Breaking the Spell with Credit-Easing*

Self-Confirming Credit Crises in Competitive Search Economies

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Abstract

We develop a theory of *self-confirming* crises in which lenders charge high interest rates because they wrongly believe that lower rates would further increase their losses. In a directed search economy, this misperception can persist because at the equilibrium there is no evidence that can confute it, preventing the constrained-efficient outcome. A policy maker with the same beliefs as lenders will find it optimal to offer a subsidy contingent on losses to induce low interest rates. As a by-product, this policy generates new information for the market that may disprove misperceptions and make superfluous the implementation of any subsidy. We provide new micro-evidence suggesting that the 2009 TALF intervention in the market of newly generated ABS was an example of the optimal policy in our model.

Keywords: public information, credit crisis, unconventional policies, self-confirming equilibrium, directed search, asset-backed securities (ABS), Term Asset-backed securities Lending Facility (TALF).

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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.)

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 AAA-rated 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

[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

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 produces counterfactuals that with low rates borrowers adopt safe projects. Thus, with the policy in place (mis)beliefs can no longer be equilibrium beliefs. The policy corrects out-of-equilibrium behavior, so that in equilibrium no losses realize, and no subsidy is actually implemented.

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 ex-post riskiness 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 lead to smaller losses. Thus, according to market information in the absence of TALF, it was rational for investors to increase rates to minimize losses. 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 lead 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.

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, 2016b); iii) coordination failures, as in models of self-fulfilling credit (Bebchuk and Goldstein (2011)) or debt (Cole and Kehoe (2000) and Ayres et al. (2018)) crises, 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[2]. However, buyers may (mis)believe that they are correctly pricing the asset.

The optimal policy can correct this friction by producing new information. In this respect, our work also relates to an interesting literature that focuses the production of public information for trading and related policies, as for example Kim et al. (2012), Bond and Goldstein (2015), Gale and Chamley (1992) and Caplin and Leahy (1998). Gorton and Ordoñez (2016a) is related to our work, in that public interventions let agents put less weight on public information (e.g. observed interest and default rates) and , which would have otherwise prolonged the crises. However, 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.

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

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

[3]Some of this 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, we maintain lenders' beliefs may be possibly misspecified, which then requires that matching probabilities are not directly observable.

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 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 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 modeling 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. In the economy that we analyze, given a set of exogenous parameters, there is a unique REE – i.e. *there are not Self-fulfilling REE* – and, in this sense, we contribute to the literature that studies crises as a multiplicity of equilibria phenomena by introducing self-confirming crises.

Finally, few articles have tried to explain the rather unique design and impact of TALF; e.g. Agarwal et al. (2010), Ashcraft et al. (2012) and Rhee (2016). The only previous article that has attempted a theoretical foundation for TALF is Ashcraft et al. (2011). In their model, TALF operated through a haircut channel reducing margin requirements on ABS[6]. However, this explanation implies that prices of securities in *secondary* markets were very sensitive to unexpected changes of eligibility criteria, which, however, has been proved not to be the case by Campbell et al. (2011).[7] Moreover, our paper is the first to provide direct evidence of the effect of TALF on the *primary* market, focusing on how TALF changed the original riskiness of ABS measured as realized losses. All other papers focus on the secondary market, thereby missing the link between

[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 is sometimes (mis)used by accounting only for the first but not for this second key feature, as for example in Sargent et al. (2009).

[6]See Woodford's discussion of Ashcraft et al. (2011) in the *NBER macroeconomics Annual 2010*.

[7]The authors conclude that "the impact of the TALF 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" (Campbell et al., 2011). This seems to be the case also, indirectly, in other markets – such as new vehicles – which are highly sensitive to the credit conditions Johnson et al. (2014).

the introduction of TALF and the incentives that issuers had in packing ABS. Although we do not deny the importance of TALF in alleviating liquidity constraints through a haircut channel, we think that learning market profitability at low rates was of crucial importance in inducing investors to actually use these margins. In doing so, we give a new angle of interpretation to the consensual view that "without support by the public sector, it could have taken considerable time for a market-clearing price of leverage to reemerge"(Ashcraft et al., 2011).

2 Self-Confirming Crises in Competitive Markets

This section introduces and characterises Self-Confirming equilibria in a simple competitive search model of the credit market. Although our setting is general, we will provide a tight interpretation in terms of the market for *newly generated* ABS in Appendix B.1.

2.1 A simple search model of the credit market

Borrowers, lenders and credit contracts

The market is populated by 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 only 1 otherwise. A safe project yields $1 + y$ for sure 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) and borrowers applying for loans being offered; once the match is realized, 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 ρ that belongs to $\{s, r\}$. The optimal adoption policy is given by

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

with

$$\begin{aligned} \pi^b (r; R, \omega) &\equiv (y - R) \alpha, && (2) \\ \pi^b (s; R, \omega) &\equiv y - R - k, && (3) \end{aligned}$$

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

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

$$\pi^l(R; s, \delta) \equiv R - \delta, \quad (5)$$

depending on the type of project implemented by the borrower, where δ is the per-unit opportunity cost of liquidity[8]. Hence, the lender also bears the cost of risk.

Note that 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, $\mathcal{S}(R, r) = \alpha y - \delta$ and $\mathcal{S}(R, s) = y - k - \delta$. In particular, we assume $\bar{R}(\omega) \equiv y - k(1-\alpha)^{-1} > 0$, which implies $\mathcal{S}(R, s) > \mathcal{S}(R, r)$, that is, safe projects yield higher social benefit than risky ones. However, R determines the splitting of the surplus between the two agents, and therefore the incentives of the borrower to adopt a particular project. Specifically, a borrower with ω will choose to implement a safe project if and only if the offered interest rate is sufficiently low but still profitable – specifically, $\delta \leq R \leq \bar{R}(\omega)$

Finally, it is worth remarking that there are neither externalities in contractual payoffs, either across lenders or across borrowers, nor moral hazard or adverse selection problems in this market; we do not study these problems here.

Objective and subjective probability distributions

Borrowers and lenders can differ in their beliefs. 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 $\phi(\tilde{\omega})$[9]. 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 expected lender's profit evaluated with the probability distribution induced by β, where $E^\beta[(\cdot)] \equiv \int_\Omega (\cdot)\beta(\tilde{\omega})\, d\tilde{\omega}$ is a subjective expectation operator. Note that we allow for subjective density function $\beta(\tilde{\omega})$ to possibly - but not necessarily - differ from the objective density function, $\phi(\tilde{\omega})$.

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

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

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

the match is established they observe the actual ω and make their technology adoption.

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. For the same reason we assume 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.

Matching in the credit market

We model the credit market as a *directed search competitive market*. Lenders and borrowers match to form a credit relationship in the context of a competitive direct search framework, as intoduced by Moen (1997) along the simplified variant described by Shi (2006). 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 $\gamma \in (0, 1)$.[10] 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

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

The competitive behavior of borrowers implies that the mass of applicants to a submarket $R' \in H$, namely $a(R')$ increases (resp. decreases), whenever $\mathrm{J}(R') > \mathrm{J}(R'')$ for each $R'' \in H$ (resp. $\mathrm{J}(R') < \mathrm{J}(R'')$ for at least an $R'' \in H$). 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.

[10]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.

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. Note that (10) is a direct implication of (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, the 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. This is the reason why their subjective expectation operator includes the matching probabilities: these, although well defined at any submarket, are not directly observable to lenders. Note that the competitive behavior of borrowers implies that (9) holds[11], which together with (10), 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 run at zero profits.

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 the risk that a posted contract is not filled and that she wrongly evaluates a borrower reaction to a credit offer.

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).

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

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

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 only locally around the realized equilibrium contracts.

The third condition (sc3) restricts lenders' beliefs $\beta(\tilde{\omega})$, regarding borrowers' actions (and so actual matching probabilities), to being correct in a neighbourhood of an equilibrium R^*. This 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. It should be noted that the definition does not put bounds on the size of set of contracts for which lenders' beliefs are correct, provided the equilibrium contract is an optimomum for all the lenders in that set.

The definition of SSCE requires lenders to behave optimally, given their subjective beliefs. This, crucially, leaves open the possibility that, in an SSCE, better contracts outside of a neighborhood of the equilibrium could be wrongly believed by lenders to be strictly dominated by existing ones. Thus, lenders may misperceive the actions the borrowers would take – and the resulting risks – when offered interest rates that are *sufficiently* low. Since such contracts will not be posted, then in equilibrium there do not exist counterfactual realizations that can confute wrong beliefs. Thus, SSCE may be highly persistent outcomes.

An REE is a stronger notion than an 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 which 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[12]. The objective function (13) provides a convenient characterization of equilibria:

Lemma 1. *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 $R^* \in \arg\max_{R\in\Re} \mu^\phi(R)$.*

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

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

Note that (14) is nothing more than the famous Hosios (1990) condition – that is, R^* is such that the surplus is efficienty divided: $\gamma E^\beta[\pi^l(R^*;\rho^*(R^*,\omega))] = (1-\gamma)E^\beta[\pi^b(\rho^*(R^*,\omega))]$. 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.

