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Abstract

In the presence of idiosyncratic risk, the public revelation of information about uncertain aggregate outcomes such as policy choices can be detrimental to social welfare. By announcing informative signals on non-insurable aggregate risk, the policy maker distorts agents' insurance incentives and increases the riskiness of the optimal allocation that is feasible in self-enforceable arrangements. As an application, we consider a monetary authority that may reveal changes in the inflation target, and document that the negative effect of distorted insurance incentives can very well dominate conventional effects in favor for the release of better information.

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1 Introduction

Nowadays central banks all over the world are providing more information, and they are providing it earlier to the public than ever before in their history (see e.g. Blinder, Ehrmann, Fratzscher, Haan, and Jansen 2008; Crowe and Meade 2008; Eijffinger and Geraats 2006; Woodford 2008). There seems to be widespread agreement that the recent change in disclosure policies is socially beneficial. We argue that the case for disclosure is not that obvious. In particular, we show that by providing better information on future aggregate risk, e.g. by announcing future policies or revealing economic forecasts, policy makers may decrease social welfare by distorting private insurance incentives.

We consider an environment with idiosyncratic and aggregate risk. Households can voluntarily participate in insurance arrangements for idiosyncratic risk to reduce their consumption risk. Such arrangements are self-enforceable or compatible with voluntary participation incentives if in any period following the realization of idiosyncratic uncertainty, households choose not to walk away from the arrangement to live in autarky from that period on. The latter option may be tempting for households with a high current income since the insurance arrangements prescribe transfers from these households to households with a low income in the current period. The lack of commitment thus creates a tension for high income households between higher current consumption and the future benefits of insurance promised in the arrangements.

Information plays a crucial role in households' trade-off between future insurance and current incentives. We study disclosure polices by introducing a public signal through which a policy maker can reveal the future aggregate state. The signal is common to all agents and does not resolve households' idiosyncratic uncertainty. After the realization of current period idiosyncratic income and given the public signal on future aggregate risks agents decide to participate in social insurance, or alternatively, to live in autarky.

As our main result, we formally show that less precise public information about the future aggregate state is preferable over perfect public information when incentive constraints matter. The mechanism is the following. Under the socially optimal insurance arrangement, the amount of the consumption good that the agents with high income in the current period are willing to transfer reflects future benefits of the insurance relative to the outside option. The key point is that agents value the insurance arrangement conditionally not only on their idiosyncratic realization but also on the aggregate state. In particular, if the signal indicates that the future aggregate state is likely to be one in which the benefits of the arrangement are relatively large, then the agents are willing to give up a larger share of current period consumption goods for these future benefits of the arrangement. Similarly, if the signal informs of a future aggregate state in which the gains of the risk-sharing agreement are relatively low, then agents with a high current income are less willing to share their good fortune. When the signal on the aggregate state becomes more informative, the optimal consumption allocation spreads out to account for all possible realizations of the signal. Comparing informative and uninformative signals, the expected utility of high income agents before the signal materializes is independent of signal precision. This implies that the consumption allocation of high income agents under perfect information is riskier than under imperfect information. Since households are risk-averse, under perfect information high income agents are less willing to transfer goods to low income households. Correspondingly, under imperfect information low income households are better off, and ex-ante risk averse agents prefer uninformative policy announcements.

The negative effect of information relies on the relevance of rational incentives for risk sharing arrangements. When agents respect commitments or can trade a complete set of perfectly enforceable insurance contracts, better public information on aggregate risk does not affect social welfare. To the best of our knowledge, we are the first to shed light on the welfare effects of announcements by policy makers on risks that are common to all agents under the plausible assumption that the idiosyncratic risk is not completely, but only partially insurable. There are numerous possible applications including the welfare assessment of announcements on future tax, spending, debt or monetary policies, as well as the welfare effects of the public disclosure of economic forecasts.

