Privatizing Profits and Socializing Losses with Smoothly Operating Capital Markets

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Abstract

We design a three periods two generations model to challenge some of the prevailing views regarding privatizing profits and socializing losses in an environment characterized by smoothly operating capital markets. The model has a secondary asset market impaired by adverse selection and moral hazard. An exogenous stochastic shock renders some assets toxic. In the basic setup a tax financed scheme which removes toxic assets exacerbates the moral hazard problem and worsens the resource misallocation. However, introducing a "search for yield" with dynamic spillover effects and/or considering a labor market with some friction makes intervention welfare improving.

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1 Introduction

The last decade has witnessed financial crises of an exceptional magnitude. One of the defining characteristic of these crises centered around assets that had been regarded as safe but at some point became worthless. Moreover, the prevailing market structures produced an adverse selection environment making it next to impossible to separate "good" assets from "toxic" ones. In response to these dramatic events a plethora of government programs have been developed. For instance, in the 2008 crisis, the U.S. government chose to directly remove "troubled assets" from the market (among other things).[1] The most prominent example is the TARP scheme which had initially allocated up to \$700 billion for that purpose.[2] In the context of the Greek debt crisis, policies were much more diverse and complicated. Nonetheless, in the final analysis the policy responses involved reducing the exposure of private banks to Greek debt (largely through ECB measures) and providing public guarantees on a large part of the remaining debt (see e.g. Arslanalp and Tsuda, 2012, p. 50 Annex Figure 1).

While there is a prevailing sentiment that these government measures were essential to stabilize the system in the middle of the turmoil, the actual policies have raised concerns on several grounds. One of the main misgivings centers around fairness issues summarized by rhetorics around the buzz-phrases "privatizing profits and socializing losses" or "Main Street vs. Wall Street". Such policies appear particularly unfair since it means that while investors were expecting to keep their profits in good times, they could shed their loss during a crisis. Moreover, as most governments used debt to finance their respective policies, additional intergenerational equity issues were voiced.[3] Further concerns regard the impact of moral hazard on resource allocation once the policy is anticipated. Intuitively, the intervention amounts to a subsidy of investors' return in the bad state of the world.[4] If

[1] There is an immense body of literature discussing the events leading to that crisis. For a succinct overview see Blanchard (2009).

[2] The goals of the program may be found in http://www.ustreas.gov/press/releases/hp1150.htm For details of the program, see http://www.federalreserve.gov/bankinforeg/tarpinfo.htm. Other countries have implemented similar programs. For instance, in Ireland through the National Asset Management Agency, or in numerous other European countries via a "Bad Bank" concept, see Goddard, Molyneux and Wilson (2009).

[3] For instance, Tagkalakis (2013) studies the significant increase in national debt due to financial crises in OECD countries. With respect to the 2008 crisis, he notes that "the debt to GDP ratio increased due to financial rescue packages" (see p. 199).

[4] This concern is also reflected by Katsimi and Moutos (2010, p. 575), who note that "(I)mplicit loan guarantees provided by governments have also intensified private-sector

this is anticipated, it induces investors to ignore the down risk and over-invest in risky assets.[5]

There is a recent literature briefly overviewed below explaining the collapse of financial markets and lending freezes based on informational frictions. A natural component of that research program is to consider public policies aimed at restoring confidence in adverse states of the world. Notwithstanding the findings of that line of investigation, the aim of our paper is to show that the aforementioned fairness and moral-hazard arguments cannot be used to rule out intervention even when financial markets operate smoothly.

For that purpose, we introduce a stylized model with which we perform a qualitative logical exercise. The model uses a three periods and two overlapping generations framework.[6] The key element is the introduction of an intermediate good traded across risk-neutral generations in a secondary asset market.[7] In that context, a crisis is characterized by the following features. Before intermediate goods are traded, it becomes common knowledge that a fraction of them have turned worthless. Moreover, adverse selection impairs trade because buyers cannot distinguish across assets. As a result, the price of all intermediate goods becomes depressed by the worthless assets referred to hereafter as "toxic".[8]

In the absence of a public intervention, the rational expectations equilibrium leads to underinvestment in safe goods and overinvestment in the risky ones relative to the first-best allocation. A tax financed policy which removes a fraction of the toxic assets at market price is shown to increase all investments. However, it turns out to be welfare decreasing. Intuitively, the rational expectations price always adjusts to fully incorporate the market risk. When toxic assets are removed the market risk understates the social risk, which cannot be welfare improving with risk-neutral individuals.

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moral hazard" as "(U)nderpriced loan guarantees .... lead to greater lending, due to the lower cost of capital, and as well riskier lending." See also Taglakakis (2013, p. 198) for a related observation.

[5] These concerns are reflected in President Obama's speech at Wall Street on the first anniversary of the Lehman Brothers bankruptcy, where he said: "Those on Wall Street cannot resume taking risks without regard for consequences, and expect that next time, American taxpayers will be there to break their fall." http://www.huffingtonpost.com/2009/09/14/obama-wall-streetspeech_ n_285841.html

[6] Bental and Demougin (2014) use a standard OG framework with similar conclusions. The current version greatly simplifies the derivation of asset prices.

[7] The idea is taken from the paper by Bencivenga, Smith and Starr (1996).

[8] The adjective "toxic" is commonly associated with assets whose value suddenly drops, causing markets to freeze when due to adverse selection owners of "good" assets withdraw from the market (see, e.g. Morris and Shin 2012). We use this terminology even though in our setting toxicity does not lead to market collapse.

While the foregoing analysis seems to lend support to opponents of intervention, we argue that its conclusion is in fact a "knife-edge" result. For that purpose, we consider two minor extensions of the basic model. In the first extension, we introduce *search for yield* which has been often identified as a main culprit contributing to recent financial crises (see, e.g. the ECB's 2014 *Financial Stability Review*). We identify a condition which guarantees that in the presence of dynamic search externalities removing some of the toxic goods becomes socially beneficial. Intuitively, "socializing losses" acts like a subsidy of investors' return. It increases search by the first generation which has a positive spillover effect on the next generation. On the whole, the policy trades-off a worsening in the resource allocation of savings across investment alternatives against an improved allocation in search and knowledge creation. It is noteworthy that the second generation also benefits from the intervention program, thus alleviating some of the intergenerational "fairness" concerns.[9]

The second extension focuses on the "Main Street vs. Wall Street" tension. To do so, we introduce a labor market characterized by sticky wages. Ex-post, this feature implies an inefficient allocation of labor. In this context, a policy of removing toxic goods has two effects. As above, it acts as a capital subsidy and raises investments. Due to the complementarity of factors, demand for labor increases in all states of the world. In and of itself, this has a positive welfare effect. More importantly, the policy stabilizes the price of the intermediate good during a crisis. In view of the pre-determined wages, this is welfare improving.[10] Intuitively, the stable price avoids a sharp decrease in labor demand during the crisis which would have exacerbated the inefficient labor allocation. Altogether the two extensions demonstrate that the heuristic intuition derived from competitive environments is quite fragile, and that realistic deviations from this environment overturn the knife-edge negative conclusion with respect to the desirability of direct government intervention in the capital market.

[9] The intergenerational externality underlying intervention would also justify direct subsidization. This raises the question as to whether society may not be better off using direct tools to align incentives. Our study does not provide an answer to this important question as we do not conduct a cost-benefit analysis across different subsidy schemes. However, in practice governments are unlikely to correctly identify and subsidize all innovative activities (including among others developments of new financial instruments, new management and marketing methods, etc.) while avoiding opportunistic behavior at the receiving end. If this is the case, the remaining intergenerational externalities should continue to warrant some intervention based on the above justification, albeit to a lesser extent.

[10] A similar observation to footnote 9 applies, as we do not include other corrective instruments. However, as is known from the new Keynesian literature, governmental policies cannot fully restore efficiency in face of labor market frictions (see e.g. Gali 2008).