[12] 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.

Equilibria

We use (14) to compute the locus of equilibria relative to the adoption of safe and risky projects. Recall that a borrower with ω technologies is indifferent between the safe and the risky technology if he can borrow at:

$$\overline{R}(\omega) = y - k(1-\alpha)^{-1}. \tag{15}$$

However, as we have seen, lenders will not offer interest rates which are too low. Let $\overline{R}'(\omega) = \max\{\overline{R}(\omega), \delta\}$, which defines an upper bound for α, namely $\overline{\alpha}(k)$ such that $\overline{R}(\overline{\alpha}(k), k) = \delta$.

Condition (14) for the safe technology results in:

$$\hat{R}_s(\omega) = (1-\gamma)(y-k) + \gamma\delta, \tag{16}$$

and we restict Ω by *assuming* $y - k > \delta$, which guarantees that $\hat{R}_s(\omega) > \delta$. However, (14) must be constrained to be in the 'safe' region of Ω, determined by (15); therefore we define: $R^*_s(\omega) = \min\left\{\overline{R}(\omega), \hat{R}_s(\omega)\right\}$, which in turn defines a lower bound[13] $\underline{\alpha}(k)$ such that $\hat{R}_s(\underline{\alpha}(k), k) = \overline{R}(\underline{\alpha}(k), k)$. Similarly, (14) for the risky technology defines the locus

$$\hat{R}_r(\omega) = (1-\gamma)y + \gamma\delta\alpha^{-1}, \tag{17}$$

which must be feasible for the borrower; therefore we define: $R^*_r(\omega) = \min\left\{y, \hat{R}_r(\omega)\right\}$. Figure 1 shows the locus (15), (16) and (17). We can now fully characterize the sets of equilibria (also shown in Figure 1):

Proposition 1. *There exists a threshold $\hat{\alpha}(k) \in (\underline{\alpha}(k), \overline{\alpha}(k))$, decreasing in k, and subjective beliefs $\beta(\widetilde{\omega})$ 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 a unique SSCE that is not REE, which is characterized by excessive credit tightening and risk taking (item (*iv*)). Hence, in this model, misbeliefs can only sustain credit crises.

[13] Simple algebra shows that: $\underline{\alpha}(k) = \frac{\gamma(y-k)-r\delta-k}{\gamma(y-k)-r\delta}$ and $\overline{\alpha}(k) = \frac{y-\delta-k}{y-\delta}$.

The conditions for the existence and uniqueness of a non REE risky SSCE 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 sufficiently high; in other words, lenders must believe themselves to be in global maximum of their value function while they are in a local one – formally, $\alpha < \hat{\alpha}(k)$ and $E^{\beta}[k]$ sufficiently high that $E^{\beta}[\hat{\alpha}(k)] < E^{\beta}[\alpha] = \alpha$.[14] On the other hand, a non REE safe SSCE does not exist because of the requirement of *strong* in our definition (condition (12)). In fact, non REE safe SSCE could only exist along the contract frontier $\bar{R}$, but SSCE requires lenders to have correct beliefs about borrowers' reaction in at least a neighborhood of $\bar{R}$; in this case (12) would imply knowledge of both α and k and so missbeliefs cannot be part of an equilibrium on $\bar{R}$.

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, which 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 Figure 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 can only 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 can increase their interest rates self-confirming high default rates, which in turn justify high interest rates.

Figure 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 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_a^{ree}, 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

[14] Note that the restrictions on subjective beliefs needed to sustain a Self-Confirming crisis are compatible with belief heterogeneity. It should also be noted that considering risk aversion or ambiguity would expand the set of beliefs that sustain a Self-Confirming crisis, see, Battigalli et al. (2015).

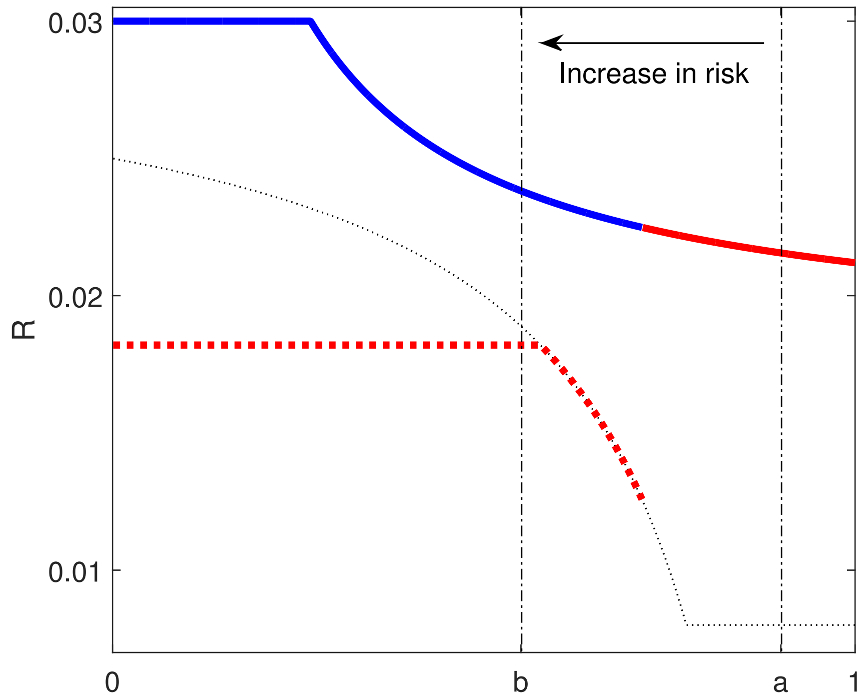

Figure 1: **(i) Equilibria in the (α, R) space**, given $k = 0.005$. The thick solid line denotes R_r^* whereas the thick dotted denotes R_s^*. Red curves indicate $\mathbb{R}^{ree}$ and blue curves $\mathbb{R}^{ssce}$ not $\mathbb{R}^{ree}$. The thin dotted curve plots $\bar{R}$. Other parameters are: $y = 0.03, \delta = 0.008, \gamma = 0.4, c = 0.001, A = 0.1$. **(ii) Weaker fundamentals (α going from a to b) create room for a Self-Confirming crisis.**

curve. The new curve, supported by subjective beliefs, peaks at $R_b^{ssce} > R_a^{ree}$, accounting for higher risk premia factored into interest rates.

A subjectively perceived lottery

In Figure 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 $p = 0.07$ on k being low, i.e. $k_L = 0.005$, and residual probability 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.

Figure 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, respec-

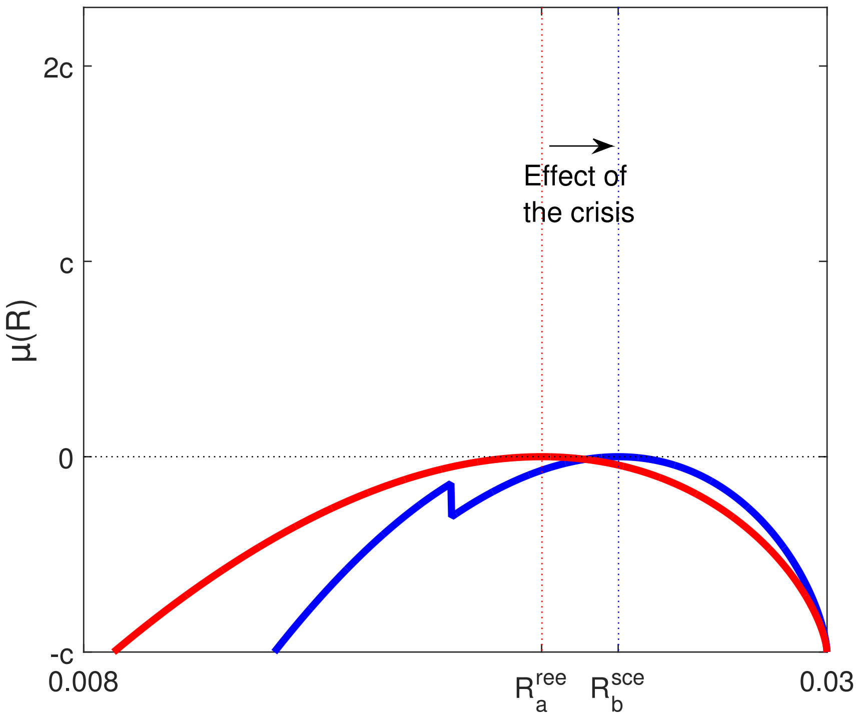

Figure 2: **In a Self-Confirming crisis, an increase in risk implies higher interest rates.** The figure plots the borrower-expected payoffs in the $(\mu^{\beta}(R), R)$ space whenever everybody else posts equilibrium contracts, in two situations: with $\alpha = a$ (red curve) and with $\alpha = b$ (blue curve). The optimal contract moves from R_a^{ree} to R_b^{sce}. Other parameters are: $y = 0.03, \gamma = 0.4, c = 0.001, A = 0.1$.

tively. Although a lender may understand that R_b^{ree} entails the strictly dominant action in case of a low k, this state is believed with too small a probability to induce an individual deviation. This misbelief is a necessary condition for R_b^{ssce} to be an equilibrium.