As our main application, we develop a general equilibrium model that integrates the risk-sharing mechanism into a monetary production economy in which households are subject to a cash-in-advance constraint and face idiosyncratic employment opportunities. To insure against the idiosyncratic risk, households may engage in risk-sharing arrangements consistent with voluntary participation incentives. The monetary authority is assumed to pursue a stochastic inflation target. The target is known to the monetary authority one period in advance, and the authority may choose to release that information with certain precision. Our novel finding is that more precise announcements on future monetary policy are detrimental to social welfare. Furthermore, we show that the level of patience needed to sustain perfect risk sharing as the first best allocation is strictly increasing in the precision of the monetary policy announcement.

To evaluate the detrimental effect of policy announcements, we extend the model by introducing a fraction of firms, which need to set prices one period in advance. With this extension, better information affects the economy in two ways. First and conventionally, more precise announcements allow the sticky price firms to preset their prices correctly, thereby resulting in less price distortions and a better allocation of resources. Second – and this is the new effect – early announcements distort risk sharing, increase consumption inequality and thereby worsen the contractual insurance possibilities ex-ante. We calibrate the monetary production economy to match basic inflation and income characteristics of the U.S. economy on an annual basis. The negative effect of information on aggregate risk is sizeable: the costs of information disclosure account for 18 percent of the benefit from removing aggregate fluctuations all together. Employing recent evidence on the frequency of price adjustments (Bils and Klenow 2004), the negative effect of information quantitatively dominates the positive aspect for reasonable degrees of risk aversion. Furthermore, the recent increase in income inequality in the U.S. (Gottschalk and Moffitt 2002; Krueger and Perri 2006) amplifies the negative rather than the positive effect of public information.

The social value of information has been extensively studied in the literature. Our paper builds a bridge between two distinct and separate strands of literature: the literature on global games that focuses on aggregate risk, and the literature on efficient risk sharing that concentrates on the insurance of idiosyncratic risk. The model we develop puts us into the position to analyze the welfare effects of more precise information on the aggregate state of the economy under the realistic assumption that the idiosyncratic risk is not fully diversifiable.

In a global games framework, Morris and Shin (2002) show that better public information on aggregate risks may be undesirable in the presence of private information on these risks when the coordination of agents is driven by strategic complementarities in their actions. The result is due to the inefficient weight that agents assign to public information relative to private information. While the conditions for a welfare-decreasing effect of more precise public information are rather special and controversial (see e.g. Svensson 2006; Woodford 2005), Angeletos and Pavan (2007) draw a general conclusion that in the presence of a signal-extraction problem the social value of information is ambiguous if the first best is different from the equilibrium under perfect information. The main focus in this field is on aggregate risk, while idiosyncratic risk is either absent or assumed to be completely insurable due to the existence of complete financial markets.

Our study is closely related to the literature on efficient risk sharing. Hirshleifer (1971) is among the first to point out that perfect information makes risk averse agents ex-ante worse off if this leads to an evaporation of risks that otherwise could have been shared in a competitive equilibrium. Schlee (2001) shows under which general conditions better public information about idiosyncratic risk is undesirable. Thomas and Worrall (1988) are among the first to analyze the role of self-enforcing contracts or contracts consistent with voluntary participation incentives in the insurance of idiosyncratic risk. They find that wages in the optimal contract are sticky and less variable than spot market wages, which serve as the outside option. Kocherlakota (1996a) shows that the lack of commitment can explain the empirically observed positive correlation between current income and current consumption. The properties of stationary contracts in comparison to the first best are characterized by Coate and Ravallion (1993). Attanasio and Rios-Rull (2000) and Krueger and Perri (2005) argue that in economies where agreements are not enforceable, public insurance may crowd out private insurance arrangements. This literature focuses on the role of information on idiosyncratic risk in efficient risk-sharing arrangements. More relevant and important from a practical perspective, we consider the role of information on aggregate risk. Moreover, the analysis of the welfare effects of better information on aggregate risk involves technical challenges that are absent in frameworks that focus on idiosyncratic risk.

The remainder of the paper is organized as follows. In the next section, we start with a simple two-period example to highlight the basic voluntary risk-sharing mechanism involved, and state our main result in that simple environment. In Section 3 we set up a model that integrates the mechanism into a monetary production economy with infinite horizon and flexible prices. In Section 4 we state the main results for that application. In Section 5 we evaluate the importance of the distortions of risk-sharing possibilities caused by policy announcements. The last section concludes.