Our analysis is related to the large body of research that has developed in wake of the recent financial turmoils. A large part of that research also singled out adverse selection as the key characteristic. However, unlike our analysis the focus of that literature has been on financial intermediation and the negative impact of informational asymmetries on trade between lenders and borrowers. That negative impact may even completely freeze the market.[11] Hence, removing the worst assets reduces the adverse effect of hidden information and may restore trade (see, among others, Thakur 2015, Guerrieri and Shimer 2014, Dang, Gorton and Holmström 2013, Tirole 2012, Bebchuk 2009). The analysis of Holmström and Tirole (1998, 2011) emphasizes in addition the adverse impact of a crisis on the collateral value of assets which is shown to magnify the downturn in the real economy. Further contributions view the crisis as a new version of the standard Diamond and Dybvig (1983) bank-run argument (e.g. Gorton and Metrick 2012, Uhlig 2010 and Keister 2015). Notwithstanding the importance of intermediation, our analysis indicates that removing toxic assets may be beneficial even when capital markets operate smoothly. In that respect our findings should be understood as complementary to the financial intermediation literature.[12]

The paper proceeds as follows. Section 2 presents the model discussing technology and agents. The initial environment without informational frictions is analyzed in section 3. In section 4, we study the effect of adverse selection and show that in our example intervention is not desirable. The fragility of this conclusion is demonstrated in section 5 which consists of the two extensions mentioned above. The final section offers some concluding remarks.

2 The Model

We consider an economy which exists for three periods. At $t = 1, 2$ generations of two-period lived agents appear. Both generations have the same size.

All members of both generations receive an endowment X of a good in the first period of their lives but only care about expected consumption in the second period of their lives. Given their preferences, agents must use saving technologies to transfer resources to the second period of their life.

[11] In our case, the assumption of two-period lived individuals guarantees that trade always takes place, since owners of good assets sell them at any price.

[12] Bianchi (2012) also discusses tradeoffs generated by the moral-hazard impact of government intervention. In his DSGE model, a government policy transfering resources to firms whenever capital-market frictions become binding is welfare enhancing .

There are three potential saving technologies; storage that converts time-t units of X into the same quantity of the time-$t+1$ consumption good, and two technologies indexed by H and L. Technology $i = H, L$ converts K units of time-t good into $\mu_i F(K)$ time-$t+1$ consumption and $\mu_i G(K)$ time-$t+1$ intermediate goods whereby $\mu_H > \mu_L$. The latter are sold in a secondary market and stochastically turn into time-$t+2$ consumption. Both G and F are increasing concave functions satisfying the Inada conditions.

Intermediate goods are indistinguishable from one another and their origin is private information. However, with probability α a "crisis" may occur at $t = 2$ (hereafter we denote the "crisis" and "no crisis" states by "$s = c$" and "$s = n$"). In state c intermediate goods originating from the H-technology become useless and are referred to hereafter as "toxic". In all other cases, time-$t+1$ intermediate goods convert into the same quantity of the time-$t+2$ consumption goods.

All agents have access to the linear storage technology. However, only a fraction ϕ_H of generation 1 and φ_H of generation 2 young agents have access to the H-technology. The complementary fractions ϕ_L and φ_L, can only use technology L.

The economy has a government which may intervene in the case of a crisis, committing itself at the beginning of time to remove a fraction ρ of toxic goods. Due to the informational structure concerning the origin of these goods, the policy offers to buy them at the current market price. This offer is weakly incentive compatible and owners of intermediate goods are assumed to correctly self-select. The government uses lump-sum taxes to finance interventions. We denote by T and $\mathcal{T}$ the respective tax paid by members of the first and second generations during a crisis. For the sake of parsimony, we make the following assumptions.

Assumption 1: $F(K) = G(K) = 2K^{1/2}$.

Assumption 2: *Without loss of generality* $\mu_H = \mu > \mu_L = 1$.

The setup implies that agents born in $t = 1$ allocate their savings either to storage or the respective concave technology (hereafter primary investment). Intermediate goods are sold to agents born at $t = 2$ in the secondary market. Agents born at $t = 2$ split their endowment between storage, primary investments and intermediate goods bought in the secondary market.

Assumption 3: *The endowment X is sufficiently large to guarantee that in the respective equilibria of the ensuing setups all optimal investment problems have interior solutions.*

The timing in the economy is as follows. First, the government announces a contingent policy $(\rho, T, \mathcal{T})$ implemented in case of a crisis. Second, at $t = 1$

generation 1 appears and is endowed. Moreover, nature allocates technology to members of generation 1. Third, these members decide on the allocation of their savings across storage and primary investment. Fourth, at $t = 2$ generation 2 appears and is endowed. Fifth, nature selects the state and allocates technology to members of generation 2. Depending on the state, the policy is implemented. Sixth, the secondary market opens; members of the second generation allocate their saving across storage, primary investments and intermediate goods from the secondary market while generation 1 consumes. Finally, at $t = 3$ generation 2 consumes.

Before solving for the equilibrium, we briefly elaborate on some of critical features of the model. The assumption that individuals care only about second period consumption allows us to eliminate the saving decision and focus attention on the allocation across assets. The assumption of joint production captures the notion that investment produces consumption in the following period as well as future potential productive capacity. To fix ideas, consider the following metaphor taken from Bental and Demougin (2014); K stands for seedlings which grow into trees in the following period producing $\mu_i F(K)$ fruits and $\mu_i G(K)$ new seedlings. Next period, the new seedlings transform one to one into fruit except during a crisis where seedlings originating from H-trees wither without producing fruit. Our setup fully associates "toxicity" with the H-technology. We chose this dichotomous structure in order to emphasize the tension between yield and aggregate risk. In that respect, the two state specification and the assumption that in the crisis the true value of toxic assets is zero are made purely for convenience. Removing the latter assumption would allow for the possibility that some of the government-owned assets may generate profits.

3 The No Friction Case

In order to identify the role of the various frictions, we first consider the case where the origin of intermediate goods is common knowledge thereby removing the adverse selection issue. Let p denote the rationally expected price of intermediate goods which generate period 3 consumption. First-generation L-individuals face no risk. Accordingly, they solve:

$$\max_{0 \leq K_L \leq X} \; F(K_L) + pG(K_L) + X - K_L \tag{1}$$

In contrast, first generation H-individuals face the risk that with probability α their intermediate goods will not be productive and have no value. Hence, they solve:

$$\max_{0 \leq K_H \leq X} \ \mu F(K_H) + (1-\alpha)\, p\mu G(K_H) + X - K_H \tag{2}$$

Since the economy ends at period 3, intermediate goods generated by the primary investments of the second generation have no value. Nevertheless, members of that generation engage in primary investment and in storage. Moreover, they can purchases some of the (productive) intermediate inputs produced by generation 1. Accordingly, j-individuals of that generation, $j = H, L$, solve:

$$\max_{K_j, S_j, g_j} \ \mu_j F(K_j) + S_j + g_j \tag{3}$$
$$s.t.$$
$$K_j + S_j + pg_j = X, \ \ K_j, S_j, g_j \geq 0$$

where g_j denotes the amount of intermediate inputs purchased. Given that there are no market failures in the current environment, the resulting allocation is Pareto optimal and denoted hereafter by the superscript PE.

By Assumption 3, the no-arbitrage condition implies $p^{PE} = 1$. Using this observation the first-order conditions from (1)-(3) implicitly define first-best investments, K_i^{PE}, K_j^{PE} where by convention i and j index, respectively, generations 1 and 2, and $i, j = H, L$.

4 Adverse Selection

In this section, we return to the setup where the origin of intermediate goods is unknown to second-generation buyers and study the impact of adverse selection on the economy. For that purpose, we introduce the fraction π^s, $s = c, n$ of period 2 intermediate goods that will transform into period 3 consumption goods. In the "no-crisis" state, $\pi^n = 1$, hence the no-arbitrage condition between storage and intermediate goods implies $p^n = 1$.