Private vs. social cost of uncertainty

The interest rate R is an individual choice of a lender. One could wonder whether, in our economy, a lender could have incentives to potentially experiment with large deviations, risking losses. 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 Figure 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. The definition of *large* is given implicitly by the size of the set of contracts for which lenders' beliefs are correct, on which, as we said, the definition of equilibrium does not put restrictions. Moreover, as noted by Battigalli et al. (2015) risk or ambiguity aversion may increase the perceived cost to experiment which further decreases individual

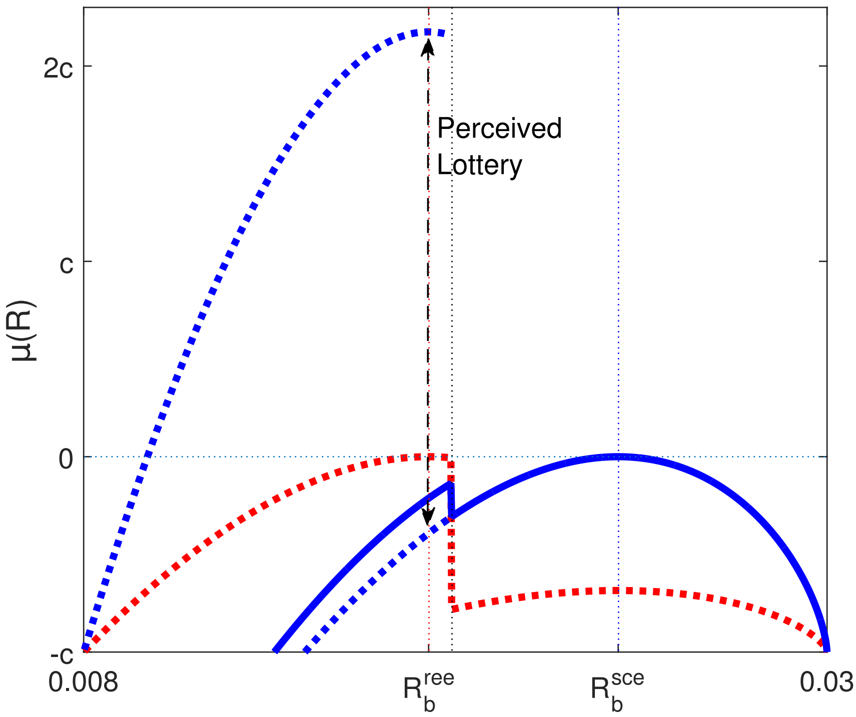

Figure 3: **At a Strong Self-Confirming Equilibrium, a lender perceives a out-of-equilibrium lottery with negative expected value.** The figure plots individual expected values of contracts in the $(\mu^{\beta}(R), R)$ space whenever everybody else posts equilibrium contracts in the case where $\alpha = b$ – 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: $y = 0.03, \gamma = 0.4, c = 0.001, A = 0.1$.

incentives to do that. Concerning expected gains, 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. If one one side, one may argue that the introduction of noisy learning may weaken this mechanism, on the other, it may also increases the perceived individual costs of experimenting.

From a social point of view on the other hand, the evaluation of different equilibria changes dramatically. Figure 4 plots social welfare, measured in terms of cost-per-vacancy c, as a function of α. Colors 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 an REE where borrowers adopt safe projects (i.e. in the interior of the 'safe adoption set' in Figure 1). Social welfare is instead decreasing in α when $\alpha \in (\underline{\alpha}, \bar{\alpha})$ i.e. the safe equilibrium arises as a corner

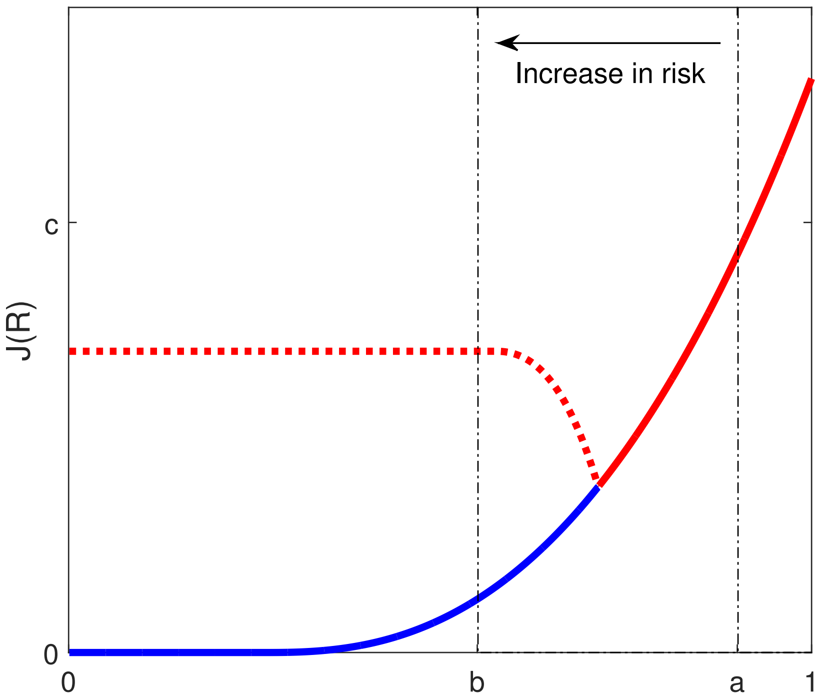

Figure 4: **Social welfare in a self-confirming crisis.** Social welfare, i.e. $J(R^*)$, is represented in the $(J(R), \alpha)$ space. The thick solid line denotes $J(R_r^*)$ whereas the thick dotted line denotes $J(R_s^*)$. Red curves indicate $\mathbb{R}^{ree}$ whereas the blue curve indicates $\mathbb{R}^{ssce}$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

solution. 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 denoted in the figure with a blue line. The drop would have been much lower at the unique REE.

3 Credit Easing as an optimal policy

In this section we study optimal policy. 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; i.e. the planner is a *Ramsey planner*. The socially most preferred R, namely[15] $R^\star$, 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,

$$\max_R E^\beta[\underbrace{p\left(R\right)\pi^b\left(\rho^*\left(R\right)\right)}_{\equiv J(R)}], \tag{18}$$

subject to

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

and

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

Note that in (18) the subjective beliefs are those of the planner[16]. 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 plugging constraints into the objective we can derive a welfare criterion to evaluate contracts:

$$\bar{\mu}^\beta(R) \equiv E^\beta[\pi^l(R;\rho^*(R,\omega))]^{\frac{1-\gamma}{\gamma}} E^\beta[\pi^b(\rho^*(R))], \tag{19}$$

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: $E^\beta\left[J\left(R_1\right)\right] \geq E^\beta\left[J\left(R_2\right)\right] \Leftrightarrow \bar{\mu}\left(R_1\right) \geq \bar{\mu}\left(R_2\right)$. Comparing (19) 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:

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

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

Lemma 2. *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 2 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 planners' 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 recover a 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:

$$\max_{d} E^{\beta}[\underbrace{p(R)\,\pi^{b}(\rho^{*}(R,\omega)) - d}_{\equiv J(R,d)}], \tag{20}$$

subject to

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

and

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

where d denotes a subsidy to lenders financed by taxing borrowers. Plugging 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

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

then $d^{\star}(R) = \arg\max_{d} v^{\beta\star}(d;R)$. Since $v^{\beta\star}(\cdot;R)$ is concave, a necessary and sufficient condition for $d^{\star}(R)$ to be an optimal subsidy for a given R is [17]:

$$\frac{1-\gamma}{\gamma} \frac{1}{E^{\beta}[\pi^{l}(R;\rho^{*}(R,\omega))] + d^{\star}(R)} - \frac{1}{E^{\beta}[\pi^{b}(\rho^{*}(R,\omega))] - d^{\star}(R)} = 0, \tag{22}$$

that is,

$$d^{\star}(R) = (1-\gamma)E^{\beta}[\pi^{b}(\rho^{*}(R,\omega))] - \gamma E^{\beta}[\pi^{l}(R;\rho^{*}(R,\omega))]. \tag{23}$$

The optimal subsidy defined by (22) 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:

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

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

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 (22) and (14), we obtain:

Lemma 3. *If $R^{*} \in \mathbb{R}^{ssce}$ then $d^{\star}(R^{*}) = 0$.*

Lemma 3 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

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

with a different allocation. Given the contingent optimal subsidy $d^\star(R)$, the socially most preferred R gives the optimal policy target, as we discuss below.