2 Simplified two-period real economy

We set up a simple example that captures the interaction between individual incentives and the precision of public signals on aggregate risk. When participation in a risk-sharing arrangement is voluntary we show that risk averse agents prefer completely uninformative public signals on the aggregate risk over perfectly informative signals.

Consider a two period pure exchange economy with a continuum of ex-ante identical agents. In each period an agent obtains either a high endowment y^h or a low endowment y^l with equal probability – independent across time and agents. Furthermore, in the second period households' income is affected by taxes. To ease the exposition, we assume that with equal probability the government can either tax away all goods (type-b policy) or impose zero tax (type-g policy), and assume that tax revenues are completely wasted by the government.

The preferences of agents are given by

$$E[u(c_1) + \beta u(c_2)], \tag{1}$$

where c_1 and c_2 are consumption in the first and in the second period respectively, β is the discount factor, and u is a period utility function, which is assumed to be increasing and strictly concave. We measure social welfare according to (1), i.e. as households' expected utility before any uncertainty has been resolved.[1]

If agents are able to commit before their endowments realize in the first period, the optimal risk-sharing arrangement is perfect risk sharing. The commitment requirement is crucial. After observing current endowments an agent with a high income may have an incentive to deviate from the perfect risk-sharing agreement, making such an agreement unsustainable.

To capture this rational incentive we analyze risk-sharing possibilities under two-sided lack of commitment by introducing voluntary participation constraints. In the two-period model, the voluntary participation constraints apply only for the first period and characterize the trade-off between the first period consumption and the value of risk sharing provided by the arrangement in the second period. A risk-sharing arrangement is sustainable if each agent after observing his first period endowment at least weakly prefers to follow the arrangement than to defect into autarky. In other words, it is in the best of all agents' rational interest to support the agreement. For the second period we assume that agents respect the commitments made in the first period. Otherwise, if voluntary participation were allowed in both periods, there would be no room for social insurance as agents would always choose to consume their endowments. While limited commitment is necessary for the existence of insurance in the two-period model, we do not need to impose any commitment in the infinite horizon model provided in the next section.

We compare two environments different in information precision about the future government policy. In the environment of perfect information agents know the second period government policy when they decide in the first period to sustain the risk-sharing agreement or to deviate to autarky. In the environment of completely imperfect information agents are left uninformed about the government policy in the second period.

In the first environment, when future government policy is known, participation con-

[1]We consider equal Pareto weights across ex-ante identical agents. If we were to allow for non-equal Pareto weights social welfare would still be higher under imperfect information than under perfect information about aggregate risk.

straints are given by

$$u(c_{1g}^h) + \beta\frac{1}{2}\left(u(c_{2g}^{hh}) + u(c_{2g}^{hl})\right) \geq u(y^h) + \beta\frac{1}{2}\left(u(y^h) + u(y^l)\right) \tag{2}$$

$$u(c_{1b}^h) + \beta u(0) \geq u(y^h) + \beta u(0) \tag{3}$$

$$u(c_{1g}^l) + \beta\frac{1}{2}\left(u(c_{2g}^{lh}) + u(c_{2g}^{ll})\right) \geq u(y^l) + \beta\frac{1}{2}\left(u(y^h) + u(y^l)\right) \tag{4}$$

$$u(c_{1b}^l) + \beta u(0) \geq u(y^l) + \beta u(0), \tag{5}$$

where c_{1k}^i is period-1 consumption of an agent with y^i first period endowment under k-type government policy, and c_{2k}^{ij} is period-2 consumption of an agent with y^i endowment in the first period and y^j endowment in the second period. In the constraints we explicitly substituted $c_{2b}^{ij} = 0$ for the type-b policy. The first two constraints are relevant for agents with high first period income and the latter describe the incentives of agents with low first period income. The left hand side of each constraint constitutes expected utility of the arrangement, and the right hand side is the value of living in autarky as the outside option.

