the existence of an SSCE that is not an REE. In Appendix B.2 we establish the mapping between our optimal policy and TALF.

3.1. *Welfare in* laissez-faire *economies*

We first analyze the preferences of a benevolent social planner in a *laissez-faire* economy, i.e. one in which the planner has no other instrument than R to affect the terms of trade. The socially most preferred R, namely[16] $R^{\star}$, is the one that maximizes social welfare – i.e. the expected payoff of borrowers – subject to the directed search competitive restrictions, in particular taking lenders' zero profit condition, and the market tightness, as constraints; formally,

$$\max_R E^{\beta}[\underbrace{p(R)\pi^b(\rho^*(R))}_{\equiv J(R)}], \tag{17}$$

[16] From here onward, we will use $\star$ to denote a policy outcome, as opposed to $*$ denoting a market outcome.

subject to

$$c = E^{\beta}[q(R)\pi^{l}(R;\rho^{*}(R))]$$

and

$$p(R) = A^{\frac{1}{\gamma}} q(R)^{-\frac{1-\gamma}{\gamma}};$$

Note that in (17) the subjective beliefs are those of the planner.[17] Having the same beliefs implies that the planner knows the β beliefs of the lenders. Our results generalize to the case in which the planner has different subjective beliefs from private agents (even more pessimistic), provided she can properly assess their zero profit condition.

As before, by substituting constraints into the objective we can derive a welfare criterion to evaluate contracts:

$$\bar{\mu}^{\beta}(R) \equiv E^{\beta}[\pi^{l}(R;\rho^{*}(R,\omega))]^{\frac{1-\gamma}{\gamma}} E^{\beta}[\pi^{b}(\rho^{*}(R))], \tag{18}$$

so that $R^{\star} \in \arg\max \bar{\mu}^{\beta}(R)$. That is, given two *laissez-faire* economies trading at interest rates R_1 and R_2, respectively, from the planner's perspective: $E^{\beta}[J(R_1)] \geq E^{\beta}[J(R_2)] \Leftrightarrow \bar{\mu}(R_1) \geq \bar{\mu}(R_2)$. Comparing (18) and (13) we can easily see that $\bar{\mu}^{\beta}(R) = \left(\mu^{\beta}(R)\right)^{\frac{1-\gamma}{\gamma}}$; therefore, the two criteria are maximized at the same equilibrium contract, i.e. $R^{*} = R^{\star}$. We obtain the following result, which is a weaker version of the well known result on the efficiency of the directed search competitive equilibrium:

Lemma 5. *In a laissez-faire economy where lenders and the planner have the same subjective beliefs, the competitive allocation is a solution to the planner's problem.*

In an economy in which the social planner has no instrument to alter the terms of trade, the *laissez-faire* equilibrium maximizes the surplus under subjective beliefs of the lenders. Lemma 5 mimics the standard result on the constrained efficiency of directed search equilibria; however this is a weaker result in our context. In fact, in our model, a market equilibrium is a *locally constrained efficient* but may fail to be a *globally constrained efficient*, as consistency of beliefs (of policy maker and lenders) is not guaranteed out of equilibrium.

3.2. Welfare with optimal fiscal transfers

We now introduce the possibility that the social planner can use transfers between borrowers and lenders. The transfer is announced before lenders post their offers and borrowers apply for them. We consider a structure of transfers that have two desirable features:

i) the transfer that an agent - a lender or a borrower - *expects* in a match is independent of individual actions, i.e. of posted interest rates and project adoptions;
ii) the transfer scheme is revenue neutral, i.e. subsidies must be entirely financed by taxes on market transactions.

The availability of a fiscal instrument introduces the possibility of insuring lenders against their perceived counterpart risk, inducing lower interest rates in the market. In turn, lower interest rates incentivize borrowers to implement safe projects, maximizing social surplus.

The planner's problem can be decomposed into sub-problems. We distinguish between the design of the optimal policy and its implementation. The design of the optimal policy (**P**) consists of two steps. First, we compute the optimal transfer $d^{\star}(R)$ contingent to a given market rate R; second, knowing the optimal reaction to any market rate, we use the welfare criterion to define an optimal target $R^{\star}$, i.e. the socially most preferred market rate given that the optimal policy is in place.

The market implementation of the optimal policy (**R**) requires us to establish the mapping between a fixed transfer $\bar{d}$ to the induced market rate $R^{m}(\bar{d})$, and to finally check that indeed fixing $\bar{d} = d^{\star}(R^{\star})$ gives $R^{m}(d^{\star}(R^{\star})) = R^{\star}$, i.e. the optimal policy is credibly (i.e. there is no incentive to deviate ex-post) implementable as a market outcome.

P: Optimal policy design.

P1: The optimal policy reaction: $d^{\star}(R)$

The optimal transfer at a given interest rate R solves the problem:

$$\max_{d} E^{\beta}[\underbrace{p(R)\pi^{b}(\rho^{*}(R,\omega)) - d}_{\equiv J(R,d)}], \tag{19}$$

subject to

$$c = E^{\beta}[q(R)\pi^{l}(R;\rho^{*}(R,\omega)) + d],$$

and

$$p(R) = A^{\frac{1}{\gamma}} q(R)^{-\frac{1-\gamma}{\gamma}},$$

[17] As in (8) we have applied the consistency condition $E^{\beta}[E^{\phi}[(\cdot)]] = E^{\beta}[(\cdot)]$.

where d denotes a subsidy to lenders financed by taxing borrowers. Substituting constraints into the objective we obtain the optimal subsidy for a given R:

$$d^\star(R) = \arg\max_d \left(A^{\frac{1}{\gamma}} c^{-\frac{1-\gamma}{\gamma}} \left(E^\beta[\pi^l(R; \rho^*(R, \omega))] + d \right)^{\frac{1-\gamma}{\gamma}} \left(E^\beta[\pi^b(\rho^*(R))] - d \right) \right).$$