P2: The optimal interest rate target: $R^\star$. Equation (23) defines an optimal subsidy for every feasible interest rate R. Plugging (23) into (21) provides a simple characterization of the planner's preferences over interest rates, given the optimal policy reaction:

$$\mu^{\beta\star}(R) \equiv v^{\beta\star}(d^\star(R); R) = \gamma(1-\gamma)^{\frac{1-\gamma}{\gamma}} E^\beta[\mathcal{S}(R, \rho^*(R,\omega))]^{\frac{1}{\gamma}}. \tag{26}$$

This reduces the social evaluation to a simple total expected surplus criterion, given by $\log\left(\mu^{\beta\star}(R)\right)$. In other words, if we consider two alternative economies trading at interest rate R_1 with a transfer $d^\star(R_1)$ and R_2 with a transfer $d^\star(R_2)$, respectively, from the planner's perspective $E^\beta\left[J\left(R_1, d^\star(R_1)\right)\right] \geq E^\beta\left[J\left(R_2, d^\star(R_2)\right)\right] \Leftrightarrow E^\beta[\mathcal{S}(R_1, \rho^*(R_1))] \geq E^\beta \mathcal{S}(R_2, \rho^*(R_2))]$.

In general, the evaluation given by $\bar{\mu}^\beta(R)$ defined by (19) and $\mu^{\beta\star}(R)$ defined by (26) 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 4. *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 $\rho^*(R^\star) = s$

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.

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 $E^\beta[\pi^l\left(R; \rho^*(R,\omega)\right)]$ and $E^\beta[\pi^l\left(R; \rho^*(R)\right)]$, respectively. As a result, the private evaluation criterion in the case of a subsidy becomes

$$\mu^{\beta}(R;d) \equiv \left(E^{\beta}[\pi^{b}\left(\rho^{*}(R,\omega)\right)] - d\right)^{\frac{\gamma}{1-\gamma}} \left(E^{\beta}[\pi^{l}\left(R;\rho^{*}(R)\right)] + d\right) \tag{27}$$

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 (24) and (25) in (27), 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 2. *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 5. *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 $\rho^{*}(R^{\star}) = s$. Since, by proposition 1 safe equilibria must also be 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). However, lenders are totally indifferent to the implementation of the policy. The fact that all the distribution of posted contracts moves after the subsidy, leaves the lenders at zero expected profits anyway – that is, they do not get any advantage from 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 Figure 3. In that example, the probability of a low k_L, namely p, is also the probability that

$$\mathcal{S}(R', s) > E^{\beta}\left[\mathcal{S}(R_{b}^{ssce}, r)\right], \tag{28}$$

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):

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

and given that, by Lemma 3, $d^\star(R_s^{ree}, s) = 0$ then, by (23), we finally have

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

which satisfies (22). Through the subsidy, lenders internalize the social evaluation of interest rates (27), 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 Figure 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:

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

so that $d^\star(R_b^{ree}) = bd^\star(R_b^{ree}, \mathsf{c}) + (1-b)d^\star(R_b^{ree}, \mathsf{f})$. 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

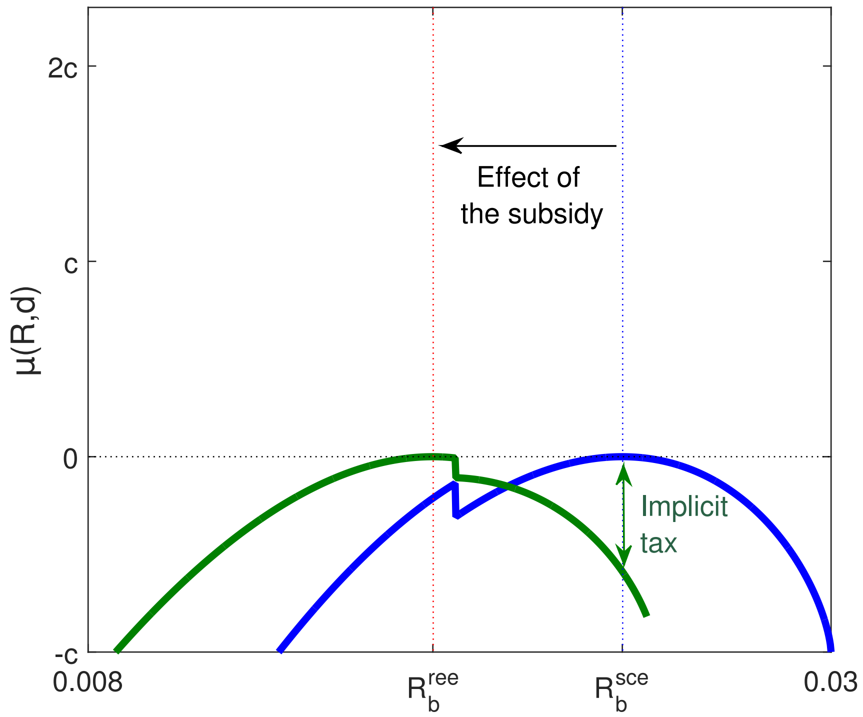

Figure 5: **The effect of the optimal subsidy.** The figure plots individual expected values of contracts in the $(\mu(R), R)$ space, whenever everybody else posts equilibrium contracts, in the case where $\alpha = b$ with (green curve) and without (blue curve) subsidy. In this example, the subsidy targets 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: $y = 0.03, \gamma = 0.4, c = 0.001, A = 0.1$.

matched borrower finances *in expectation* a matched lender.[18] 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

Theories based on the concept of Self-Confirming Equilibrium rely on out-of-equilibrium beliefs as a free explanatory variable. This raises some questions: what may induce misperceptions in the first place? Why are such misperceptions similar across agents? What kind of evidence identifies misbeliefs in the data? What eventually may correct missbeliefs?

To answer these questions the macro literature on Self-Confirming Equilibria (e.g.

[18]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.

Primiceri (2006) and Sargent et al. (2006)) relied on the natural (and experimentally validated) assumption that agents form their expectations based on publicly available data. Similar missbeliefs about never observed counterfactuals are more likely to emerge in markets that strongly rely on public information. Shifts across SCE equilibria are then determined by shifts in agents' inference as changes in fundamentals and/or policy produce new available data.

In this section we provide empirical support to our theory by adopting a similar approach. We focus on a specific policy event: the implementation of the TALF policy in the primary ABS market briefly described in our introduction. Our main goal is to demonstrate that the general logic of self-confirming equilibria can rationalize the evidence relative to TALF. Our empirical test however cannot reject the relevance of alternative explanations.[19] As we discuss at the end of our introduction, we see these alternatives, in particular the one on liquidity shortage, as complementary to ours.

In a nutshell, we focus on the publicly observable information available before and after TALF implementation in one of the key ASB sectors: Auto Loans. We show that before TALF similar perceptions on the correlation between interest rates and risk were sustained by public market data. Then we show that the new evidence that emerged after the introduction of TALF actually confuted pre-TALF (mis)perceptions. We conclude that in the absence of TALF the Auto ABS market would have shut down; in such a case, it would have been unlikely to restart it even under more favorable liquidity conditions. In the following we define our test, we discuss the data and present the results.

Explaining skepticism about TALF and its success

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 Figure 1. Imagine for a moment that all companies are equal in primitives. A shift induced by an exogenous increase in underlying risk moved the equilibrium from a risky REE to a risky SCE.[20] In the risky SCE we observe higher interest rates in response to higher risk. We should have observed then that, for a given cost of funding, higher interest rates were required by ABS buyers to hedge against losses. More precisely, Figure 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) produces 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

[19] In the end, the existence of observationally equivalent theories is the quintessence of the Self-Confirming logic. As a matter of fact, only counterfactuals can distinguish between observationally equivalent theories and these can be rarely invoked in Macroeconomics without any leap of faith.

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

increase in risk, evidence of higher losses at lower rates should sustain high market rates. We use cross-sectional differences across firms to elicit information about this prediction.

Let us refer to "interest spreads" as the difference between interest rates and the cost of funding (i.e. $R - \delta$ in our model), 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 losses at the expense of the US taxpayer, as Paul Krugman's quote, opening our introduction, suggests.

The effect of the TALF could be understood as the effect of our optimal policy, illustrated in Figure 5. Interest rates decrease due to the effect of the insurance on counterpart risk. Competition drives interest spreads down, finally revealing the lower losses associated with lower interest rates. More precisely, Figure 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 marginally lower interest rates than R_b^{sce} result in lower losses, which are 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. We also use cross-sectional differences across firms to elicit information about this prediction.

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.

4.1 Dataset for *newly-generated* ABS Auto Loans

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. In what follows we describe our dataset.

Our Dataset

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 Table 2. 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.

[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".

The monthly flow of cumulative losses follows a strong deterministic non linear pattern, documented in appendix C.3, with most of the losses occurring in the first half of the security life[23].

A first look at the rough data gives a sense of the specific impact of the TALF on the ABS Auto market in the context of the general macroeconomic outlook. We report figures and discussion in the Appendix C.4. Here it is worth noting that the evolution of our sample suggests that the introduction of the TALF had a positive impact on the Auto ABS market, which was asynchronous to the evolution of the general US macro outlook. Looking at rough data, the naked eye can easily distinguish between two periods: a pre-TALF period where ABS interest spreads increase, issuance falls and losses are high, and a post-TALF where interest spreads dramatically fall and stay low, issuance recovers and losses decrease. In what follows we are going to measure this pattern in the data precisely and show that there is a – statistically significant – flip in sign of the correlation between interest rates and losses in line with our hypothesis.