The resource feasibility constraints are

$$c_{1g}^h + c_{1g}^l = c_{1b}^h + c_{1b}^l = c_{2g}^{hh} + c_{2g}^{ll} = c_{2g}^{hl} + c_{2g}^{lh} = y^h + y^l. \tag{6}$$

The optimal risk-sharing arrangement in the perfect information environment is a consumption allocation $\{c_{1k}^i, c_{2k}^{ij}\}$ that maximizes ex-ante utility (1) subject to participation constraints (2)-(5) and resource constraints (6).

The second environment is set to represent completely imperfect information. In the first period after observing their current endowments – without knowing the government policy in the second period – agents decide about participation in the risk-sharing agreement. Correspondingly, the voluntary participation constraints read

$$u(c_1^h) + \beta\frac{1}{4}\left(u(c_{2g}^{hh}) + u(c_{2g}^{hl}) + 2u(0)\right) \geq u(y^h) + \beta\frac{1}{4}\left(u(y^h) + u(y^l) + 2u(0)\right) \tag{7}$$

$$u(c_1^l) + \beta\frac{1}{4}\left(u(c_{2g}^{lh}) + u(c_{2g}^{ll}) + 2u(0)\right) \geq u(y^l) + \beta\frac{1}{4}\left(u(y^h) + u(y^l) + 2u(0)\right), \tag{8}$$

where c_1^i is period-1 consumption of an agent with y^i first period endowment, and resource feasibility requires

$$c_1^h + c_1^l = c_{2g}^{hh} + c_{2g}^{ll} = c_{2g}^{hl} + c_{2g}^{lh} = y^h + y^l. \tag{9}$$

The optimal risk-sharing arrangement under completely imperfect information is a consumption allocation $\{c_1^i, c_{2k}^{ij}\}$ that maximizes ex-ante utility (1) subject to participation constraints (7)-(8) and resource constraints (9).

Our goal is to highlight that information about aggregate risk can be harmful for social welfare since it distorts the insurance of idiosyncratic risk under voluntary participation. The result is formally stated in Theorem 1. The intuition is the following. From an ex-ante perspective, the agents desire to insure their consumption against their idiosyncratic endowment risk. The optimal insurance scheme prescribes transfers from ex-post high income agents to ex-post low income agents in all states. While thus agents with a low ex-post income are never worth-off in the agreement, for agents with a high ex-post income to live alternatively in autarky may be an attractive outside option. The key to understand the negative effect of more precise information is that the more agents with a high income know about the future tax policy the less willing they are to transfer resources to the less fortunate agents.

Theorem 1 *Under completely imperfect information social welfare is strictly higher than under perfect information about future government policies.*

Proof. One can distinguish three cases depending on which participation constraints are binding. In the first case, all participation constraints for high endowment agents under perfect and imperfect information are binding. In the second case, only the participation constraints for high income agents under the type-b policy are binding. In the third case, which is an intermediate case between the first two, for high income agents the participation constraints under the type-b policy and imperfect information are binding.

In the first case, it follows from the optimal risk-sharing problem that consumption of the agents under the type-g policy should be perfectly smoothed over time for both information environments. In the imperfect information environment this condition reads

$$c_{1g}^h = c_{2g}^{hh} = c_{2g}^{hl},$$

and similarly under imperfect information

$$c_1^h = c_{2g}^{hh} = c_{2g}^{hl}.$$

The algebraic details for this result are provided in the technical appendix. Under the type-b policy there is no private consumption in the second period, and we immediately obtain that in the perfect information environment $c_{1b}^h = y^h$ and $c_{1b}^l = y^l$. We thus compare the information environments in terms of the first period allocations. From the binding participation constraints (2), (3), and (7) it follows that the first period allocations under the two informational environments are characterized by the following inequalities $c^h_{1g} < c^h_1 < c^h_{1b}$, which are further illustrated in Figure 1.