Hence, if we define

$$\upsilon^{\beta\star}(d; R) \equiv \left(E^\beta[\pi^l(R; \rho^*(R, \omega))] + d \right)^{\frac{1-\gamma}{\gamma}} \left(E^\beta[\pi^b(\rho^*(R, \omega))] - d \right), \tag{20}$$

then $d^\star(R) = \arg\max_d \upsilon^{\beta\star}(d; R)$. Since $\upsilon^{\beta\star}(\cdot; R)$ is concave, a necessary and sufficient condition for $d^\star(R)$ to be an optimal subsidy for a given R is[18]:

$$\frac{1-\gamma}{\gamma} \frac{1}{E^\beta[\pi^l(R; \rho^*(R, \omega))] + d^\star(R)} - \frac{1}{E^\beta[\pi^b(\rho^*(R, \omega))] - d^\star(R)} = 0, \tag{21}$$

that is,

$$d^\star(R) = (1-\gamma) E^\beta[\pi^b(\rho^*(R, \omega))] - \gamma E^\beta[\pi^l(R; \rho^*(R, \omega))]. \tag{22}$$

The optimal subsidy defined by (21) implies a split of the total expected interim surplus generated by a given offer R that is determined by the relative elasticities of the matching function to the mass of applications and offers:

$$E^\beta[\pi^b(\rho^*(R, \omega))] - d^\star(R) = \gamma E^\beta[\mathcal{S}(R, \rho^*(R, \omega))], \tag{23}$$

$$E^\beta[\pi^l(R; \rho^*(R, \omega))] + d^\star(R) = (1-\gamma) E^\beta[\mathcal{S}(R, \rho^*(R, \omega))]. \tag{24}$$

Note that the optimal policy reaction to a given market interest rate R results in an efficient sharing of the *interim* surplus (which, remember, is independent of R) generated by that contract within the match. Furthermore, comparing (21) and (14), we obtain:

Lemma 6. *If $R^* \in \mathbb{R}^{ssce}$ then $d^\star(R^*) = 0$.*

Lemma 6 is a consequence of the fact that at $\mathbb{R}^{ssce}$ the sharing of the surplus is locally optimal. That is, conditional on being at $\mathbb{R}^{ssce}$, there is no transfer that can improve it: in other words Hosios condition locally holds. However, $d^\star(R)$ implies an optimal splitting at any given R. Therefore, with the policy in place, any $R \neq \mathbb{R}^{ssce}$ is now associated with a different allocation. Given the contingent optimal subsidy $d^\star(R)$, the socially most preferred R results in the optimal policy target, as we discuss below.

P2: The optimal interest rate target: $R^\star$

Equation (22) defines an optimal subsidy for every feasible interest rate R. substituting (22) into (20) provides a simple characterization of the planner's preferences over interest rates, given the optimal policy reaction:

$$\mu^{\beta\star}(R) \equiv \upsilon^{\beta\star}(d^\star(R); R) = \gamma (1-\gamma)^{\frac{1-\gamma}{\gamma}} E^\beta[\mathcal{S}(R, \rho^*(R, \omega))]^{\frac{1}{\gamma}}. \tag{25}$$

This reduces the social evaluation to a simple total expected surplus criterion, given by $\log\left(\mu^{\beta\star}(R)\right)$.

In general, the evaluation given by $\bar{\mu}^\beta(R)$ defined by (18) and $\mu^{\beta\star}(R)$ defined by (25) do not necessarily coincide. The reason is that, without the subsidy, the interest rate R determines at the same time two choices by affecting i) the incentive of the borrower in choosing a project, and ii) the incentive of the lender in posting an offer, which depends on the split of the expected surplus. The subsidy enables the policy maker to disentangle these two dimensions. In particular, the optimal subsidy achieves an efficient share of the (subjectively expected interim) surplus for a given R, i.e. it makes the *Hosios condition* hold globally. The absence of share inefficiency redefines social preferences over contracts as stated by the following result:

Lemma 7. *An optimal interest rate target, $R^\star$ satisfies:*

$$R^\star \in \arg\max_R E^\beta \mathcal{S}(R, \rho^*(R)).$$

In particular, since $\bar{R} > 0$, $R^\star$ is such that $\rho^*(R^\star) = s$, provided s is a REE choice.

Therefore, given the optimal policy reaction to a market contract, the planner would prefer a contract that maximizes the social surplus; this constitutes an optimal target. But how can a social planner induce lenders to select such a contract? We now address this question showing how the optimal policy can also implement the optimal target as a *market equilibrium* outcome.

[18] Note that here we exploit the linearity of our pay-off structure, i.e. $\partial\pi^l/\partial R = -\partial\pi^b/\partial R$.

R: Market (Ramsey) Implementation

R1: Market reaction to a transfer: $R^m(d)$

Suppose the authority implements an arbitrary fixed transfer d. To recover the market reaction, we need to solve **the lender's problem** (8) where we subtract and add a fixed transfer d to $E^\beta[\pi^l(R;\rho^*(R,\omega))]$ and $E^\beta[\pi^l(R;\rho^*(R))]$, respectively. As a result, the private evaluation criterion in the case of a subsidy becomes

$$\mu^\beta(R;d) \equiv \left(E^\beta[\pi^b(\rho^*(R,\omega))] - d\right)^{\frac{\gamma}{1-\gamma}} \left(E^\beta[\pi^l(R;\rho^*(R))] + d\right) \tag{26}$$

where $\mu^\beta(R;0)$ is nothing other than (13) – i.e. $\mu^\beta(R;0) = \mu^\beta(R)$. Let $R^m(d) \in \arg\max_R \mu^\beta(R;d)$.