4.2 Testing H1 and H2

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

$$mL_{i,T,t} = \beta_0 + \beta_1 D_T + \beta_2 \Delta r_{i,T} + \beta_3 D_T \Delta r_{i,T} + controls + \epsilon_{i,t,T}, , \tag{29}$$

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 corresponding interest spread computed as the average of interest rates across the different categories of notes issued at time t by company i weighted for their volumes minus the 1-month Libor at the time of the first payment of the tranche[24], and D_T denotes a dummy which is 1 when $mL_{i,T,t}$ belongs to a tranche issued after the introduction of TALF – i.e. T >March 2009 – and 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. 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). Therefore, the losses that we observe at a

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

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)		
$\Delta r_{i,T}$	$\boxed{-0.774^{**}}$	$\boxed{-0.377^{**}}$	$\boxed{-0.372^{***}}$	$\boxed{-2.193^{**}}$	$\boxed{2.203^{***}}$
	(0.301)	(0.147)	(0.102)	(0.881)	(0.565)
$D_T\Delta r_{i,T}$	$\boxed{1.812^{**}}$	$\boxed{1.038^{**}}$	$\boxed{1.080^{***}}$		
	(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

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

Table 1

given time t enter in our regression in two different ways depending on whether they belong to tranches issued before TALF – for which $D_T = 0$ – or after TALF – for which $D_T = 1$. In practice we test whether the correlation losses-spreads – across tranches and time – induced in a high-spread regime is different from the correlation induced in a low-spread regime, with the switch between these two regimes being triggered by the activation of TALF.

It is important to remark that our dummy is active if the tranche was issued after TALF independent of whether or not this tranche directly benefited from TALF (i.e. has been taken on the balance sheet of the Fed). First of all, bear in mind that no subsidy was actually implemented (i.e. all loans were repaid in full and the ABS given as collateral taken back). Moreover, our choice depends on the fact that we are testing the effect of public learning: whether or not a particular tranche was actually taken by the Fed does not affect the ability of issuers of new tranches to learn about profitability at low-spreads levels from publicly available performances of other tranches in the past. This is also relevant after the TALF window expired, once issuers learned issuance had been permanently stable at low spreads.

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 of them 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 we show that our results are robust to sample choice.

Base 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 acting across all losses of all companies at the same date; among them there are business-cycle fluctuations but also specific measures adopted by the Auto sector in this period.[25] The security life effect is intended to control for the non-linear deterministic trend, documented in appendix C.3, which shows that most of the losses occur in the first half of the security life; 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 controlling all these controls are in place, contemporaneous losses may only differ for the differential effect of interest spreads. The presence of fixed effect controls lowers coefficient estimates by roughly a half, confirming their significance and increasing the R^2 from 0.11 of the previous specification 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[26]. 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

[25] See, for example, Agarwal et al. (2015) and Ramcharan et al. (2015).

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

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.[27] 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 Figure 8: 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 Figure 8.

Summary. The results in Table 1 strongly suggest that our hypotheses H1 and H2 hold true. In the Appendix we present a similar analysis by considering different samples. First we perform Amounts, pre-talf and post-talf specifications by excluding non-offered notes in the computation of the average interest spread, but controlling for their volumes. Then we run 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 here.

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

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

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.

Discussion: Why looking at ABS Auto Loans?

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 postpone a more detailed mapping to Appendix B.1-Appendix B.2.

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. [28] We chose to look at this market because the peculiar characteristics of the underlying contracts make our analysis particularly informative.

In 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 con-

[28]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.

tracts 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 in other contexts; e.g. in inefficient REE[29]. While we presented a new theory, the paper also emphasizes 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 theory.

[29]For example, if the *subjective beliefs* characterized in Section 2.3 (Figures 2 and 3) where *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.

A Appendix: Proof. of Proposition 1

Proof. First, let us investigate the set of REE as depending form α. For $\alpha < \underline{\alpha}(k)$ we have

$$\mu(R_r^*) = \pi^b(r; R_r^*, \omega)^{\frac{\gamma}{1-\gamma}} \pi^l(R_r^*; r) < \mu(\hat{R}_s) = \pi^b(s; \hat{R}_s, \omega)^{\frac{\gamma}{1-\gamma}} \pi^l(\hat{R}_s; s),$$

that is,

$$\gamma^{\frac{\gamma}{1-\gamma}}(1-\gamma) \max\left\{(\alpha y - \delta)^{\frac{\gamma}{1-\gamma}}, 0\right\} < \gamma^{\frac{\gamma}{1-\gamma}}(1-\gamma)(y-k-\delta)^{\frac{\gamma}{1-\gamma}},$$

which is true given $\bar{R} > 0$. We conclude that whenever $R_s^* = \hat{R}_s$ thenR_s^* is an REE.

For $\alpha > \bar{\alpha}(k)$, contracts that induce the safe adoption require an R lower than the cost of money δ, therefore R_r^* will be the unique REE for $\alpha > \bar{\alpha}(k)$.

For $\alpha \in (\underline{\alpha}(k), \bar{\alpha}(k))$ we have that $R_s^* = \bar{R}$. The relevant equation for $R_s^* = \bar{R}$ to be unique REE is

$$\mu(R_r^*) = \pi^b(r; R_r^*, \omega)^{\frac{\gamma}{1-\gamma}} \pi^l(R_r^*; r) < \mu(\bar{R}|\rho = k) = \pi^b(r; \bar{R}, \omega)^{\frac{\gamma}{1-\gamma}} \pi^l(\bar{R}; s),$$

that is,

$$\gamma^{\frac{\gamma}{1-\gamma}}(1-\gamma) \max\left\{(\alpha y - \delta)^{\frac{\gamma}{1-\gamma}}, 0\right\} < \left(\left(y - \frac{k}{1-\alpha} - \delta\right)\left(\frac{\alpha k}{1-\alpha}\right)^{\frac{\gamma}{1-\gamma}}\right).$$

On the one hand, $\mu(R_r^*)$ is always monotonically increasing in α. On the other hand, $\mu(\bar{R})$ is always monotonically decreasing in α, given that:

$$\frac{\partial\left(\left(y - \frac{k}{1-\alpha} - \delta\right)\left(\frac{\alpha k}{1-\alpha}\right)^{\frac{\gamma}{1-\gamma}}\right)}{\partial \alpha} = \frac{(1-\alpha)\gamma(y-k-\delta) - 2k\alpha}{\alpha(1-\alpha)^2(1-\gamma)}\left(\frac{\alpha k}{1-\alpha}\right)^{\frac{\gamma}{1-\gamma}} < 0,$$

holds for $\alpha \in (\underline{\alpha}, \bar{\alpha})$.[30] Hence, we can conclude that

$$\left(y - \frac{k}{1-\alpha} - \delta\right)\left(\frac{\alpha k}{1-\alpha}\right)^{\frac{\gamma}{1-\gamma}} = \gamma^{\frac{\gamma}{1-\gamma}}(1-\gamma) \max\left\{(\alpha y - \delta)^{\frac{\gamma}{1-\gamma}}, 0\right\},$$

defines a threshold $\hat{\alpha}(k)$, such that for $\alpha < \hat{\alpha}(k)$ $R_s^* = \bar{R}$ is the unique REE, whereas for $\alpha > \hat{\alpha}(k)$, R_r^* is the unique REE. The hedge case $\alpha = \hat{\alpha}(k)$ is the only one where two REE exist. To conclude, note that

$$\frac{\partial\left(\left(y - \frac{k}{1-\alpha} - \delta\right)\left(\frac{\alpha k}{1-\alpha}\right)^{\frac{\gamma}{1-\gamma}}\right)}{\partial k} = \frac{(1-\alpha)\gamma(y-\delta) - k}{k(1-\alpha)(1-\gamma)}\left(\frac{\alpha k}{1-\alpha}\right)^{\frac{\gamma}{1-\gamma}} < 0$$

[30] Note that $\alpha k/(1-\alpha(k))$ is increasing in α and $k\underline{\alpha}/(1-\underline{\alpha}) = \gamma(y-k-\delta)$.

holds for $\alpha \in (\underline{\alpha}(k), \bar{\alpha}(k))$.[31] This implies that $\hat{\alpha}(k)$ has to be decreasing in k. $\square$

Let us now discuss the condition for an SSCE that is not REE. Suppose lenders play R_r^* and that $\alpha < \hat{\alpha}(k)$. By definition of SSCE their expectations about $\rho^*(R_r^*, \omega)$ are correct at the equilibrium, which implies that lenders know α but can have misspecified beliefs about k. In particular, for a $E[k]$ sufficiently high, such that $\hat{\alpha}(E[k])$ is sufficiently low, we can have $\alpha > \hat{\alpha}(E[k])$ which implies that lenders wrongly believe that R_r^* is the unique REE (i.e. the global maxima when evaluated by β).