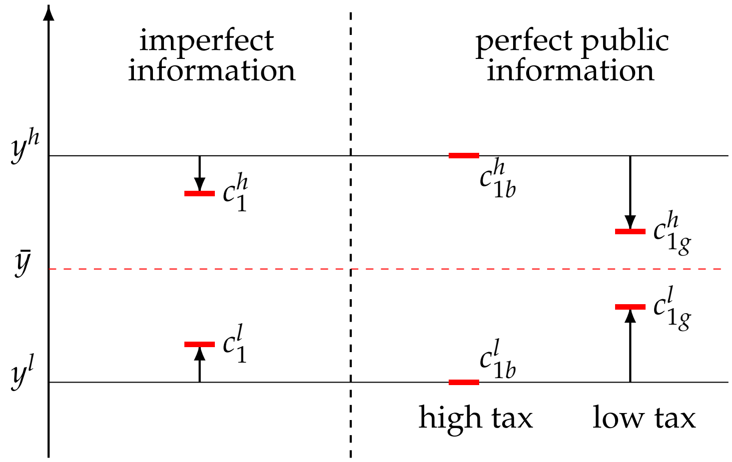

Figure 1: Optimal allocations for perfect and imperfect information under binding participation constraints.

From the binding participation constraints (2), (3), and (7) it also follows that agents with a high first period endowment obtain the same expected utility under perfect and imperfect information

$$\left(\frac{1}{2}+\frac{\beta}{2}\right)u(c^h_{1g})+\frac{1}{2}u(c^h_{1b})=\left(1+\frac{\beta}{2}\right)u(c^h_1). \tag{10}$$

Therefore the consumption allocation for the high income agents under perfect information is riskier from an ex-ante perspective. Due to strictly concave preferences, Equation (10) implies that

$$\left(\frac{1}{2}+\frac{\beta}{2}\right)c^h_{1g}+\frac{1}{2}c^h_{1b}>\left(1+\frac{\beta}{2}\right)c^h_1. \tag{11}$$

For the expected utility of agents with a low income in the first period under perfect and imperfect information this implies

$$\begin{aligned}\left(\frac{1}{2}+\frac{\beta}{2}\right)u(c^l_{1g})+\frac{1}{2}u(c^l_{1b}) &< \left(1+\frac{\beta}{2}\right)u\left(\frac{1+\beta}{2+\beta}c^l_{1g}+\frac{1}{2+\beta}c^l_{1b}\right) \\ &= \left(1+\frac{\beta}{2}\right)u\left(y^h+y^l-\frac{1+\beta}{2+\beta}c^h_{1g}-\frac{1}{2+\beta}c^h_{1b}\right) \\ &< \left(1+\frac{\beta}{2}\right)u(y^h+y^l-c^h_1)=\left(1+\frac{\beta}{2}\right)u(c^l_1),\end{aligned} \tag{12}$$

where the first inequality is due to strict concavity and the second one is implied by (11). Thus, agents with low first period endowments are strictly better off under completely imperfect information. Taking unconditional expectation, adding up (10) and (12) we get that imperfect information is strictly preferable for this case.

In the second case when the participation constraints in the environment of imperfect information are not binding, the optimal allocation in this environment is perfect risk sharing. This outcome is preferable to the one under perfect information where the first best is not incentive compatible because the participation constraints for the type-b policy (3) and (5) always hold with equality.

In the third case when the participation constraints for high first period endowment agents under the type-g policy (2) are not binding but the participation constraints for high income agents in the completely uninformative environment (7) do bind, imperfect information is still preferable. It can be seen that as agents become more patient the first period allocation for perfect information cannot be improved upon, but under imperfect information social welfare is still increasing towards the first best. ■

The result of the negative social value of public information about second period government policies is robust to any policies which lead to a non-identical dispersion of agents' disposable income. For example, if the government were to redistribute the tax revenues equally among agents, better information on the taxes would be still undesirable. Moreover, it is not crucial for the finding in Theorem 1 to require a policy under which the idiosyncratic risk vanishes completely. Even if taxation were not as extreme as a 100% tax, our main result on the negative value of information stays valid.

Morris and Shin (2002) too provide an argument for a negative value of better information on aggregate risk in the presence of a signal-extraction problem. However, their argument has been criticized from a normative perspective (Woodford 2005). Woodford's main criticism is that the strong coordination incentive necessary to render the value of public information negative is at odds with the type of preferences typically assumed in macroeconomic modeling. Moreover, he points out that the Morris-Shin result hinges crucially on the assumption that individual preferences, but not social welfare feature the coordination motive. In contrast, we show that the social value of information can be negative even under standard preferences and even when individual preferences and social welfare coincide. Compared to the literature on efficient risk sharing and public information (e.g. Berk and Uhlig 1993; Hirshleifer 1971; Schlee 2001), we show that not only public information on idiosyncratic risk but also on non-insurable aggregate risk can be harmful to social welfare.