R2: Implementation of the optimal target R^*

Note that when $d = d^\star(R)$, by substituting the (Hosios) efficiency conditions (23) and (24) in (26), one can easily prove that, for a given R we have: $\mu^\beta(R;d^\star(R)) = \mu^{\beta\star}(R)^{\gamma/(1-\gamma)}$, i.e. the private and social evaluations become the same. Formally, we have shown:

Proposition 8. *Suppose the authority targets a contract R' fixing a targeted subsidy $d^\star(R')$, then*

$$R^m(d^\star(R')) = R',$$

i.e. $d^\star(\cdot)$ provides an implementable targeting policy.

The following lemma summarizes the description of the optimal policy and its implementation and lays out the implications in terms of equilibrium beliefs.

Lemma 9. *A policy maker with the power to make transfers will implement a contingent subsidy from borrowers to lenders $d^\star(R^\star)$ inducing the optimal target $R^m(d^\star(R^\star)) = R^\star$ such that $\rho^*(R^\star) = s$, provided s is a REE choice. By Proposition 4,* when *safe equilibria are also REE, with the optimal policy in place, SSCE that are not REE cannot exist.*

In sum, the authority will announce a subsidy policy no matter how small the subjective probability that total surplus could improve, is. The implementation of the subsidy is, in general, *ex-ante* the right decision for the authority, irrespective of what agents can eventually learn after exploring new submarkets (notably, that the status quo was not an REE). Gaining always zero profits, existing lenders are indifferent to the implementation of the policy. On the contrary, from the borrowers' point of view the subsidy induces entry of other lenders into the market, which means easier credit conditions for them.

The optimal subsidy as an implicit tax on high-interest rate offers.

To understand the effects of the optimal policy more deeply it is useful to look back to Fig. 3. In that example, the probability of a low k_L, namely p, is also the probability that

$$\mathcal{S}(R',s) > E^\beta\left[\mathcal{S}(R_b^{ssce},r)\right], \tag{27}$$

for any positive $R' < \overline{R}(b,k_L) = y - k_L(1-b)^{-1}$. This implies that the authority would like to implement a contingent subsidy at any of such R'. Let us focus on the case where the authority targets a contract R_s^{ree}, which is the best contract conditional to the realization of the good state k^L (as shown in Figure 3). In particular, the optimal targeted subsidy can be designed as the β expected value of two state contingent subsidies (e.g. subsidies conditional on observed losses):

$$d^\star(R_s^{ree}) = p\,d^\star(R_s^{ree},s) + (1-p)d^\star(R_s^{ree},r),$$

and given that, by Lemma 6, $d^\star(R_s^{ree},s) = 0$ then, by (22), we finally have

$$d^\star(R_s^{ree}) = (1-p)((1-\gamma)b(y-R_s^{ree}) - \gamma(bR_s^{ree} - \delta)),$$

which satisfies (21). Through the subsidy, lenders internalize the social evaluation of interest rates (26), therefore *all lenders* strictly prefer to post offers at R_s^{ree}. This situation is illustrated by the curved green line in Figure 5, which represents the *expected* value function when the subsidy $d^\star(R_s^{ree})$ is implemented. The peak of the green line is exactly at R_s^{ree}, where the zero profit condition is satisfied. Note that in this case lenders reply to the *credit easing* policy by offering loans at the interest rate R_s^{ree}. At such low interest, borrowers will choose the safe technology if the implementation cost is low, finally unveiling the true state. As a result, the effect of implementing a subsidy to lenders at the cost of taxing borrowers results in no rent for lenders, but in an *implicit tax* if they do not offer the planner's desired equilibrium interest rate. In particular, as lenders stop pricing risk, too-high interest rates will generate too few matches yielding losses (indicated in Fig. 5 with a double arrow).

Credit Easing *as a self-financed policy*

Finally, we show here how a credit easing intervention can be self-financed in the context of our example. Condition ii) requires that the subsidy to lenders is financed by a tax applied to matched borrowers. Nevertheless, in the case of a risky project adoption, matched borrowers could fail and not have pledgeable income to finance the policy. To ensure that the policy is self-financing, we shall consider individual-specific taxes on borrowers $d(R,\mathsf{i})$ where $\mathsf{i} \in \{\mathsf{c},\mathsf{f}\}$ denotes the *ex-post* state of the project of the borrower being either a success (c) or a failure (f). The realization of the state i, it should be noted, is not under the control of a borrower, so that condition i) is still satisfied. Self-financing, in our example, implies:

$$d^\star(R_b^{ree},\mathsf{c}) = b^{-1}d(R_b^{ree}) \quad \text{and} \quad d^\star(R_b^{ree},\mathsf{f}) = 0,$$