On the other hand, R_s^* cannot be SSCE without being REE. Suppose such an equilibrium exists, then it would arise as a corner solution posted at the frontier $\bar{R}$ because it turns out that interior solutions $\hat{R}_s$ are always REE (i.e. the global maxima when evaluated by ϕ). Nevertheless, by definition of an SSCE, agents would have correct beliefs for local deviations from the equilibrium that, at the frontier, are indeed sufficient to induce safe project adoption. Therefore at an SSCE posted along the frontier $\bar{R}$, agents would know the actual α. Hence lenders can correctly forecast $\rho(R, \omega)$ at any R, and so they cannot sustain a safe SSCE that is not an REE. A contradiction arises.

B Appendix: mapping model and policy

B.1 Mapping the model into the market for *newly-generated* ABS

Here, we discuss the mapping between our model and the market for *newly-generated* ABS. It is important to remark at the outset that our theory fits the case of primary market for the *newly-generated* ABS, whereas it does not apply to secondary markets, as the one for legacy CMBS. We will come back to this important point later.

a) Payoffs, liquidation and risk retention. We can think of a borrower as a financial company that collects a pool of illiquid loans that matures in one period.[32] Loans can be of two types: safe and risky. One unit of safe loans always yields one unit of capital plus receivables for a total of $1 + y$; risky loans instead yield $1 + y$ with a probability α, and only 1 otherwise. Collecting safe loans, in contrast to risky loans, requires a per-unit cost of k, which accounts for screening or opportunity costs needed to secure receivables y.

To liquidate its pool of loans, the borrower issues an ABS, i.e. an obligation which is backed by one unit of the pool of loans. This obligation is sold at 1 and will yield $1 + R$ in one period. However, the liability of ABS issuers (who formally issues the asset via an ad-hoc created special purpose vehicle) is limited to the value of the underlying pool of credits, so the borrower will be able to repay R only in the case that receivables y mature. Notice that the borrower also bears the risk of failure, which is consistent with the practice of ABS issuers to retain part of the risk in the attempt to signal the

[31] Note that $k/(1 - \alpha)$ is increasing in α and $k/(1 - \underline{\alpha}(k)) = \gamma(y - \delta) + (1 - \gamma)k$.

[32] Whether payments occur in one or several periods does not make any difference as long as the schedule of payments is fixed at the beginning of the contract.

absence of asymmetric information. Indeed, note that in our model there is no asymmetric information on equilibrium outcomes, but only on out-of-equilibrium behavior.

c) The role of public information. A buyer of the ABS, i.e. the lender, does not observe the actual quality of the underlying credit, as well as the particular pooling and tranching strategy adopted by the ABS issuer. This generates counter-part risk in the market. In particular, in these markets, investors' valuation relies almost exclusively on the historical performances, which are published quite regularly and classified according to precise rating rules. In this sense, market conditions - and hence the offered R for a given class of ABS - are predetermined at the moment of the ABS generation and there is no credible way of signalling the quality of the underlying asset. Importantly, this institutional arrangement forces issuers to closely maintain the same ABS structure over time, as investors are typically reluctant to buy ABS for which there are no sound historical records.

However, an ABS issuer observes the market conditions at which it can sell its ABS. Therefore, pricing in the *newly-generated* market may affect the way issuers pack ABS, which ultimately determines their riskiness. This is a specific feature of primary markets; by contrast in secondary markets the riskiness of an asset is independent of agents' trade. The key mechanism of our theory therefore does concern only the *newly-generated* ABS market and not legacy CMBS.

c) Search and matching. Finally, our competitive search setting captures the fact that competition in ABS markets is mainly driven by prices, but there is no agent on the market that can trade infinite amounts.[33] On the one hand, borrowers cannot generate whatever quantity of ABS is demanded, since available credit (especially of AAA quality) is limited; on the other hand, buying ABS requires costly intermediation in specialized financial institutions and exposures are normally bounded by the availability of funds and other micro-prudential concerns.

B.2 Mapping optimal policy into TALF design

In this subsection we want to discuss how some key features of TALF on *newly-generated* ABS map into our optimal policy.

a) A contingent subsidy to ABS investors. TALF offered non-recourse loans against highly rated ABS with a 15% haircut. The non-recourse nature of the loan gave the option to the ABS investor to eventually default on the loan putting the ABS collateral back into the hands of the Fed. Thus, TALF constitutes a subsidy to ABS investors contingent on losses on the ABS value, where losses are defined as the ABS losing more than 15% of its market value.[34].

[33]The interpretation of competitive search models as models of price competition with quantity constraints was originally introduced by Peters (1984). We thank Philipp Kircher for this reference. Note also that by pushing entry cost to zero, the model approximates Bertrand competition.

[34]To be precise, one could consider the rate of the Fed loan as an uncontingent component of the TALF subsidy. However such a rate was generally high, relative to the historical coupon rate of ABS. This feature was intended to induce a smooth exit from the program (for further details, see Ashcraft

b) Ramsey implementation TALF relied on the purchases of ABS by private investors. The policy intervention did not undermine the ability of the private sector to price the new securities. In this sense, with the TALF the Fed did not substitute itself for the market, as with other more intrusive types of policies (e.g. direct purchases of traditional quantitative easing).

c) The subsidy was independent of specific terms of trade. In particular, the program did not require a particular amount or a particular level of coupon rates, so in this sense it was independent of the single trading actions of investors and issuers. Thus, as in our model, the evaluation of the pros and cons of TALF could be done by investors on a per-unit base.

d) TALF required explicit fiscal backing. With TALF, the Fed committed itself to being a buyer of last resort in the event of a further abrupt collapse of the market, taking tail risk that at that time the market did not want to take (but leaving first-order losses to private investors!). TALF required an explicit backing by the Treasury to allow the Fed to take up this risk.[35] In our model, we made the policy a self-financed one, which is of course a tighter requirement for policy intervention.

C Appendix: Empirics

C.1 Data on ABS in the Automotive Industry

The data that we have collected provides information on Asset Backed Securities (ABS) in the US automotive sector. The data include information on: Cumulative Losses with respect to the original Pool Balance, Interest Rates, Principal Amounts in US dollars. The information is collected for 9 issuers in the automotive sector, namely: BMW Vehicle Lease Trust, CarMax Auto Owner Trust, Ford Credit Auto Owner Trust, Harley-Davidson Motorcycle Trust, Honda Auto Receivables Owner Trust, Hyundai Auto Receivables Trust, Nissan Lease Trust, Nissan Auto Receivables Owner Trust, World Omni Auto Receivables Trust.

Every year, each of these companies delivers a variable number of tranches. For instance, World Omni in 2008 extended loans in two tranches (2008-A, 2008-B), while the same company extended only one tranche in 2009 (2009-A). As far as our analysis is concerned, we collected all the free available online information on tranches issued from 2007 till 2012, a time span which includes the introduction of the Term Asset-Backed Securities Loan Facility (TALF). Table 2 reports the tranches sorted by issuers for which we have found information. Each of these Trusts issued loans of a different "Class" (or Asset Backed Notes): A1, A2, A3, A4, B, C and D. Obviously, the Principal Amount of

et al. (2012)).

[35] In the words of Ben Bernanke on 13 January 2009: "Unlike our other lending programs, this facility [TALF] combines Federal Reserve liquidity with capital provided by the Treasury, which allows it to accept some credit risk" "The Crisis and the Policy Response", the Stamp Lecture, London School of Economics.

	BMW	Carmax	Ford	Harley	Honda	Hyundai	Nissan Lease	Nissan Owner	World Omni
2007	2007-1	2007-1 2007-2 2007-3	2007-A 2007-B	2007-1 2007-2 2007-3	2007-1 2007-2 2007-3	2007-A	2007-A	2007-A 2007-B	2007-A 2007-B
2008		2008-1 2008-A 2008-2	2008-B 2008-B 2008-C	2008-1	2008-1 2008-2	2008-A	2008-A	2008-A 2008-B 2008-C	2008-A 2008-B
2009	**2009-1**	**2009-1** **2009-A** 2009-2	**2009-A** **2009-B** **2009-C** **2009-D** 2009-E	**2009-1** **2009-2** **2009-3** **2009-4**	**2009-2** **2009-3**	**2009-A**	**2009-A** **2009-B**	2009-1 **2009-A**	**2009-A**
2010	2010-1	2010-1 2010-2 2010-3	2010-A 2010-B	2010-1	2010-1 2010-2 2010-3	2010-A 2010-B	2010-A 2010-B	2010-A	2010-A
2011	2011-1	2011-1 2011-2 2011-3	2011-A 2011-B	2011-1 2011-2	2011-1 2011-2	2011-A 2011-B 2011-C	2011-A 2011-B	2011-A 2011-B	2011-A 2011-B
2012	2012-1	2012-1 2012-2 2012-3 2012-3	2012-A 2012-B 2012-C 2012-D	2012-1		2012-A 2012-B 2012-C	2012-A 2012-B	2012-A 2012-B	2012-A 2012-B

Table 2: List of tranches for every issuing company (in **bold** the tranches that were eligible collateral under TALF).

these loans differs by Class, and each Class is also characterized by a different degree of risk (interest rate). It goes from the more secure loan with the lowest interest rate (A1) progressively to the riskier categories (A2, A3 and so on). The Trust will pay interest and principal on the notes on the 15th day of each month (or the next business day).