In the next section we embed this mechanism into a richer environment with a monetary authority which announces a signal on its future inflation target. In that application we extend the simple example in several dimensions. First, we do not impose any commitment and consider an economy with an infinite number of periods. Second, we allow for continuity in information precision.

3 Monetary policy and infinite horizon

We proceed by integrating the voluntary risk-sharing mechanism into a monetary production economy. In this section we introduce an economy and describe the notion of equilibrium. In the economy, households' consumption expenditures are linked to nominal balances from the previous period with a cash-in-advance constraint originated by Clower (1967). As in Lucas (1980), each household consists of a worker-shopper pair. The production part consists of two sectors. Each sector is populated by a continuum of monopolistic competitive firms (Blanchard and Kiyotaki 1987; Dixit and Stiglitz 1977), and productivity of the monopolistic firms is different across sectors. The random assignment of workers to firms with different productivity constitutes idiosyncratic risk. The notion of equilibrium is introduced in two steps. First, we describe the equilibrium for given risk-sharing transfers among households. Second – and this is our main contribution here – we introduce the possibility for households to insure the idiosyncratic risk in arrangements that are consistent with their rational participation incentives. The exchange of consumption goods prescribed by the arrangements is reflected in risk-sharing transfers among households. Furthermore, we define the optimal pure insurance transfers under voluntary participation in order to find out how informative signals on future inflation affect the optimal insurance.

We consider a production economy with a continuum of households of measure one and a single perishable consumption good.

Households are identical ex-ante, and their preferences over the stream of consumption are given by

$$E\left[\sum_{t=0}^{\infty}\beta^t u(c_t^i)\right], \tag{13}$$

where c_t^i is consumption of household i in period t, $0 < \beta < 1$ is the time discount factor, and u is the period utility function. We assume the period utility function to be twice-differentiable, increasing, and strictly concave.

Each household consists of two members: a shopper and a worker. Each period, the worker earns idiosyncratic income and inelastically supplies one unit of labor to one of the two production sectors, while the shopper buys consumption goods. Money is the only means for facilitating transactions and transferring wealth across periods. The period budget constraint of household i is

$$M_t^i + p_t c_t^i = M_{t-1}^i + p_t w_t^f + d_t + p_t \tau_t^i, \tag{14}$$

where M_t^i are nominal money holdings at the end of period t, d_t are shares of nominal profits of monopolistically competitive firms, τ_t^i are real transfers prescribed by a risk-sharing arrangement, w_t^f is the real wage in production sector f where the worker is employed, and p_t is the aggregate price level.

Shopper and worker are distinguished by activities. In each period, while a worker works and earns money, a shopper exchanges the money earned by the worker in the previous period for consumption goods

$$p_t x_t^i = M_{t-1}^i, \tag{15}$$

where $x_t^i = c_t^i - \tau_t^i$ is the amount of the consumption good directly bought in the market.[2]

The production part of the economy is represented by two production sectors. Both sectors include a final good firm and a continuum of intermediate good firms. In each period the final good firms in both sectors produce an identical consumption good by aggregating over sector-specific differentiated intermediate goods. The intermediate goods are aggregated into the final good with a constant elasticity of substitution

$$y_t^f = \left(\int_0^1 (y_t^{fj})^{1-\rho} dj \right)^{1/(1-\rho)}, \tag{16}$$

where y_t^f is the amount of the consumption good produced by final good firm f, y_t^{fj} is an intermediate good produced by differentiated good firm fj, and ρ is the inverse of the elasticity of substitution between differentiated goods. The production technology of the differentiated good firms is given by

$$y_t^{fj} = a_t^f l_t^{fj}, \tag{17}$$

where l_t^{fj} is the labor input. The productivity of the differentiated good firms a_t^f is the same for all intermediate good firms with a production sector, but different across the

[2] Alternatively, the cash-in-advance constraint can be stated with inequality and restrictions on the set of risk-sharing transfers are imposed (for a sufficiently large lower bound on inflation) such that the cash-in-advance constraint is binding in equilibrium.

sectors.