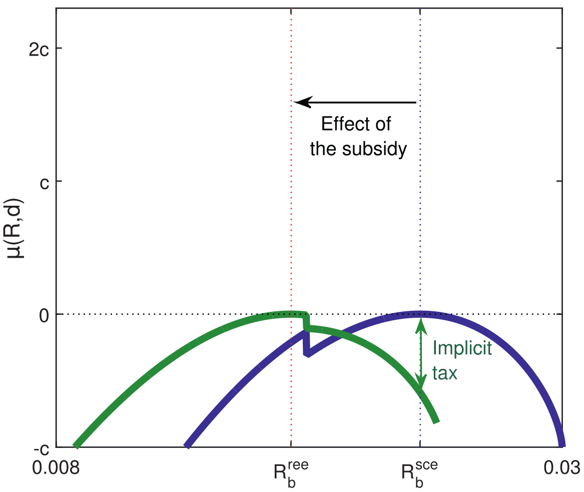

Fig. 5. The effect of the optimal subsidy. The figure plots individual expected values of contracts in the $(\mu(R), R)$ space, whenever everybody else posts equilibrium contracts, in the case where $\alpha = b$ with (green curve) and without (blue curve) subsidy. In this example, the subsidy targets R_b^{ree}. Because of free entry, the presence of the subsidy translates into an implicit tax on lenders that post high interest rates via lower matching probabilities. Other parameters are: $y = 0.03, \gamma = 0.4, c = 0.001, A = 0.1$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

so that $d^\star(R_b^{ree}) = bd^\star(R_b^{ree}, \mathrm{c}) + (1-b)d^\star(R_b^{ree}, \mathrm{f})$. This structure of contingent transfers ensures that the government can finance the subsidy to lenders, relying on the same pledgeable income on which private contracts also rely. In practice, in equilibrium each matched borrower finances *in expectation* a matched lender.[19] In particular, in the case that k_L does not realize, matched borrowers with successful projects still have pledgeable resources to pay the tax.

4. Breaking the spell: the evidence of TALF

Our Self-Confirming theory of credit crises requires that lenders agree that lower interest rates would generate some losses. This raises some questions: what may induce correlated misperceptions in the first place? What kind of evidence identifies misbeliefs in the data? What eventually may correct missbeliefs?

In models where agents form their subjective expectations based on experience, their *common* market experience implicitly provides some coordination. By extrapolating from the same equilibrium data to evaluate never experienced outcomes, agents' beliefs may converge to a misspecified Self-Confirming Equilibrium. The macro literature following Primiceri (2006) and Sargent et al. (2006) have emphasized the role of misspecified policies in producing market evidence that could sustain such equilibria. In our theory instead we stress the role of new policies in 'resolving' privately-sustained self-confirming crises.

In this section we provide empirical support to our mechanism by focusing on a specific policy event: the implementation of the TALF policy in the primary ABS market. Our main goal is to demonstrate that extrapolation from pre-TALF market evidence could have sustained missbeliefs later confuted by the new evidence induced by TALF. Before going into the details, let us briefly discuss the existing empirical studies on TALF to highlight our contribution.

4.1. Previous evidence on TALF and our contribution

Few articles have discussed the rather unique design and impact of TALF; e.g. Agarwal et al. (2010), Ashcraft et al. (2012) and Rhee (2016). None really has proposed a theory that is specific to TALF, with the notable exception of Ashcraft et al. (2011). According to their model of the haircut channel, TALF would have generated a *demand asset-specific* effect, that is, a relaxation of an ABS-specific margin requirement on investors' demand.[20] Ashcraft et al. (2011) estimate the price effect of TALF in secondary markets to be significant but rather small: the differential variation in price conditional on a particular security being rejected to TALF eligibility is at most 40 bps, whereas the increase on the eligibility acceptance is only few base points. The little impact of TALF on the pricing at the asset-level has been confirmed forcefully by Campbell et al. (2011).

Although there is little evidence of a demand asset-specific effect, it looks undeniable that the ABS market as a whole has benefited of the introduction of TALF. One possible interpretation is that TALF has been a way to more broadly relax

[19] Moreover, note that in our example $y - R_b^{ree} \geq d(R_b^{ree})$ always holds. This implies that borrowers still have incentives to participate in the market despite the tax.

[20] See the discussion by Woodford (2011) about the asset-level specificity of the channel assumed by Ashcraft et al. (2011).

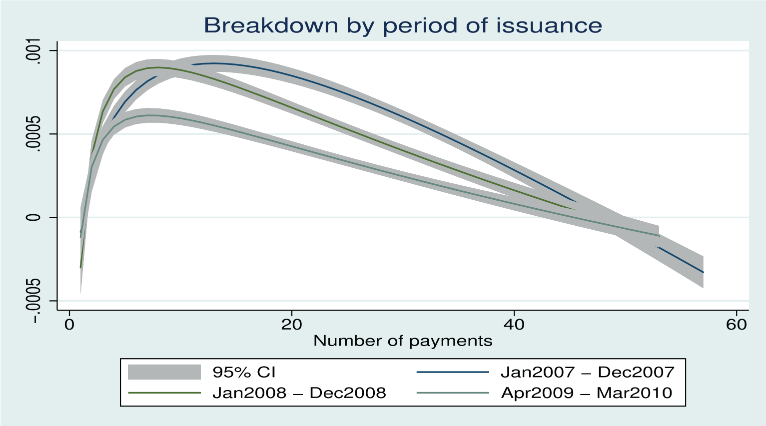

Fig. 6. Predicted mean of ABS monthly losses over time for three subsamples: ABS issued during 2007, ABS issued during 2008 and ABS issued one year after TALF, from April 2009 to March 2010. The y axis measures the first differences of cumulative losses with respect to initial pool balance for each tranche, the x axis reports the time span of ABS payments. There is a common pattern that emerges for each tranche in the evolution of monthly losses over time that peaks around the 15th-20th month and then – due to clients' debt repayments of past installements (reduction of delinquencies) – progressively dies away as time goes by.

credit constraints in this particular segment. The role of TALF, as Campbell et al. (2011) put it, "may have been to calm investors, broadly speaking, about U.S. ABS markets, rather than to subsidize or certify the particular securities that were funded by the program." This liquidity provision story has certainly some merits. At the same time it is hard to disentangle the effects of TALF from the numerous other measures of liquidity provision taken in the same period by the Fed and the Treasury.