In the case of a crisis, π^c is endogenous and depends on the fraction ϕ_H of H-individuals in the population, their investments relative to total first generation investment, and on the government policy. At the individual level π^c is taken as given. Due to the adverse selection issue, it determines the expected return on intermediate goods. Together with risk-neutrality, by Assumption 3 the no-arbitrage condition implies:

$$p^c = \pi^c \tag{4}$$

In a rational expectations equilibrium members of the first generation will accurately predict the contingent prices p^s, $s = n, c$. Being risk-neutral, these individuals will use the expected price

$$\overline{p} = (1-\alpha)\cdot 1 + \alpha \cdot \pi^c \tag{5}$$

to determine their respective investment choices.

4.1 First generation investment

Individual i born at $t = 1$ faces the following budget constraint

$$X = K_i + S_i \tag{6}$$

where K_i and S_i respectively denote primary investment and storage. At $t = 2$ expected consumption by individual i is given by:

$$C_i = \mu_i F\left(K_i\right) + \overline{p}\mu_i G(K_i) + S_i - \alpha T \tag{7}$$

Since individuals only care about second period consumption their optimal investment solves:

$$U_i^1(\overline{p}) = \max_{0\leq K_i \leq X} \mu_i F\left(K_i\right) + \overline{p}\mu_i G(K_i) + (X - K_i) - \alpha T \tag{8}$$

Given Assumptions 1 and 3, primary investments follow from the first-order conditions implying:

$$\mu_i F'\left(K_i^*\right) + \overline{p}\mu_i G'(K_i^*) - 1 = 0 \Rightarrow K_i^* = \mu_i^2\left(1+\overline{p}\right)^2 \tag{9}$$

4.2 Second generation investment

When the second generation makes investment decisions the state of the world is already common knowledge. Accordingly, in state s individual j faces the following budget constraint:

$$X = p^s g_j^s + S_j^s + K_j^s + \delta^s \mathcal{T} \tag{10}$$

where g_j^s denotes the amount of the intermediate good bought by j in state s and δ^s is an indicator function taking the value 1 at $s = c$ (i.e. when the contingent policy is implemented) and 0 otherwise. Decision by individual j is state s yields the following expected consumption:

$$C_j^s = \pi^s g_j^s + S_j^s + \mu_j F(K_j^s) \tag{11}$$

From the respective no-arbitrage conditions we have $\pi^s g_j^s + S_j^s = p^s g_j^s + S_j^s = X - K_j^s - \delta^s \mathcal{T}$ where the second equality follows from the budget constraint (10). Using this observation, the utility of j becomes:

$$U_j^{2,s} = \max_{0 \leq K_j^s \leq X} \mu_j F\left(K_j^s\right) + X - K_j^s - \delta^s \mathcal{T} \ . \tag{12}$$

From the first-order condition, we find that the optimal choice of K_j^s is state-independent. Slightly abusing notation, we obtain by Assumption 1:

$$K_j^* = \mu_j^2 \tag{13}$$

Observe that in the current setup, apart from taxation, members of generation 2 are completely insulated from the crisis and from the investment decisions of the first generation. This follows because in an interior solution the storage technology serves as a buffer guaranteeing that the intermediate good price correctly reflects the average third-period output it generates.

4.3 Equilibrium

In this section, we derive the rational expectations equilibrium. At $t = 1$, before generation 1 individuals allocate their saving, they know their endowments, their respective type and the contingent policy $(\rho, T, \mathcal{T})$. From (9) that policy does not directly affect $t = 1$ investments. However, it impacts investment indirectly through changes in $\overline{p} = 1 - \alpha + \alpha\pi^c$.

In order to evaluate π^c observe that in a crisis the market supply of intermediate goods per member of the second generation is:

$$G^c = \phi_L G(K_L^*) + (1-\rho)\, \phi_H \mu G(K_H^*) \tag{14}$$

Out of that supply only the fraction $\phi_L G(K_L^*)$ generates third period consumption, implying:

$$\pi^c = \frac{\phi_L G(K_L^*)}{\phi_L G(K_L^*) + (1-\rho)\phi_H \mu G(K_H^*)} \tag{15}$$

We now exploit Assumption 1 to explicitly solve for the rationally expected (average) price $\overline{p}$.

Lemma 1 *Under rational expectations, in the crisis the fraction of non-toxic assets remaining in the market is given by*

$$\pi^{RE} = \frac{\phi_L}{\phi_L + (1-\rho)\phi_H \mu^2} \ , \tag{16}$$

and the expected (average) price becomes

$$\overline{p}^{RE} = 1 - \alpha \frac{(1-\rho)\phi_H \mu^2}{\phi_L + (1-\rho)\phi_H \mu^2} \tag{17}$$

Proof. From Assumption 1 and (9), we obtain the relationship $K_H^* = \mu^2 K_L^*$ for generation 1 individuals. Using the definition of the production functions (15) becomes:

$$\pi^c = \frac{\phi_L 2 K_L^{*1/2}}{\phi_L 2 K_L^{*1/2} + (1-\rho)\phi_H 2\mu^2 K_L^{*1/2}} \tag{18}$$

verifying (16) by cancelling common terms. The second part of the claim follows directly by substituting (16) into (5) and rearranging terms. ■

Proposition 2 *In the rational expectations equilibrium, primary investments of generation 1 individuals are given by* $K_i^{RE} = \mu_i^2 \left(2 - \alpha \frac{(1-\rho)\phi_H \mu^2}{1-\phi_L + (1-\rho)\phi_H \mu^2}\right)^2$ *and are therefore increasing in the policy parameter* ρ*.*

Proof. Follows immediately from the proof of Lemma 1 and (9). ■

Intuitively, by offering to buy "toxic assets" at market price the government makes it incentive compatible for H-individuals to sell their intermediate goods to the policy scheme. Consequently, the remaining supply of intermediate goods to the market includes a lower fraction of toxic ones (equation 14) increasing their average return. By the no-arbitrage condition, this raises the crisis price of the intermediate good (equation 15) and therefore the expected equilibrium price. The latter induces a corresponding response in primary investments.

To conclude this section we briefly discuss the impact of ρ on equilibrium primary investments of generation 1 in comparison to the Pareto efficient solution of section 3. In the latter case, we know from the optimization problems (1)-(2) that efficient investments are characterized by:

$$F'(K_L^{PE}) + p^{PE} G'(K_L^{PE}) = 1 = \mu \left[F'(K_H^{PE}) + (1-\alpha)\, p^{PE} G'(K_H^{PE})\right] \tag{19}$$

with $p^{PE} = 1$. In contrast, the equilibrium generated by the contingent policy $(\rho, T, \mathcal{T})$ is characterized by $\overline{p}^{RE} \leq 1$ and by:

$$F'(K_L^{RE}) + \overline{p}^{RE} G'(K_L^{RE}) = 1 = \mu F'(K_H^{RE}) + \overline{p}^{RE} \mu G'(K_H^{RE}) \tag{20}$$

We denote by $K_i^{RE}(\rho)$ the rational expectations investments associated with a policy that removes the fraction ρ of toxic assets from the market. At $\rho = 1$, we have $\overline{p}^{RE} = 1$ and therefore a first-generation L-individual sets $K_L^{RE}(1) = K_L^{PE}$, i.e. invests efficiently, while H sets $K_H^{RE}(1) > K_H^{PE}$. Intuitively, H overinvests because he does not internalize the potential output loss.

However, the resulting equilibrium cannot be second-best efficient. To see this, consider a small reduction in ρ away from 1. This would reduce $\overline{p}^{RE}$ and therefore both investments. The first-order effect of the reduction in $K_H^{RE}(\rho)$ is strictly Pareto improving while at the margin the reduction in K_L away from the Pareto optimal investment has only a second-order effect.