All the issuing entities listed in **bold** in Table 2 were eligible for the TALF program. The number of tranches that were eligible varies by issuer. The program started on 25 March 2009. The tranches covered by the TALF program that are included in the database are sufficiently representative of the whole sample of Asset Backed Securities covered by TALF in the US automotive sector; more precisely, the sum of the loan amounts mentioned above represents around 46.5% of all Auto-ABS covered by TALF (calculations are our own, reference "TERM ASSET-BACKED SECURITIES LOAN FACILITY DATA" from FED). 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 the Trusts' prospectuses.

C.2 Construction of the variables for the Empirical analysis

Cumulative Losses with respect to the original Pool Balance, $mL_{i,T,t}$. The cumulative net losses for each issuing entity and for every tranche refer to the total pool, which includes all risk classes. Therefore, data on losses are not available at disaggregated class level. The losses are reported monthly and the time span of monthly losses varies depending on the date Trusts are issued and the number of payments expected.

Rate Spreads, $\Delta r_{i,T}$. Interest rates vary within tranches according to seniority. For some Asset Backed Notes the loans are issued as a combination of fixed and floating components of interest rates. For instance, in the case of Ford Credit Auto Owner Trust 2007-A the Class A2 is divided into the 'a' and 'b' components, where the 'a' component extends loans with a fixed interest rate of 5.42% and the 'b' component has the floating rate of one-month Libor + 0.01%. In those few cases we calculate the weighted average of class A2, where the weights are the principal amounts in US dollars for each component and the floating component is substituted by the corresponding FED one-month Libor at the time when the first payment was made (source: *http://www.fedprimerate.com/libor.htm*) plus 0.01.

As an example of computation of rate spreads we use World Omni Auto Receivables Trust 2009-A where for the Classes A1,A2,A3 and A4 the calculated interest rate differentials are 1,17%, 2.43%, 2.88% and 4.67%, respectively, while the corresponding principal amounts in US million dollars are 163, 192, 248 and 147, respectively. Table 3 gives an example of the structure of the data and how the information on Principal Amounts and Interest Rates are presented for each tranche in all prospectuses. The resulting weighted average of rate spreads for each Trust is $((1.17\% * 163m.) + (2.43\% * 192m.) + (2.88\% * 248m.) + (4.67\% * 147m.))/(163m. + 192m. + 248m. + 147m.)$.

Asset Backed Notes 2009-A	Class A1 Notes	Class A2 Notes	Class A3 Notes	Class A4 Notes
Principal Amount	$163m.$	$192m.$	$248m.$	$147m.$
Interest Rate	1.62%	2.88%	3.33%	5.12%
Payment Dates	Monthly	Monthly	Monthly	Monthly
Initial Payment Date	May 15,2009	May 15,2009	May 15,2009	May 15,2009
Final Scheduled Payment Date	April 15,2010	October 17,2011	May 15,2013	May 15,2014

Table 3: World Omni Auto Receivables Trust 2009-A (04-2009; 1m. libor at 0.45)

Principal Amounts in US dollars, $V_{i,T}$. Principal Amounts vary within Trusts according to the Class being considered. In our empirical exercise, it stands for a control; it is included as the sum of the Amounts within each Trust of all Asset Backed Notes. In the previous example for World Omni Auto Receivables Trust 2009-A, it enters the model as $(163m. + 192m. + 248m. + 147m.) = 750m.$

C.3 Non-linear trend in monthly losses

There is a common pattern that emerges for each tranche in the evolution of monthly losses over time, which tends to peak around the 15th-20th month and then progressively dies away as time goes by. This means that losses concentrate in the first half of the life of each trend, whereas late losses can even be positive due to the recovery of earlier delinquencies. The pattern is well illustrated in Figure 6 which shows the predicted mean of monthly cumulative losses of ABS over time within a 95% confidence interval. The resulting decreasing trend over time is determined by clients' debt repayments of past instalments (reduction of delinquencies) which contributes to the flattening of the curve.

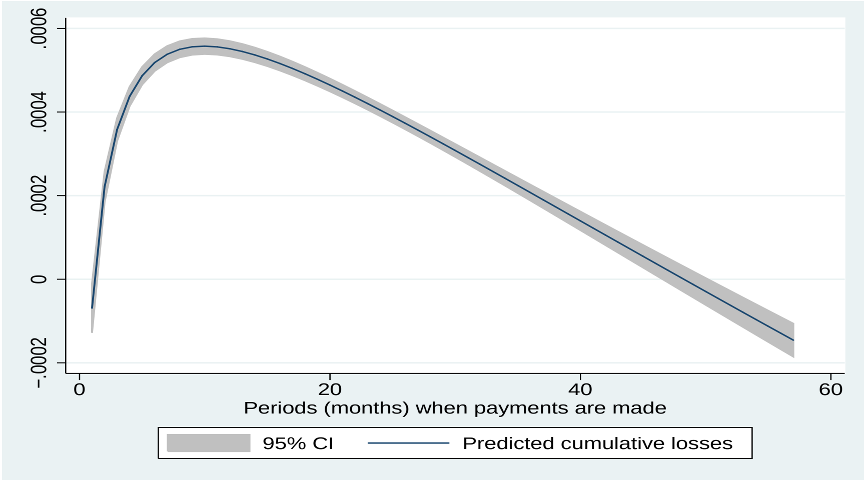

Figure 6: Predicted mean of ABS monthly cumulative losses over time: the y axis has the first differences of cumulative losses with respect to initial pool balance for each tranche $q(t)$, the x axis reports the time span of ABS repayments

C.4 Descriptive statistics

Figure 7 plots the sum of $V_{i,T}$ across companies at each point in time T. Note the collapse of issuance at the end of 2008 and the following recovery in 2009 during the TALF window. Contrast this with the course of the dotted green line, which denotes the total value (y-axis on the left) of minimal risk loan issued by US banks in the same period. The contrast highlights that the recovery in the ABS auto market during the TALF intervention coincides with the lowest pick of the safest segment of the credit market in the US economy.

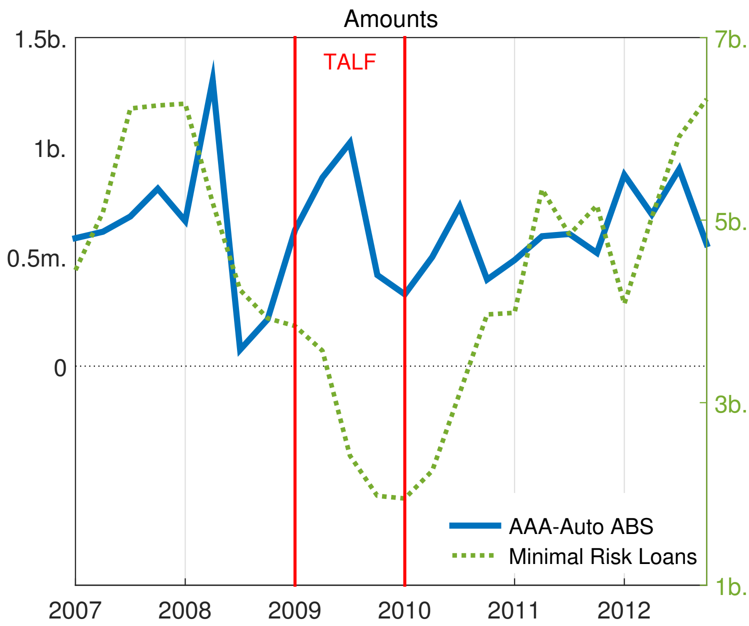

Figure 7: Total quarterly principal amounts issued in our sample for different categories of riskiness; the dotted line denotes the total amount of minimal risk loans agreed during the same period by US banks (3-quarter rolling window; scale on the right axis; source: ST. Louis FRED dataset.

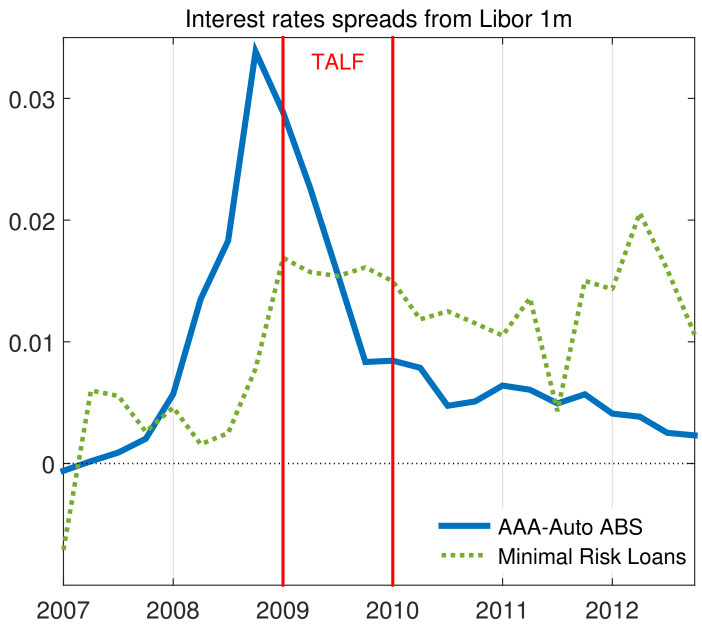

Figure 8: Quarterly weighted average (each company is weighted by its relative issued amount) of interest rate differentials from one-month Libor for different categories of riskiness; the dotted line denotes the interest rate differential from the one-month Libor on minimal risk loans agreed during the same period by US banks; source: St. Louis FED dataset.