We believe that the new facts that we document in this section may shed a different light on the TALF episode, providing an alternative to the generic and still unproven broad liquidity provision argument. A key innovation in our study is the focus on changes in asset *pay-offs* rather than in asset *prices* in secondary markets. In particular, we look at whether the policy may have had any effect on the intrinsic quality of the asset rather than on its demand.

To do this we collect data on the cumulative losses over total asset pool generated along the life of Auto ABS and try to understand how TALF may have affected their evolution. These losses are originated by delinquencies on the original pool of loans backing the security: they represent the realization of the ex-ante uncertain component in asset pay-offs. We focus on nine companies issuing Auto Loan ABS sector from 2007 to 2012. Our dataset is described below and the reasons for choosing Auto ABS are discussed at the end of this Section. For the moment let us focus on Fig. 6, which already provides a snapshot of the informativeness of our new data. In the figure we plot the unconditional distribution of monthly changes in cumulative losses of fixed-rate Auto-Loans ABS for each month of the life of an asset. We do this for three different subsamples: ABS issued during 2007, ABS issued during 2008 and ABS issued one year after the introduction of TALF, from April 2009 to March 2010.

A first stark result visually emerges: tranches originated after the introduction of TALF exhibit significant smaller losses. What could have been the causes of such drop?

Losses only depend on the ability of the selected pool of loans to generate due payments. In principle, this ability may be influenced by two factors. We will refer to a *supply asset-specific* effect to mean a change in losses due to different contractual conditions established at the ABS level before its issuance. Such contractual conditions, notably fixed interest rates, reflect the cost of funding for the issuing company and, as a consequence, for the subscribers of the auto loans belonging to that particular backing pool. In contrast, we will refer to a *general equilibrium* effect to generically indicate all common forces that, for *given* (and potentially different) contractual terms, may have *indiscriminately* improved the ability of all auto loan debtors to repay their due payments at a given point in time.

By just looking at Fig. 6 one cannot tell apart to which extent the drop in losses for post-TALF assets is due to the effect of lower fixed contractual terms at which Auto loans where generated rather than the improving general equilibrium conditions along the life of the assets. The objective of the rest of this section is twofold: first, nailing down exactly the connection between TALF, fixed ABS interest rates and ABS loss performance, controlling for general-equilibrium effects; second, explaining how this fact fits with our self-confirming theory.

4.2. *Econometric analysis of* newly-generated *ABS auto loans*

In what follows we describe our dataset, define our hypothesis in relation to our theory and show the results.

Dataset

For our empirical application on TALF we have decided to focus on the Auto loan segment of ABS. At the end of this section we discuss in detail the advantage of this choice and the drawbacks of alternatives. We have collected all the available free, online information[21] on Auto ABS tranches issued from 2007 to 2012 by 9 different issuers in the automotive sector. These nine companies are listed in Appendix C.4 Table C.1. For each company, we list the tranches issued by year with its own identifying tag.[22] In bold we report the tranches that were eligible collateral under TALF, which amounts to the 46.5% of all ABS-Auto covered by TALF.

The face value of all the 109 tranches in our dataset amount to 122.2 billions of dollars of which 41.81 were issued before TALF, 22,94 under TALF and the rest after TALF. Each tranche issued by company i at time (month) T consists of a set of obligations, henceforth notes, that pay a monthly payment for a number of months (median is 49 months, with min of 10 and max of 57) which is fixed at the time of the issuance. At the time of the issuance, the amount of the monthly payment in terms of an interest rate on the face value of the note is also decided. The interest rate is typically fixed (time-invariant along the life of the security) but there is a minority of notes – amounting to 11.76% of the total, all issued before TALF – with variable interest rate determined as a fixed margin on the 1-month Libor.

Notes differ in seniority. Going from the most senior to the most junior, notes are labeled with tags A1, A2, A3, A4, B, C, D. This means that, for example, payments due to A3 occurs only if payments to A2 has been carried over in full. Therefore junior notes are the most likely to absorb losses on the backing pool of auto loans. A notes, which fulfill the AAA-rating requirements, amount to 96.66% of the total – 96.31% before TALF, 98.25% under TALF and 96.34% after TALF. Finally not all the notes are publicly offered, some are retained by the issuing company or one of its affiliates as a risk retention strategy to foster buyers' trust; the amount of not offered notes amounts to 7.70% of the total; more precisely 6, 80% of A notes (5.99% before TALF, 10.24% under TALF and 5.49%) and the 33.83% of non-A notes (28.79% before TALF, 75.75% under TALF and 13.74% after TALF).

Concerning losses, for each tranche we have the monthly cumulative loss on receivables, measured as a fraction of initial pool balance, generated along the life of a tranche. The monthly flow of cumulative losses follows a strong deterministic non linear pattern, similar to the ones showed in Fig. 6, with most of the losses occurring in the first half of the security life[23]

Our model can be tightly interpreted as a stylized model of the primary market of ABS once we interpret lenders as buyers, borrowers as issuers and the ABS as the project that can be safe or risky depending on unobserved pooling and tranching. The optimal policy discussed in the previous section also captures salient features of TALF. In the interest of space, we postp1 a more detailed mapping to Appendix B.1- B.2.

Hypothesis

The different stages surrounding the TALF episode can be thought of as transitions between different equilibria in our model. We generally identify two phases: pre- and post-TALF.