At the other extreme with $\rho = 0$, we have $(1-\alpha) < \overline{p} < 1$. Accordingly, L-investments are penalized while H-investments continue to benefit from the presence of adverse selection in the market. Consequently, L-individuals are induced to underinvest, $K_L^{RE}(0) < K_L^{PE}$, but H-individuals still overinvest, $K_H^{RE}(0) > K_H^{PE}$. Notice however that $K_H^{RE}(1) > K_H^{RE}(0)$ so that the distortion in the H-investments is reduced. To further evaluate the intervention policy, we now introduce a social welfare function.

4.4 Welfare analysis

We define social welfare as the sum of the per person expected utility across both generations. Accordingly, given a contingent policy $(\rho, T, \mathcal{T})$, welfare at the rational expectations equilibrium becomes

$$\begin{aligned} W^{RE} = {} & \phi_L U_L^1(\overline{p}^{RE}) + \phi_H U_H^1(\overline{p}^{RE}) + \\ & (1-\alpha)\left[\varphi_L U_L^{2,n} + \varphi_H U_H^{2,n}\right] + \alpha\left[\varphi_H U_L^{2,c} + \varphi_H U_H^{2,c}\right] \end{aligned} \tag{21}$$

Feasibility of the policy requires that the taxes levied during a crisis should be sufficient to just finance the asset buyout program. Accordingly, the crisis-contingent government budget constraint becomes:

$$T + \mathcal{T} = p^{c,RE}\rho\phi_H\mu G(K_H^{RE}) \tag{22}$$

where $p^{c,RE}$ denotes the rational expectations equilibrium price of the secondary investments in the crisis state.

Using the government budget constraint and the respective definitions of utilities, we can rewrite (21) as:

$$\begin{aligned} W^{RE} = {} & \phi_L\left[F(K_L^{RE}) + G(K_L^{RE}) + \left(X - K_L^{RE}\right)\right] \\ & + \phi_H\left[\mu F(K_H^{RE}) + (1-\alpha)\,\mu G(K_H^{RE}) + \left(X - K_H^{RE}\right)\right] \\ & + \textstyle\sum_j \varphi_j\left[\mu_j F(K_j^{RE}) + \left(X - K_j^{RE}\right)\right] \end{aligned} \tag{23}$$

Not surprisingly, due to the linearity of utilities, the economy's welfare is equivalent to the economy's aggregate expected output. Based on this observation, we provide a formal proof of the following result in the Appendix.

Proposition 3 *Under rational expectations and assuming that agents' types are exogenously given, a "no intervention" policy which sets $\rho = 0$ is efficient.*

To gain some insight into this result, observe from (17) that K_L^{RE} and K_H^{RE} are functions of $\overline{p}^{RE}$. However, from (20) $\overline{p}^{RE}$, and hence also welfare, are functions of ρ. Taking the derivative of (23) with respect to ρ, we obtain:

$$\frac{\partial W}{\partial \rho} = \left[\phi_L \frac{1 - \overline{p}^{RE}}{1 + \overline{p}^{RE}} \frac{\partial K_L^{RE}}{\partial \overline{p}^{RE}} + \phi_H \frac{1 - \alpha - \overline{p}^{RE}}{1 + \overline{p}^{RE}} \frac{\partial K_H^{RE}}{\partial \overline{p}^{RE}} \right] \frac{\partial \overline{p}^{RE}}{\partial \rho} \tag{24}$$

Using (9), to solve for the effect of $\overline{p}^{RE}$ on the respective investments and substituting for $\overline{p}^{RE}$ from (17), the derivative in (24) simplifies to:

$$\frac{\partial W}{\partial \rho} = -2\rho \frac{\alpha \phi_H \phi_L \mu^2}{\phi_L + (1-\rho)\phi_H \mu^2} \frac{\partial \overline{p}^{RE}}{\partial \rho} \tag{25}$$

From (17), we know $\frac{\partial \overline{p}^{RE}}{\partial \rho} > 0$ so that $\frac{\partial W}{\partial \rho} \leq 0$ and vanishes at $\rho = 0$. In order to gain some insight on this rather technical result, observe from (17) that the rational expectations price in the secondary market satisfies:

$$\overline{p}^{RE} \cdot \left[\phi_L + (1-\rho)\phi_H \mu^2 \right] = 1 \cdot \left[\phi_L + (1-\alpha)(1-\rho)\phi_H \mu^2 \right] . \tag{26}$$

The term in the square bracket on the RHS of (26) measures the expected numbers of secondary goods traded in the secondary market that turn into period-$t+2$ consumption goods. In the absence of adverse selection, we know that the market would have traded these intermediate goods at a price of 1 due to the no-arbitrage requirement with the storage technology. The square bracket on the LHS measures the number of intermediate goods traded and reflects the presence of adverse selection. Due to the risk-neutrality the rational expectations price adjusts to fully incorporate the market risk faced by the buyers.

For $\rho > 0$ the market risk understates the social risk. The latter is given by the expected numbers of secondary goods present in the economy that turn into period-$t+2$ consumption goods, i.e. $\phi_L + (1-\alpha)\,\phi_H \mu^2$. However, in the presence of risk-neutral traders this cannot be optimal. Intuitively, with risk neutrality the allocation of risk is unaffected by a potential intervention, while resource allocation is distorted.[13] Hence, despite the inefficient investment allocation generated by adverse selection, removing toxic assets using a tax financed scheme is never welfare enhancing.

5 Robustness

We designed the foregoing model in order to map standard objections against a policy designed at removing toxic assets. By construction, the model's conclusion lends support to opponents of intervention. However, whether Proposition 3 is truly useful or only a "knife-edge" result obtained by a lucky combination of assumptions depends on whether the foregoing finding is robust to variations in the environment.

In the remainder, we consider two rather minor deviations from the foregoing model.[14] We selected the variations according to two criteria; we tried to minimize changes of the initial model to a minimum and, attempted to represent some of the aspects which have been at the center of the public debate on the desirability of intervention. In the first extension, we introduce a search for yield and include a spillover effect across generations to capture the idea that tomorrow's discoveries build on past findings. In the second extension, we add a labor market. Intuitively, we try to capture the idea that a crisis in the market for assets will naturally feed back into other segments of the economy and in particular to the labor market. This in turn should affect future generations and may justify having them participate in financing an intervention policy.

5.1 Search for yield

"Search for yield" has been perceived by many observers as a major contributing factor to the recent financial crises. Moreover, it continues to be regarded as a potential destabilizer of financial markets (see, e.g. section 2 of the ECB's 2014 *Financial Stability Review*).[15] A policy of removing toxic

[13] In contrast, with risk-averse agents some insurance would become efficient which suggests some form of intervention. In a former version of this paper we used that feature to justify intervention (see Bental and Demougin 2014).

[14] In Bental and Demougin (2014) we studied a different extension. There we considered a standard OG model with risk-averse agent and also found that removing some of the toxic assets was beneficial.

[15] The report argues that in some segments of the market "investor behaviour is consistent with an intense search for yield, the sharp unwinding of which could have broad-based consequences for global financial markets" (p. 47). For similar concerns on the developments in China at the beginning of 2016, see the NY-Times article "Toxic Loans Around

assets would seem to exacerbate the harmful externality encompassed in the hunt for yield. In and of itself this observation speaks against such a policy. However, focusing on the negative impact of search for yield ignores potential benefits in normal times which is at the core of this extension.