Figure 9: Average monthly loss for each tranche in the sample plotted in its quarter of issuance; the dashed line denotes losses experienced by US banks in the same period (scale on the right axis).

Figure 8 plots the average $\Delta r_{i,T}$ across companies weighted for their issuance at each point in time T. Note the sharp increase of interest rate differentials at the end of 2008 and the following decrease in 2009 during the TALF period. Contrast this with the evolution of the dashed green line, which denotes the interest rate differential on minimal risk loan issued by US banks in the same period. From the comparison we note that the decrease in rate spreads in the automotive market during the TALF intervention is in stark contrast with a permanent increase in rate spreads in the safest credit market in the US economy, which occurred at the beginning of 2009.

Figure 9 shows, for three representative companies, the evolution of the average $mL_{i,T,t}$ across time t relative to different issuance dates T. Note that the TALF period coincides with a drastic drop in average losses for each company. After TALF, losses never again reached the pre-crisis level. The figure also plots, with a dashed green line, the evolution of credit losses reported by all US banks in the same period. One can observe that while losses diminished in the AAA-Auto market, US banks were experiencing a rapid increase in delinquencies.

In each picture, the contrast with macro benchmarks – such as the ones represented by dotted/dashed lines in each figure – suggests that TALF had a specific effect in the ABS market that was asynchronous to the business cycle.

C.5 Other robustness tests

In Table 4 we quantify how the presence of Not-Offered-Notes (NON) in issuances may affect the results. To do this, we recalculate interest spreads by excluding NON, which we denote by $\Delta\tilde{r}_{i,T}$; we maintain company, data, security-life fixed effects and volumes as in our "Amounts" specification, but in addition we include the volumes of NON as controls and check for their differential impact. We get about the same result and we conclude that the presence of NON does not significantly alter our estimates.

In our "pre-talf$_{NON}$" we perform the same "pre-talf" exercise as in the main text taking into account the NON notes. In analogy to NON specification, we recalculate interest spreads excluding NON and we include the amounts of NON as controls. The results are very similar to our original "pre-talf" specification.

In our "post-talf$_{NON}$" we perform the same "post-talf" exercise as in the main text taking into account the NON notes. In analogy to NON specification, we recalculate interest spreads excluding NON and we include the amounts of NON as controls. The results are very similar to our original "pre-talf" specification.

In Tables 5 and 6 we re-estimate all our specifications on two larger samples: i) all the A-rated notes, including floating rates and ii) the whole dataset, including B, C, D notes. The results are slightly less significant but the main findings are confirmed. We conclude that the exclusion of notes with floating rates and non A-rated notes did not affect our main results.

Sample: A-fixed-rates notes, dep. var.: $mL_{i,T,t}$

	NON	pre-talf$_{NON}$	post-talf$_{NON}$
D_T	-0.414^{**} (0.166)		
$\Delta\tilde{r}_{i,T}$	$\boxed{-0.358^{***}}$ (0.106)	$\boxed{-2.197^{*}}$ (1.017)	$\boxed{1.532^{**}}$ (0.603)
$D_T\Delta\tilde{r}_{i,T}$	$\boxed{0.840^{**}}$ (0.346)		
$V_{i,T}$	-0.01 (0.001)	-0.032^{***} (0.009)	-0.045 (0.025)
$D_TV_{i,T}$	0.018^{**} (0.008)		
$\tilde{V}_{i,T}$	5.04×10^{-04} (3.30×10^{-04})	5.24×10^{-04} (9.12×10^{-04})	-2.28×10^{-04} (2.84×10^{-04})
$D_T\tilde{V}_{i,T}$	-4.73×10^{-06} (4.08×10^{-06})		
R^2	0.6713	0.2408	0.4313
Obs.	4.845	535	535

Table 4: Standard errors, which and reported in brackets, are clustered by issuing company. Estimates are multiplied by 100. Significance level: $^{*}p \leq 0.1,^{**}p \leq 0.05,^{***}p \leq 0.01$.

Sample: A notes, dependent variable: $mL_{i,T,t}$

Variable	base	FEXs	Amounts	NON	pre-talf	pre-talf$_{NON}$	post-talf	post-talf$_{NON}$
D_T	-0.046^{***}	-0.028^{**}	-0.398^{***}	-0.434^{**}				
	(0.010)	(0.009)	(0.117)	(0.175)				
$\Delta r_{i,T}$	$\boxed{-0.953^{*}}$	$\boxed{-0.417^{*}}$	$\boxed{-0.382^{**}}$		$\boxed{-2.095^{*}}$		$\boxed{2.203^{***}}$	
	(0.428)	(0.215)	(0.137)		(1.018)		(0.565)	
$D_T\Delta r_{i,T}$	$\boxed{2.026^{**}}$	$\boxed{1.096^{**}}$	$\boxed{1.006^{**}}$					
	(0.751)	(0.448)	(0.385)					
$\Delta\tilde{r}_{i,T}$				$\boxed{-0.433^{***}}$		$\boxed{-2.197^{*}}$		$\boxed{1.532^{**}}$
				(0.128)		(1.017)		(0.603)
$D_T\Delta\tilde{r}_{i,T}$				$\boxed{1.039^{**}}$				
				(0.399)				
$V_{i,T}$			-0.002	-0.04	-0.042^{**}	-0.047^{**}	-0.042	-0.045
			(0.001)	(0.003)	(0.014)	(0.017)	(0.023)	(0.025)
$D_TV_{i,T}$			0.017^{**}	0.019^{*}				
			(0.005)	(0.008)				
$\tilde{V}_{i,T}$				6.42×10^{-04}		0.00001		-2.28×10^{-04}
				(3.75×10^{-04})		(0.00001)		(2.84×10^{-04})
$D_T\tilde{V}_{i,T}$				-4.42×10^{-04}				
				(5.07×10^{-04})				
R^2	0.1266	0.6626	0.6713	0.6730	0.3071	0.3117	0.3403	0.4313
Obs.	4.845	4.845	4.845	4.845	535	535	557	557

Table 5: Standard errors, which and reported in brackets, are clustered by issuing company. Estimates are multiplied by 100. Significance level: $^{*}p \leq 0.1,^{**}p \leq 0.05,^{***}p \leq 0.01$.

Sample: ABCD notes, dependent variable: $mL_{i,T,t}$

Variable	base	FEXs	Amounts	NON	pre-talf	pre-talf$_{NON}$	post-talf	post-talf$_{NON}$
D_T	-0.047^{***}	-0.023^{**}	-0.404^{**}	-0.540^{***}				
	(0.010)	(0.008)	(0.127)	(0.122				
$\Delta r_{i,T}$	-0.890^{*}	-0.376^{*}	-0.377^{**}		-2.095^{*}		1.807^{***}	
	(0.401)	(0.179)	(0.123)		(1.021)		(0.454)	
$D_T\Delta r_{i,T}$	1.968^{**}	0.834^{**}	0.910^{**}					
	(0.714)	(0.335)	(0.362)					
$\Delta\tilde{r}_{i,T}$				-0.318^{**}		-2.281^{*}		0.834
				(0.099)		(1.082)		(0.603)
$D_T\Delta\tilde{r}_{i,T}$				0.868^{*}				
				(0.381)				
$V_{i,T}$			-0.001	-0.007^{*}	-0.039^{**}	-0.042^{**}	-0.043	-0.051^{*}
			(0.001)	(0.003)	(0.013)	(0.013)	(0.026)	(0.025)
$D_TV_{i,T}$			0.018^{**}	0.025^{***}				
			(0.006)	(0.005)				
$Tot\tilde{V}_{i,T}$				2.16×10^{-04}		0.001		1.12×10^{-04}
				(2.54×10^{-04})		(0.001)		(5.06×10^{-04})
$D_TV\tilde{A}_{i,T}$				$-9.84^{*}\times10^{-04}$				
				(4.47×10^{-04})				
R^2	0.1249	0.6607	0.6694	0.6749	0.2894	0.2985	0.3172	0.4259
Obs.	4.845	4.845	4.845	4.845	535	535	557	557

Table 6: Standard errors, which and reported in brackets, are clustered by issuing company. Estimates are multiplied by 100. Significance level: $^{*}p\leq0.1,^{**}p\leq0.05,^{***}p\leq0.01$.

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