The pre-TALF crisis of the ABS market could be interpreted using Fig. 1. Let us abstract for a moment from heterogeneity, as we do in our theoretical benchmark, and come back to it later. A crises in the ABS market occurred as an exogenous increase in underlying risk moved the equilibrium in this market from a risky REE to a risky SCE.[24] In the risky SCE we should have observed higher interest rates in response to higher risk. In other words, for a given cost of funding, higher interest rates were required by ABS buyers to hedge against losses. More precisely, Fig. 2 shows that after the increase in exogenous risk – i.e. a decrease in α – the old optimal interest rate R_a^{ree} (optimal on the red curve) yields negative profits (a negative $\mu(R_a^{ree})$) on the new relevant curve (the blue one). It also shows that marginally higher interest rates than R_a^{ree} result in lower losses, which is denoted by a less negative $\mu(R)$ on the blue curve. In sum, after the increase in risk, evidence of higher losses at lower rates should sustain high market rates.

In our empirical exercise, we actually use cross-sectional differences across issuers and time to elicit information about the predicted *negative* correlation between interest rates and losses. Let us refer to "interest spreads" as the difference between interest rates and the cost of funding (i.e. $R-\delta$ in our model). This is the important number capturing the contractual conditions fixed at origination and that stay invariant along the life of the asset. We can then formulate of our first hypothesis as follows:

(H1) Absent TALF, tranches issued at higher interest spreads are associated with lower losses.

The validation of (H1) rationalizes the upward trend of interest rates during the ABS crises and the contextual reluctance of buyers to accept transactions at lower rates. The acceptance of (H1) also explains the fear that a policy like TALF, which aims at lowering spreads removing part of the perceived risk in the market, could merely have the effect of increasing ABS

[21] The data have been collected one piece of information at a time from prospectuses publicly available online. The major source utilized is https://www.bamsec.com/companies/6189/208 where the majority of observations are available. The other sources are the issuers' websites which sometimes contain Trust prospectuses. Official TALF transaction data are available at: http://www.federalreserve.gov/newsevents/reform_talf.htm#data. Dataset and source codes are available on request.

[22] For example, Ford issued two different tranches on two different dates in 2007, labellled "2007-A" and "2007-B".

[23] Further details on the composition of the dataset, the sources and the procedure through which the data were collected are presented in Appendix C.1.

[24] Note that with sufficiently low risk, risky project adoption is optimal and there is no efficiency loss due to uncertainty about κ.

losses at the expense of the US taxpayer, as Paul Krugman's quote, opening our introduction, suggests. But we know this is not what has happened.

The impact of the TALF could be understood as the effect of our optimal policy, illustrated in Fig. 5. Due to an implicit insurance on counterpart risk and competition among ABS issuers, interest spreads drop, revealing ex-post that lower losses are actually associated with lower interest rates. More precisely, Fig. 5 shows that after the contingent subsidy scheme is put forward, the old optimal interest rate R_b^{sce} (optimal on the blue curve) would produce negative profits (a negative $\mu(R_b^{sce})$) on the new relevant curve (the green one) because too few applicants would show up. It also shows that interest rates marginally lower than R_b^{sce} result in lower losses, denoted by a less negative $\mu(R)$ on the green curve. In sum, with the implementation of TALF, evidence of lower losses at lower rates should sustain high market rates. As before we use cross-sectional differences across issuers and time to elicit information about the predicted *positive* correlation between interest rates and losses.

We can then state our second hypothesis.

(H2) With and following TALF, tranches issued at lower interest spreads are associated with lower losses.

The acceptance of (H2) establishes that the introduction of TALF unveiled a relation between interest spreads and losses that could not have been predicted by extrapolating from pre-TALF evidence. In other words, TALF generated public learning that made it possible for the market to stabilize at low rates. As a consequence, the TALF subsidy was never implemented, although the recovery was permanent. Importantly, (H2) also states that low interest rates should remain after the TALF window closed.

In the end, through the lens of our theory, the success of TALF could have been due to its ability to drive the market towards low rates, unveiling unexpected profitability of easier credit conditions.

Results

Here, we present our econometric tests aiming at estimating the linear relation between interest spreads, which is a choice variable of the financing companies at the time of origination, and resulting losses along the life of the asset, controlling for a number of factors, notably general equilibrium ones. Our basic econometric model is:

$$mL_{i,T,t} = \beta_0 + \beta_1 D_T + \beta_2 \Delta r_{i,T} + \beta_3 D_T \Delta r_{i,T} + controls + \epsilon_{i,t,T}, \tag{28}$$

where $mL_{i,T,t}$ denotes monthly change in cumulative losses realized, at time (month) t, relative to a tranche issued by company i at time T, $\Delta r_{i,T}$ is the interest spread computed as a volume-weighted average of interest rates across the different categories of notes fixed at time T by company i minus the 1-month Libor at the time of the first payment of the tranche[25], and D_T denotes a dummy: it is 1 when $mL_{i,T,t}$ belongs to a tranche issued after the introduction of TALF – i.e. $T >$ March 2009 – it is 0 otherwise. Thus, β_3 measures the *differential* effect of our weighted average interest rate spread $\Delta r_{i,T}$ (henceforth simply interest spread) on losses $mL_{i,T,t}$ after the introduction of TALF.

Let us clarify the nature of our exercise. Consider two monthly losses, $mL_{i,T',t}$ and $mL_{i,T'',t}$, occurring at the same time t and belonging to tranches issued by company i at different dates $T' <$ March 2009 and $T'' >$ March 2009. Let $\Delta r_{i,T'}$ and $\Delta r_{i,T''}$ be the corresponding rate spreads fixed at the time of issuance. Their impact get differentially estimated as $D_{T'} = 0$ and $D_{T''} = 1$. The introduction of this type of dummy can effectively capture the impact of the *supply asset-specific* effect as distinct from the *general equilibrium* effect as discussed in relation to Fig. 6. Absent any *supply asset-specific* effect, $mL_{i,T',t}$ and $mL_{i,T'',t}$ would equally respond to rate spreads once controlled for *general-equilibrium* factors (as we do, see below); in such case, the test could not reject the absence of any differential impact of rate spreads related to the introduction of TALF.