Acting under perfect competition, final good firms minimize costs by choosing the factor demand for each intermediate good to satisfy aggregate demand. The cost minimization problem is

$$\min \int p_t^{fj} y_t^{fj} dj \tag{18}$$

subject to the technology constraint (16), where p_t^{fj} is the price of intermediate good fj that the final good firm f takes as given.

The intermediate good producers operate under monopolistic competition. A measure λ of monopolistically competitive firms maximize profits subject to the actual demand for their product. The profit maximization problem of the monopolistically competitive firms with flexible price-setting is

$$\max p_t^{fj} y_t^{fj} - p_t w_t^f l_t^{fj}, \tag{19}$$

given the demand of the final good firm and nominal sector wages, and subject to the production technology (17). The other $(1-\lambda)$ firms preset prices a period ahead based on a public signal on inflation by solving the expected profit maximization problem

$$\max E_{t-1}[p_t^{fj} y_t^{fj} - p_t w_t^f l_t^{fj} | s_{t-1}], \tag{20}$$

where s_{t-1} is the signal released in period $t-1$ about inflation target in period t.

In each period, a worker is randomly assigned either to be employed in the sector of high productivity a^h, or to work for firms with low productivity a^l. After selling the final goods to the shoppers, a worker obtains labor income and an equal share of profits of all monopolistically competitive firms.

Monetary policy is characterized by a stochastic inflation target. All agents in the economy are rational and know the stochastic properties of the inflation target process. In addition, the monetary authority knows the inflation target one period in advance, and provides a public signal on the future inflation target with a certain precision. The exogenous process for the inflation target is given by an i.i.d process with two states of equal probability: a high inflation state π_h and a low inflation state π_l.[3] Similarly, the public signal on next period inflation takes two values, a high realization s_h and a low realization s_l. The precision of the public signal is given by $\kappa \equiv \text{Prob}[\pi_j | s_j]$, with $1/2 \leq \kappa \leq 1$.

The inflation process coincides with the target by appropriate money injections. Since

[3] The inflation process and productivity are assumed to be non-degenerate $\pi_l < \pi_h$ and $a^l < a^h$.

seigniorage is spent on government expenditures,[4] the government budget constraint reads

$$p_t g_t = M_t - M_{t-1}, \tag{21}$$

where g_t denotes real government expenditures, and M_t is the aggregate money supply.[5]

Definition 1 *An incomplete markets equilibrium is an allocation* $\{c_t^i, x_t^i, M_t^i, d_t^f, y_t^f, y_t^{fj}, M_t, g_t\}$ *and a price system* $\{p_t, p_t^{fj}, w_t^f\}$ *such that given exogenous processes for the inflation target* $\{\pi_t\}$*, the public signal* $\{s_t\}$*, the assignments of households to production sectors* $\{a_t^i\}$*, and the risk-sharing transfers* $\{\tau_t^i\}$*, and initial conditions for the distribution of nominal money balances* $\{M_{-1}^i\}$*, and initial price setting of non-flexible price firms* $\{p_0^{fj}\}$*, the following conditions hold*

(i) for each household i given prices $\{p_t, w_t^f\}$ *and profits* $\{d_t^f\}$*, the allocation* $\{c_t^i, x_t^i, M_t^i\}$ *maximizes household's utility (13) subject to the budget constraint (14) and the cash-in-advance constraint (15),*

(ii) for each production sector f *given prices* $\{p_t, w_t^f\}$*, the production allocation* $\{y_t^f, y_t^{fj}\}$*, prices* $\{p_t^{fj}\}$ *and profits* $\{d_t^f\}$ *solve the cost minimization problem of the final good firms (18), and the profit maximization problems of the differentiated good firms (19) and (20),*

(iii) monetary injections are consistent with the inflation target

$$p_t = \pi_t p_{t-1},$$

(iv) the government budget constraint (21) is fulfilled, and

(v) markets clear

$$\int c_t^i di + g_t = \int y_t^f df, \quad \int M_t^i di = M_t, \quad \int l_t^{fj} dj = \frac{1}{2}.$$

We assume that the low realization of the inflation target is large enough to satisfy the resource feasibility with non-negative government expenditures. When we refer to social welfare derived from a certain allocation, we mean the ex-ante utility (13), which is evaluated before any uncertainty has been resolved.