Specifically, in the foregoing setup, adverse selection guaranteed that having access to the high-yield technology is advantageous. The extension exploits this feature by introducing a search for the high-yield technologies. In addition, we include a dynamic spillover effect. What we have in mind is that past discoveries spill over to future generations, an idea that has been incorporated in many endogenous growth models (see e.g. Romer 1990).[16]

In the sequel, it is useful to adjust notation. Specifically, we define $\phi = \phi_H$, $\varphi = \varphi_H$ and denote by $\psi(\phi)$ and $\nu(\varphi;\phi)$ the respective search cost of the first and second generations measured in utility units. These functions are assumed increasing and convex in their respective search variable and satisfy the Inada condition. We capture the spillover effect by assuming $\nu_\phi(\cdot,\cdot) < 0$.

In order to incorporate these changes into the foregoing model, we modify the economy's timing as follows. In the first period, after the policy announcement $(\rho, T, \mathcal{T})$ members of the first generation determine ϕ. Nature then allocates types in accordance with ϕ and investment decisions are made. Analogously, in the second period members of generation 2 select φ after nature has determined the state of the world, but before making their investment decisions.

Adjusting the rational expectations equilibrium involves solving for $\overline{p}^{RE}$ and ϕ^{RE}. Specifically, given ϕ^{RE} and ρ the rationally expected price $\overline{p}^{RE}$ follows from (17). On the other hand, given $\overline{p}^{RE}$ every member of generation 1 optimally chooses his search variable, ϕ by equating his marginal search costs to the associated marginal benefit. Finally, rational expectations requires consistency, i.e. $\phi = \phi^{RE}$. Altogether, the equilibrium is defined by:

$$\begin{cases} \overline{p}^{RE} = 1 - \alpha \dfrac{(1-\rho)\phi^{RE}\mu^2}{1-\phi^{RE}+(1-\rho)\phi^{RE}\mu^2} \\[2ex] U_H^1(\overline{p}^{RE}) - U_L^1(\overline{p}^{RE}) = \psi'(\phi) \\[2ex] \phi = \phi^{RE} \end{cases} \tag{27}$$

the World Weigh on Global Growth" of Feb 3, 2016.

[16]As indicated in footnote 9, the search for yield represents any type of innovative activities including financial innovations, management and marketing pratices and the like. The externalities encompassed in such activities are best captured by the famous Newton reference from a letter to Hooke, in 1676: "If I have seen a little further, it is by standing on the shoulders of Giants."

Lemma 4 *For every ρ there is a unique rational expectations equilibrium $\left(\overline{p}^{RE}(\rho), \phi^{RE}(\rho)\right)$. In that equilibrium, search by the first generation is an increasing function of ρ.*

Proof. From the equilibrium system (27), we substitute the first equation into the second and use the definition of $A(\rho, \phi)$ from (A1). The value of ϕ^{RE} is implicitly defined as the solution to:

$$\Delta(\rho, \phi) = U_H^1(1 - A(\rho, \phi)) - U_L^1(1 - A(\rho, \phi)) - \psi'(\phi) = 0 \; . \tag{28}$$

In order to verify existence given ρ, observe that at $\phi = 0$ the LHS of (28) is positive whereas it becomes infinitely negative for $\phi \to 1$. By continuity and the intermediate value theorem an equilibrium exists. Uniqueness is obtained by observing that $\Delta_\phi < 0$. The second result follows because $\Delta_\rho > 0$. ■

The result has a straightforward intuition. Increasing the fraction of toxic assets removed during a crisis has two effects; it requires an adjustment in taxation and raises $\overline{p}$. Since informational asymmetry implies uniform taxation across types, the change in taxation has no direct impact on the utility differential $(U_H^1 - U_L^1)$. In contrast, with $\mu_H > \mu_L$ the increased $\overline{p}^{RE}$ raises the utility differential thereby inducing more search.

The choice of $\phi^{RE}(\rho)$ by generation 1 has a spillover impact on the optimization problem by members of the next generation. Applying the notation from (12), the search decision problem of a young generation 2 individual becomes

$$\max_{\varphi} \; (1 - \varphi) U_L^{2,s} + \varphi U_H^{2,s} - \nu(\varphi; \phi^{RE}(\rho)). \tag{29}$$

The corresponding search is implicitly defined by:

$$U_H^{2,s} - U_L^{2,s} = v_\varphi(\varphi; \phi^{RE}(\rho)). \tag{30}$$

Using (13) to substitute the utility maximizing choice of $K_j^* = \mu_j^2$, the LHS of (30) becomes

$$U_H^{2,s} - U_L^{2,s} = \left[\mu_H F\left(\mu_H^2\right) - \mu_H^2\right] - \left[\mu_L F\left(\mu_L^2\right) - \mu_L^2\right] \tag{31}$$

which is a constant. By convexity and the Inada condition of $\nu(\cdot; \phi)$, (30) has a unique solution. That solution will respond to variation in ρ through change in $\phi^{RE}(\rho)$ and is denoted hereafter by $\varphi^{RE}(\rho)$. Based on a proof provided in the Appendix, we have the following result.

Proposition 5 *Some intervention is desirable provided that at $\rho = 0$,*

$$|\nu_\phi\left(\varphi^{RE}(0); \phi^{RE}(0)\right)| > 2\alpha\mu^2\left(2 - A(0, \phi^{RE}(0)\right). \tag{32}$$

Proposition 5 has a natural intuition. Consider a marginal increase in ρ at the point $\rho = 0$. By Lemma 4, it induces first generation individuals to search more. Condition (32) captures the implications of that change.

The LHS of (32) represents the positive spillover effect on the second generation's search cost. The RHS captures the negative effect due to worsened adverse selection in the intermediate goods market. Whether some amount of intervention is useful depends on which of these two effects dominates. Clearly, when the crisis probability is sufficiently small the positive spillover externality prevails.

Search for high return (e.g. through the creation of complex financial assets) has been viewed by many as an instigator of toxic assets in the recent financial crisis. As a natural consequence, people have argued against intervention schemes which in effect subsidize searchers by shielding them from the potential social loss they generate. The setup leading to Proposition 3 mimics this situation concluding that without intergenerational spillover a search subsidy is undesirable. However, dynamic linkages may overturn this conclusion as shown by Proposition 5. Moreover, from the point of view of intergenerational equity, the assumption that future generations are likely to benefit from innovations made by their predecessors may justify partially insuring searchers for high yield through the intervention policy.

Before ending this subsection a remark is in order. In our setup, insuring searchers can only be achieved through a buyout of toxic assets during a crisis. *By design* this rules out the possibility that another (not modelled) instrument could perfectly correct the market failure, thereby eliminating the rationale of removing toxic assets altogether.[17] However, in practice such instruments are unlikely to exists; it is implausible that governments can correctly identify and subsidize all innovative activities (including among others developments of new financial instruments, new organizational forms, new management and marketing methods, etc.) and avoid opportunistic behavior at the receiving end. Accordingly, even if we were to include additional instruments, there would remain some scope for intervention based on the rationale developed in our analysis, albeit to a lesser extent.

[17] Observe that even if perfectly corrective instruments were to exist, our conclusion would remain valid. Though intervention would indeed become redundant, it would not be so on the basis of the commonly invoked moral hazard and fairness concerns. Instead, the argument should be grounded on the existence of other, better performing instruments.

5.2 Labor

Intervention schemes during the 2008 crisis have not been designed solely to "save Wall street". As clearly stated by Henry Paulson, the U.S. Secretary of the Treasury at the time, the main goal was to "save Main street", i.e. "save our economy from a catastrophe".[18] Berger and Roman (2016) provide a pioneering empirical analysis of the real effects of the TARP program. They show that the program "statistically and economically significantly increased net job creation and net hiring establishments".[19] In this vein, this subsection aims at addressing the real effect of intervention.