Overall, the dummy captures a change in regime in the prevailing spreads, which were high before TALF and low after it because of the competition induced by this policy, as we have explained. Conditional on the value of the dummy, the regression estimates the correlation between marginal variations in losses and marginal variations in spreads. Given the latter are predetermined to the former this correlation can be interpreted as causality.

We perform different specifications by changing the sets of controls, but always clustering residuals by issuing companies, which is our most important source of cross-sectional heterogeneity. In all our specifications regressors are pre-determined with respect to losses so that problems of endogeneity are excluded. We present now our results for the sample of only fixed rate A-class notes, including not-offered notes. In Appendix C.4 we show that our results are robust to sample choice.

Baseline specification In the first column of Table 1 we show the results of our "base" specification that includes no controls. Raising the interest rate spread of 1% leads to significant decrease of monthly losses of 0.007% on the original pool of assets; however the differential impact after the introduction of TALF is significantly positive and higher, amounting to 0.018%, giving a net positive impact of 0.011%. This result suggests that H1 and H2 are not rejected by a simple linear regression without any refinement.

Fixed-effect controls In our second specification, which is tagged by "FEXs", we include a three types of fixed-effects as controls. We introduce a fixed effect at the level of the company, a fixed-effect for each date and a fixed-effect indexing the life of the security. The company effect is a natural control, given the heterogeneity of the credit contracts constituting the underlying pool of assets. The date effect is intended to capture all common factors impacting across all losses of all companies at the same date; these include *general-equilibrium* factors like business-cycle fluctuations but also specific measures

[25] Computing an average of interest rates is necessary because interest rates are specific to class notes whereas losses are not since they are computed on the whole pool of loans backing the asset.

Table 1
Standard errors, which are reported in brackets, are clustered by issuing company. Estimates are multiplied by 100. Significance level: $^{*}p \le 0.1$, $^{**}p \le 0.05$, $^{***}p \le 0.01$.

Sample: A-fixed-rates notes, dependent variable: $mL_{i,T,t}$	base	FEXs	Amounts	pre-talf	post-talf
D_T	-0.040^{***}	-0.026^{**}	-0.420^{**}		
	(0.009)	(0.008)	(0.129)		
$\Delta r_{i,T}$	-0.774^{**}	-0.377^{**}	-0.372^{***}	-2.193^{**}	2.203^{***}
	(0.301)	(0.147)	(0.102)	(0.881)	(0.565)
$D_T \Delta r_{i,T}$	1.812^{**}	1.038^{**}	1.080^{***}		
	(0.627)	(0.324)	(0.308)		
$V_{i,T}$			-0.001	-0.033^{**}	-0.042
			(0.001)	(0.010)	(0.023)
$D_T V_{i,T}$			0.018^{**}		
			(0.006)		
R^2	0.1163	0.6616	0.6712	0.2416	0.3403
Obs.	4.845	4.845	4.845	535	557

adopted by the Auto sector in this period.[26] The security life effect is intended to control for the non-linear deterministic trend, as the one showed in Fig. 6. Concretely, we introduce a fixed effect for each n-th payment in the life of the security so that we account for the systematic loss component associated to it. Once all these controls are in place, contemporaneous losses may only differ for the differential effect of interest spreads.

The presence of fixed effect controls lower our coefficient estimates in comparison to our "base" specification by roughly a half, confirming their significance and increasing the R^2 from 0.11 to 0.66.

Given that our measure of spreads confounds price and quantities, we include the volume of issuance – namely $V_{i,T}$ in our "Amounts" specification – to control for potential quantity effects. Including amounts as an additional control leads to the same coefficient estimates of our "FEXs" specification with higher significance, except for the TALF dummy (which now compares with the estimate of the base specification). Volumes turn out to have a significant positive impact on losses only after TALF.

Splitting the sample The "pre-talf" specification is designed to capture the point of view of an observer who, a day before the introduction of TALF, uses the available market information of the previous two years to assess the impact of interest spreads on losses[27] We therefore restrict our estimation to the data originated before 25 March 2009, which is the date of implementation of TALF, amounting to 537 observations. Given that the number of observations is now lower, it is not possible to control for all the fixed effects that we considered before and thus we are forced to drop some in order to obtain meaningful results. We maintain the date-fixed effect, which is likely to be the most important, and drop the other two: the heterogeneity in companies is already partly accounted for by clustering in residuals, whereas the security life effect is minimal as we consider payments within two years of origination.[28] Obviously, we also drop the dummy variable D_T that we used before. The main result is that the relation between losses and interest spreads is estimated to be significantly negative, and double in size with respect to "base" specification. *This finding suggests that an econometrician looking at market data in the two years before the introduction of TALF would have estimated a negative impact of interest spread on losses.* Such beliefs explain the upward escape of the interest spreads before the introduction of TALF, that are documented in Appendix C.4 Fig. C.2, as buyers were asking for higher premia as they saw higher losses. Moreover, based on the estimated correlation, a mechanical decrease in interest spreads, eventually induced by TALF, would be expected to generate higher losses for the policy maker.

The "post-talf" specification is designed to capture the point of view of an observer who, two years after the introduction of TALF, uses the available market information generated by tranches issued in those previous two years to assess the impact of interest spreads on losses. We therefore restrict ourselves to the data relative to tranches issued after 25 March 2009 for the following two years, i.e. until 1 April 2011, amounting to 557 observations. As before, we only include date-fixed effects. This sample is informative about the *actual* impact that the large decrease in interest spreads induced by the TALF had on losses. *The estimated correlation is now significantly positive, meaning that lower interest rate spreads were yielding lower losses: this finding is in sharp contrast with the prediction that one could have made based on the "pre-talf" sample.* This result also explains why, in the end, there was no need to actually implement any subsidy at all, and rationalizes the further decrease in interest spreads after TALF expired, as documented in Fig. C.2.

In Appendix C.4 we present a similar analysis by considering different samples. First we perform Amounts, pre-talf and post-talf specifications by controlling for non-offered notes to account for different risk-retention strategies. Then we run

[26] See, for example, Agarwal et al. (2015) and Ramacharan et al. (2017).

[27] Recall that two years is the horizon of Krugman in the quote at the beginning of our Introduction.

[28] The truncation of the sample reduces the eventual misspecification due to non-linear trends, as argued by Hahn et al. (2001).

all our tests on the whole A notes class (i.e. including notes with floating rates) and the full dataset with all A, B, C and D notes. All the results are closely in line with the ones discussed above.

Summary The results in Table 1 strongly suggest that our hypotheses H1 and H2 hold true. This lends credit to our conjecture that changes in asset payoffs were mostly due to the change in fixed contractual rates induced by TALF (i.e. a *supply asset-specific* effect), rather than to a change in the ability of debtors to repay due to a later improvement of economic conditions (i.e. *general-equilibrium* effect).

Overall, our findings suggest that the absence of TALF would have seen the market completely shut down, and the available evidence would have been that higher interest spreads compress losses. Based on such evidence, no investor would have ever accepted low interest rate ABS. Moreover, none could have blamed the Fed for not taking risk by introducing TALF. In fact, extrapolating from this evidence, a policy aiming at lowering risk premia would merely have generated higher losses. In contrast, the introduction of TALF produced the counterfactual that, at sufficiently low levels of interest spreads, marginally higher interest spreads increase losses, which induced a persistent market stabilization.

4.3. Discussion: Why looking at ABS auto loans?

To test our hypothesis we chose to investigate the Auto loan segment of the market for newly-generated ABS. The automotive ABS is the second largest category of ABS, after credit cards, supported by the TALF program on *newly-generated* ABS.[29] We chose to look at this market because the peculiar characteristics of the underlying contracts make our analysis particularly informative.

In the Auto segment of the ABS market, contrarily to other segments, there is a lot of public information: this is exactly the case where we expect our mechanisms can have a stronger bite. Specifically, Auto loan ABS is a market segment which is fairly transparent, data are updated quite frequently and are publicly available. Prices in these markets are determined mainly on the ratings established on the performance of similar securities in the past. In short, information asymmetries are particularly low in this markets. As we stressed in Appendix B.1, this characteristic is crucial to induce similar misperceptions, but also in explaining the power of the learning induced by a public policy. At the same time, it is important to keep in mind that publicly available information is always information produced around an equilibrium. As such, it could be poorly informative about counterfactual scenarios which have never been experienced. Concretely, the existence of accurate and public information about the losses of securities designed to anticipate high interest rates is consistent with buyers' uncertainty about losses of securities designed in a counterfactual scenario of low interest rates. Could the seller then signal the existence of gains from trading at lower rates? Again, in these markets the reliance of buyers on public information about past performance (loss records, ratings, etc.) suggests that there is no way for sellers to credibly signal the quality of their security other than closely replicating the most successful securities issued in the past. It is on this precise hold-up problem that TALF may have had a bite by inducing never-observed counterfactuals.

Moreover, the structure of both the ABS security and the underlying auto loan contracts are simple, and mainly based on fixed interest rates with fixed maturity and known collateral (the auto itself). On the contrary, other ABS segments, notably credit cards, are less transparent being based on revolving unsecured credit with a peculiar structure of interest rates and fees. Finally, as in our model, auto loans do not exhibit externalities across consumers (which could operate in credit cards); in other words, credit conditions granted to a set of auto loans do not affect the likelihood of losses on a different set of auto loans. This feature is important because it excludes alternative multiple equilibrium narratives because the existence of strong general equilibrium externalities are hard to defend in these markets.

5. Conclusions

This paper presented a new approach to monetary policy in situations of high economic uncertainty, where private agents and policy makers may misperceive – and possibly underestimate – the actual strength of the economy. By developing and applying the concept of Self-Confirming Equilibrium to a competitive credit market, we have characterized a (previously non-captured) form of credit crisis and, more importantly, showed that *Credit Easing* can be the optimal policy response, breaking the credit freeze. The policy is a revenue-neutral tax to borrowers and subsidy to lenders that, in fact, acts as a tax to lenders who do not implement the policy target (of a low interest rate) and see their (high interest) offers not being accepted. Therefore, it is a policy that can correct market inefficiencies irrespective of the misspecified nature of beliefs[30], but that happens to produce new market evidence confuting potential missperceptions. While we presented a new theory, the paper also shows that the Fed TALF experience in 2009 can be seen as a frontrunner example of a constrained-optimal policy and, accordingly, our micro-empirical research as a vindication of our crisis mechanism.

[29] The TALF program for commercial mortgage-backed securities (CMBS) attracted almost exclusively *legacy* CMBS; however, as we said, our mechanism concerns primary - and not secondary - markets, so mortgages are excluded from our analysis.

[30] For example, if the *subjective beliefs* characterized in Section 2 (Figs. 2 and 3) were *objective beliefs*, the *Credit Easing* policy would still be needed to attain a constrained efficient allocation. However, in contrast with our SSCE equilibrium and the TALF experience, the subsidy would need to be permanent and would not convey any information that agents with rational expectations would not have.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jmoneco.2021.01.007

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