For this purpose, we extend the initial model by incorporating a labor market characterized by a friction in the wage setting process leading to wage stickiness. Specifically, wages are determined by a centralized bargaining procedure between a producers' representative ("employers' council") and a union. While this scheme resembles wage negotiations in Germany, other assumptions which create frictions in the labor market would generate similar results (as for instance in standard new Keynesian models, e.g. Erceg, Henderson, and Levin 2000). Our assumptions on the bargaining procedure were chosen to preserve the basic features of the initial setup.[20]

We adjust the original framework as follows. Generation t produces through its primary investment time $t+1$ capital. That capital can be combined with time $t+1$ labor in order to generate $t+1$ consumption and intermediate goods. Using N to denote labor input, we replace the production functions of Assumption 1 with the following:

Assumption 1': $F(K, N) = G(K, N) = K^{1/4} N^{1/2}$.

Labor is provided by members of the young generation who have the ability to supply ν units of labor at a utility cost $C(\nu) = \nu$. The wage is negotiated using a Nash bargaining process. For these negotiations, the respective outside options of the parties are zero for labor and the salvage value γK with $0 < \gamma < 1$ for the producer. Negotiations take place before the state s is realized. After s becomes known producers determine employment based on the negotiated wage.

As an artifact of the three-periods-two-generations structure, the labor market will only be active in period 2. It is inactive in period 1 because there is no previous generation of employers, and in period 3 since there is

[18] The Paulson quote appears as a motto in the paper of Berger and Roman (2016).

[19] Specifically, their result "suggests that over the 16 quarters of the post-TARP period (2009:Q1-2012:Q4), for every 1000 people, 8.09 jobs were created due to TARP".

[20] To be specific, our version of the sticky-wage economy yields closely related pricing functions for the intermediate goods. The key equations to see this are (16) and (40) below.

no third generation that could be employed. Together with Assumption 1', it implies that members of the second generation will not undertake primary investments.

These adjustments in the model leave the no-arbitrage conditions between intermediate goods and storage unaffected so that $p^n = 1$ and $p^c = \pi^c$. However, in order to solve for π^c, we need to analyze the production decisions of first generation L and H-individuals.

5.2.1 Labor contract and investment

We solve the economy by backward induction starting with employment decisions in period 2. Consider individual i of generation 1 who had invested K_i units of capital in the first period. Given a state s and a wage w that individual's demand for labor, $N_i^s(w)$, is determined by the solution of the optimization problem:

$$\Pi_i(K_i; p^s, w) = \max_{L_i} \ \mu_i F(K_i, N_i) + p^s \mu_i G(K_i, N_i) - wN_i \tag{33}$$

Moving backwards, consider the negotiations stage. At that point in time, the union rationally anticipates the labor demand $N_i^s(w)$ and computes the expected rent of a representative worker. By Assumption 1' that expected rent becomes:

$$\begin{aligned} U(w) = (w-1)\{&(1-\alpha)\left[(1-\phi)\, N_L^n(w) + \phi N_H^n(w)\right] \\ &+ \alpha\left[(1-\phi)\, N_L^c(w) + \phi N_H^c(w)\right]\} \ . \end{aligned} \tag{34}$$

where $(1-\phi)\, N_L^s(w) + \phi N_H^s(w)$ yields the average employment in state s and $(w-1)$ denotes the representative worker's net benefit per unit of labor. Similarly, the employers' council will rationally anticipate the $\Pi_i(K_i; p^s, w)$ when it computes the average rent, AR, associated with w:

$$\begin{aligned} AR(w) = {} & (1-\alpha)\left[(1-\phi)\,\Pi_L(K_L; p^n, w) + \phi \Pi_H(K_H; p^n, w)\right] \\ & + \alpha\left[(1-\phi)\,\Pi_L(K_L; p^c, w) + \phi\Pi_H(K_H; p^c, w)\right] - \gamma\left[(1-\phi)\, K_L + \phi K_H\right]. \end{aligned} \tag{35}$$

Nash-negotiation with equal bargaining power implies that the union and the employers' council split the total rent equally. Hence, the negotiated wage is implicitly defined by the equation

$$AR(w) = U(w) \ . \tag{36}$$

In the Appendix, we prove the following result.

Lemma 6 *Assuming generation* 1 *individuals of type-i have invested* K_i *and the parties anticipate* p^c*, the union and the employers' council negotiate the wage*

$$w(K_L, K_H, p^c) = \sqrt{\frac{\left[(1-\alpha) + \alpha\frac{(1+p^c)^2}{4}\right]\left[(1-\phi)\,K_L^{0.5} + \phi\mu^2 K_H^{0.5}\right]}{\gamma\left[(1-\phi)\,K_L + \phi K_H\right]}} \tag{37}$$

Further applying backward induction, we now move to period 1 and consider the primary investment decision by a member of the first generation. From the perspective of that individual, his own weight in the economy is negligible. Hence, he will perceive w and p^c as exogenous parameters. Accordingly, individual i solves:

$$U_i = \max_{K_i}\ (1-\alpha)\,\Pi_i(K_i; p^n, w) + \alpha\left[\Pi_i(K_i; p^c, w) - T\right] + X - K_i \tag{38}$$

At the rational expectations equilibrium, given the wage w^{RE} and the crisis price $p^{c,RE}$, the optimization (38) delivers K_i^{RE}. In turn, equation (37) requires that in equilibrium

$$w^{RE} = w(K_L^{RE}, K_H^{RE}, p^{c,RE}). \tag{39}$$

This observation allows us to derive the following result proven in the Appendix.

Proposition 7 *The rational expectations wage is* $w^{RE} = 2/\gamma$*. Moreover, in the crisis, the fraction of non-toxic assets present in the market is given by*

$$\pi^{RE} = \frac{1-\phi}{1-\phi+(1-\rho)\phi\mu^4}\ . \tag{40}$$

which by (4) also yields the crisis price $p^{c,RE}$ *of intermediate goods.*

Altogether, in the current extension the price structure of the intermediate good closely resembles that of the initial framework.

5.2.2 Results

Due to the analytical complexity of the foregoing setup, we turn to a numerical exercise. That exercise produces a simple counter-example casting doubt on the allocative concerns and the unfairness often ascribed to intervention.

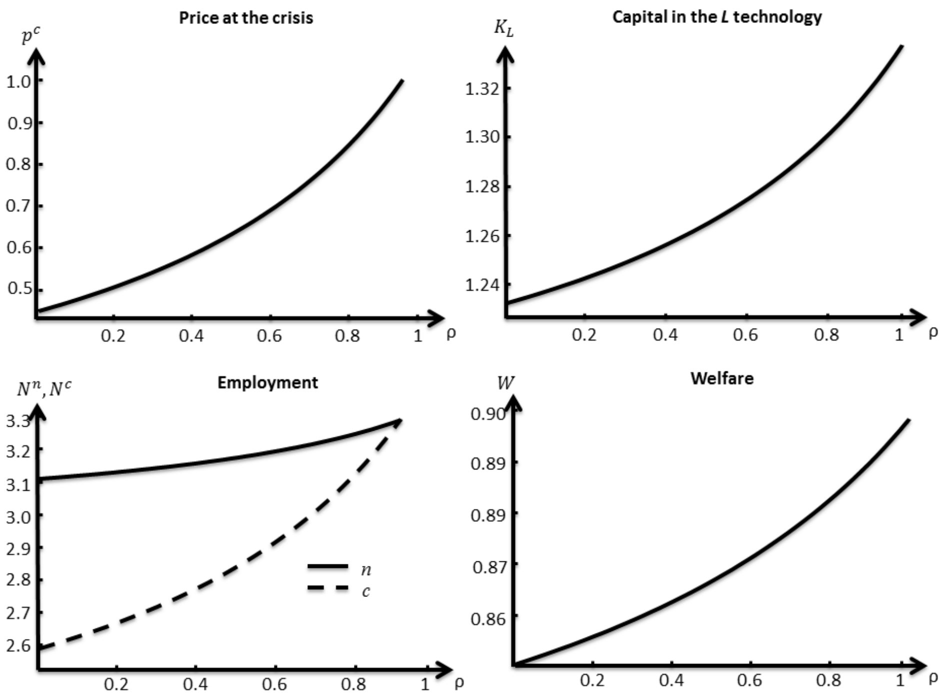

Figure 1: Economy's performance

Figure 1 presents the model's performance for the parameter values $\mu = 1.5$, $\phi = 0.2$, $\alpha = 0.1$ and $\gamma = 0.75$. Starting with the upper left panel, the first graphic shows that $p^{c,RE}$ is increasing in ρ (see 40). It reflects that removing a larger fraction of toxic goods in the crisis raises the average return on intermediate goods traded in the market which increases their price. Moreover, due to the arbitrage condition with the linear storage technology, $p^{c,RE}$ converges to $p^n = 1$ when all toxic goods are removed. The upper right graphic displays the impact of ρ on capital investment by L-individuals. That investment is increasing in ρ because expected return is increasing in the expected price of intermediate goods and, hence, in $p^{c,RE}$ (see A17 in the appendix). Similarly, with $K_H^* = \mu^4 K_L^*$ investments by type-H individuals are also increasing in ρ. Moving to the bottom row of Figure 1, the left panel depicts employment in both states of the world. At state "n" employment is increasing in ρ because of the aforementioned effects of the intervention on investments and the complementarity in production between capital and labor. In state "c" there is an added direct effect due to the increased price of the intermediate good (see A12 in the Appendix). Intuitively, in view of the fixed pre-negotiated wages, setting $\rho = 0$ leads to a sharp decrease in labor demand (by about 20% in the numerical exercise) which exacerbates the inefficiency of the labor allocation. Raising ρ increases $p^{c,RE}$ and reduces the negative impact of a crisis on employment. This has a positive effect on the economy as depicted in the final quadrant that plots the overall impact of ρ on welfare.

The finding that it is desirable to remove all the toxic assets is clearly specific to the above parameter choice.[21] However, in the current setting removing some toxic assets is always useful. To see why, consider the proof of Proposition 3. We found that in the absence of a labor market the misallocation of capital resulting from intervention led to $W_\rho^{RE} \leq 0$ with equality at $\rho = 0$. Now, considering the labor market, observe that in the current environment the equilibrium is always characterized by under-employment relative to the efficient solution. To see this simply note that $w^{RE} = 2/\gamma > 1$ whereby the RHS of that inequality measures the worker's marginal cost of labor. However, since employers determine labor by equalizing the marginal product of labor, MPL, to wage, it also implies $MPL > 1$. Accordingly, at $\rho = 0$ intervention which increases employment must necessarily be welfare improving. In addition, the existence of rents to workers implies that the second generation always benefits from increased values of ρ due to their positive impact on employment.[22]

As noted above, except for buying out toxic assets our analysis does not consider other corrective instruments. This again raises the question as to whether including other policies might eliminate the need for intervention in the context of the current extension. Here too we argue that this is unlikely. Indeed, policies that improve efficiency in the face of *sticky wages* are at the focus of the new Keynesian literature. As is well known, such policies do not fully alleviate the allocational inefficiencies stemming from frictions in the labor market. Once more, this leaves scope for intervention based on the rationale developed in our analysis.

6 Discussion and Conclusion

Privatize profits and socialize losses? There is a prevailing view that socializing the losses by removing toxic assets in the recent crisis was justified due to the unexpected nature of the event. At the same time, many agree that

[21] This extension has been designed to show the potential benefits of removing toxic assets on labor markets. In its simple form the corner solution obtains unless the crisis probability becomes large. Considering distortionary taxation would clearly alter this result.

[22] In line with this heuristic, it can be formally shown that with perfectly competitive labor markets an analogous result to Proposition 3 would emerge. Intuitively, rational expectations price and wages would adjusts to fully incorporate the market risk faced by secondary goods buyers so that intervention would not be warranted.

this policy should not be repeated in the future in order to avoid morally hazardous behavior which would lead to a misallocation of resources. In addition, many others doubt the soundness of the policy based on equity concerns. The simple examples constructed above challenge these misgivings.

Specifically, our analysis calls into question the standard heuristic arguments against a tax financed policy of removing toxic assets. Our examples show that while the logical underpinning appears correct when limiting the analysis only to the distortions associated with investment in risky assets, embedding the question in a larger setting casts doubt on the reasoning. For instance, in the extension of section 5.1 removing toxic assets continues to have a negative impact on the allocation of savings across investment channels, yet it also has a positive effect on search costs across generation. In the second extension the increased investment induced by the commitment to intervene also increases employment in all states of the world. Moreover, during the crisis the policy stabilizes employment. As a result, a commitment to remove some of the toxic assets becomes welfare enhancing.

The common feature responsible for the intervention's positive welfare implication in both extensions is the presence of a non-trivial dynamic linkage across generations. Above and beyond the examples in the paper, there are many other sources of such linkages. For instance, introducing risk aversion in our framework would suffice. Intuitively, intervention would become desirable as the second generation is affected by the risk of a crisis without an ability to directly insure itself against it.[23] Further linkages could be generated by any of the frictions invoked by the new Keynesian models or the labor search literature which would prevent wages from fully adjusting to the crisis. Accordingly, removing some of the toxic assets should have the same beneficial effects as in our labor market setting. More generally, any dynamic linkage that transfer the impact of a crisis across generations – either ex-ante (as in search for yield) or ex-post (as in the labor market example) – is likely to rationalize buying out some of the toxic assets.

For simplicity of analysis, our results have been derived using a three periods and two overlapping generation model. However, the main conclusions should extend, or even be stronger, in a standard overlapping generations framework which allows for the possibility of stochastically recurring crises. First consider embedding the basic framework of section 3. A policy that commits to remove toxic assets in case of a crisis should repeatedly yield a

[23] For an example, see Bental and Demougin (2014). In that analysis we use a standard overlapping generations framework with risk-averse agents. In that context we also conclude that removing some of the toxic assets is useful.

similar trade-off as in our model; it would increase all investments which is socially desirable for safe investments but not for potentially toxic assets. With the same production functions as in our model, the negative impact should continue to dominate and the knife-edge no-intervention result should still also apply.

However, just as in our analysis, the no-intervention result will not be robust. For instance, consider introducing a search for yield with dynamic spillover effects. A policy which removes a fraction of the toxic assets will have the same effect of increasing search. However, in an infinite horizon model repeated increases in search will clearly have an even stronger positive effect because it would benefit all future generations. Similarly, with labor market frictions the commitment to intervene would have a continued positive impact on employment and output.

Finally, it could be argued that the indirect subsidies implied by our intervention schemes should be applied directly. However, this is not always feasible. For instance, in the case of search for yield, governments are unlikely to identify all sources of innovative activities (see footnote 9). Moreover, applying direct subsidies for search and/or employment would require measures designed to avoid abuse. Therefore, in contrast to the simple and "self-enforcing" policies analyzed in our paper, direct subsidies would be associated in the very least with additional costs.

Other researchers have also argued in favor of removing toxic assets during a financial crisis. However, these arguments focused mainly on restoring trade in capital markets that froze because of informational frictions. While these concerns are fully justified, our goal was to examine the consistency of the above critical voices even when capital markets do not break down. The model we have developed for this purpose is highly stylized and qualitative in nature. A quantitative analysis regarding the desired scope of intervention would require the inclusion of many additional issues including the presence of other policy measures, risk-aversion and the shadow price of taxation. These are clearly out of the scope of the current paper and require further research.

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Appendix

Proof of Proposition 3: In order to simplify notation in the proof, we write $\phi_L = 1 - \phi_H$. Let

$$A(\rho, \phi_H) = \alpha \frac{\phi_H (1-\rho)\mu^2}{1 - \phi_H + \phi_H (1-\rho)\mu^2} \tag{A1}$$

so that

$$\overline{p}^{RE} = 1 - A(\rho, \phi_H) \tag{A2}$$

Using the first-generation rational expectations values for K_i^{RE} from (2) and the second-generation K_j^{RE} from (13), we rewrite (23), as

$$\begin{aligned} W^{RE}(\rho) &= \phi_L \left[4\left(1 + \overline{p}^{RE}\right) - \left(1 + \overline{p}^{RE}\right)^2 \right] \\ &+ \phi_H \mu^2 \left[2\left(2 - \alpha\right)\left(1 + \overline{p}^{RE}\right) - \left(1 + \overline{p}^{RE}\right)^2 \right] + 2X + \varphi_L + \varphi_H \mu^2 \end{aligned} \tag{A3}$$

Using (A2) and collecting common terms, we have

$$\begin{aligned} W^{RE}(\rho) &= \left(\phi_L + \phi_H \mu^2\right)\left(4 - \left[A(\rho, \phi_H)\right]^2\right) \\ &- 2\alpha\phi_H \mu^2 \left(2 - A(\rho, \phi_H)\right) + 2X + \varphi_L + \varphi_H \mu^2 \end{aligned} \tag{A4}$$

Omitting arguments, the derivative of $W^{RE}(\rho)$ with respect to ρ becomes:

$$W_\rho^{RE} = 2\alpha \frac{\rho \phi_L \phi_H \mu^2}{\phi_L + \phi_H (1-\rho)\mu^2} A_\rho \tag{A5}$$

Since

$$A_\rho = -\alpha \frac{\phi_L \phi_H \mu^2}{\left(\phi_L + \phi_H (1-\rho)\mu^2\right)^2} < 0 \tag{A6}$$

we obtain $W_\rho^{RE} \leq 0$. Moreover, at $\rho = 0$ we get $W_\rho^{RE} = 0$. We also have

$$W_{\rho\rho}^{RE} = 2\alpha \frac{\rho \phi_L \phi_H \mu^2}{\phi_L + \phi_H (1-\rho)\mu^2} A_{\rho\rho} + 2\alpha \frac{\phi_L \phi_H \mu^2 \left(\phi_L + \phi_H \mu^2\right)}{\left(\phi_L + \phi_H (1-\rho)\mu^2\right)^2} A_\rho \tag{A7}$$

At $\rho = 0$ the first element on the RHS is 0 so that $W_{\rho\rho}^{RE} < 0$ and also the second-order condition holds. Consequently, welfare is maximized at exactly $\rho = 0$. ■

Proof of Proposition 5: Based on (A4) we adjust the welfare function by allowing it to account for search costs. Omitting arguments, we define:

$$\begin{aligned}\widetilde{W}(\rho, \phi, \varphi) &= (1 - \phi + \phi\mu^2)\left(4 - [A(\rho, \phi)]^2\right) \\ &\quad - 2\alpha\phi\mu^2 (2 - A(\rho, \phi)) + 2X + 1 - \varphi + \varphi\mu^2 - \psi(\phi) - \nu(\varphi; \phi)\end{aligned} \tag{A8}$$

Accordingly, welfare at the rational expectations equilibrium becomes:

$$W^{RE}(\rho) = \widetilde{W}(\rho, \phi^{RE}(\rho), \varphi^{RE}(\rho)) \tag{A9}$$

Taking derivative with respect to ρ yields:

$$\frac{dW^{RE}}{d\rho} = \widetilde{W}_\rho + \widetilde{W}_\phi \phi_\rho^{RE} + \widetilde{W}_\varphi \varphi_\rho^{RE} \tag{A10}$$

Applying the logic of Proposition 3 yields $\widetilde{W}_\rho(\rho, \phi^{RE}(\rho), \varphi^{RE}(\rho)) = 0$ at $\rho = 0$. Moreover, $\widetilde{W}_\varphi(\rho, \phi^{RE}(\rho), \varphi^{RE}(\rho))\varphi_\rho^{RE}(\rho) = 0$ for any ρ by the envelope theorem on (29). Accordingly, we obtain:

$$\frac{dW^{RE}}{d\rho} = \widetilde{W}_\phi \phi_\rho^{RE} = -\left[2\alpha\mu^2 (2 - A) + \nu_\phi\right] \phi_\rho^{RE} \tag{A11}$$

Note that the term $\left(-2\left(1 - \phi^{RE} + \phi^{RE}\mu^2\right) A + 2\alpha\phi^{RE}\mu^2\right) A_\phi$ which would normally be part of (A11) takes the value 0 when evaluated at $\rho = 0$.

From Lemma 4, we know $\phi_\rho^{RE} > 0$. Accordingly, $\frac{dW^{RE}}{d\rho} > 0$ whenever the condition $2\alpha\mu^2 (2 - A) + \nu_\phi < 0$ is satisfied, thereby verifying the claim. ■

Proof of Lemma 6: Using Assumption 1', the first-order condition of (33) becomes:

$$\frac{1 + p^s}{2}\mu_i K_i^{0.25} N_i^{-0.5} - w = 0 \;\Rightarrow\; N_i^s = \frac{(1 + p^s)^2 \mu_i^2}{4w^2} K_i^{0.5}\ . \tag{A12}$$

Substituting (A12) into (34) and factorizing yields:

$$U(w) = \left(1 - \frac{1}{w}\right)\left\{(1 - \alpha) + \alpha\frac{(1 + p^c)^2}{4}\right\}\left[\frac{1 - \phi}{w} K_L^{0.5} + \phi\frac{\mu^2}{w} K_H^{0.5}\right]\ . \tag{A13}$$

Also substituting (A12) back into the production function, we obtain:

$$\mu_i F(K_i, N_i^s) + p^s \mu_i G(K_i, N_i^s) = \frac{(1 + p^s)^2 \mu_i^2}{2w} (K_i)^{1/2}\ . \tag{A14}$$

Using (A12) and (A14) in (33), it further implies:

$$\Pi(K_i; p^s, w^s) = \frac{(1+p^s)^2 \mu_i^2 K_i^{0.5}}{4w} \tag{A15}$$

Accordingly, (35) takes the form:

$$\begin{aligned} AR(w) = \left((1-\alpha) + \alpha \tfrac{(1+p^c)^2}{4}\right) \left[\tfrac{1-\phi}{w} K_L^{0.5} + \phi \tfrac{\mu^2}{w} K_H^{0.5}\right] \\ - \gamma \left[(1-\phi) K_L + \phi K_H\right] \end{aligned} \tag{A16}$$

Equalizing (A13) and (A16) while cancelling common terms verifies the claim. ■

Proof of Proposition 7: Taking w as given and using (A15) to solve the investment decision of individual i yields:

$$K_i^* = \frac{1}{w^2} \left(1 - \alpha + \frac{\alpha (1+p^c)^2}{4}\right)^2 \frac{\mu_i^4}{4} \tag{A17}$$

Taking Assumption 2 into account, it implies the relationship $K_H^* = \mu^4 K_L^*$. Using the characterization (37) of $w(\cdot, \cdot)$ at a point $K_H^* = \mu^4 K_L^*$ allows us to simplify for the wage:

$$w^2 = \left((1-\alpha) + \alpha \frac{(1+p^c)^2}{4}\right) \frac{(K_L^*)^{-0.5}}{\gamma} . \tag{A18}$$

Accordingly, substitution into (A17) yields $w^{RE} = 2/\gamma$. Finally, computing i's production of the intermediate good in state s, we have:

$$\pi^c = \frac{(1-\phi) \frac{(1+p^c)}{2w} (K_L^*)^{1/2}}{(1-\phi) \frac{(1+p^c)}{2w} (K_L^*)^{1/2} + (1-\rho) \phi \frac{(1+p^c)\mu^2}{2w} (K_H^*)^{1/2}} \tag{A19}$$

Together with $K_H^* = \mu^4 K_L^*$, it verifies (40). ■