[4] Alternatively, when seigniorage is equally distributed back to households our main results stated in Theorem 2 stay valid.

[5] In our formulation the stochastic inflation target process represents aggregate risk and is exogenously given. As a result, government spending is endogenous.

The main element of our model is households' risk-sharing arrangement under voluntary participation. Without risk-sharing transfers the consumption allocation that results from the incomplete markets equilibrium is not efficient from an ex-ante perspective due to market incompleteness which prevents households from optimal borrowing and lending. However, the efficient use of a complete set of securities requires commitment or enforceability of the arrangements. In the absence of commitment the consumption allocation can still be improved by risk-sharing transfers consistent with voluntary participation incentives. We determine the socially optimal transfer scheme under voluntary participation in the incomplete markets equilibrium. Voluntary participation in social insurance provided by the risk-sharing transfers means that in each period households may decline the offered risk-sharing arrangement. In such a case they live forever in an economy with no transfers, consuming only the goods bought directly in the market.

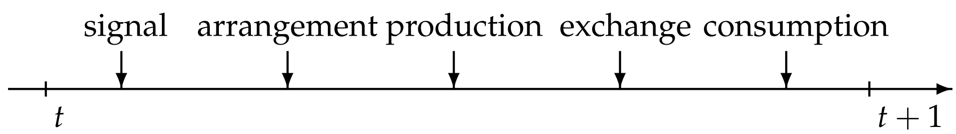

Figure 2: Timing of events in the monetary production economy.

The timing of events is illustrated in Figure 2. In each period, first, agents obtain a public signal on next period's inflation target and observe the current period inflation target.[6] Second, households decide on sustaining a risk-sharing arrangement that prescribes transfers $\{\tau_t^i\}$. Third, workers and shoppers separate, and the former inelastically supply their labor services into the production process. Fourth, market exchange takes place. Flexible price monopolistic firms set prices for the current period, shoppers receive consumption goods in exchange for cash held from the previous period, workers receive wages and shares of profits and the government collects seigniorage from money injections. Fifth, among shoppers an exchange according to the risk-sharing arrangement takes place. Finally, members of each household meet again, consume, money balances are passed from the worker to the shopper for next period consumption purchases, and sticky price firms preset prices for the next period based on the public signal on the future inflation target.

Formally, the risk-sharing arrangement is built upon the consumption allocation of the incomplete markets equilibrium with no transfers as the outside option. This "off-equilibrium" allocation coincides with the equilibrium amount of consumption goods

[6] An alternative timing of events that leads to exactly the same results and does not require the awareness of current period inflation includes shoppers' trading first, followed by the risk sharing decision, and workers' realization of income.

directly bought in the market $\{x_t^i\}$ since there is no choice how much money the agents hold from this period to next, and therefore how much they purchase. Moreover, since the equilibrium on the goods' market is not linked to the distribution of consumption among households, prices in the equilibrium without and with transfers are identical.

Let the individual public state at time t be $h_t^i = (x_t^i, X_t, s_t)$, where s_t is the public signal about inflation in period $t+1$, and X_t denotes aggregate resources available for private consumption. We restrict our analysis to pure insurance arrangements as emphasized by Kimball (1988), Coate and Ravallion (1993), and Ligon, Thomas, and Worrall (2002), which implies that the current risk-sharing transfers do not depend on transfers received in the past.[7]

Definition 2 *A consumption allocation $\{c_t^i\}$ is sustainable if there exist transfers $\{\tau_t^i\}$ such that*

(i) the consumption allocation $\{c_t^i\}$ solves the incomplete markets equilibrium with the transfers $\tau_t^i(h_t^i)$,

(ii) for each household i and state h_t^i, the consumption allocation $\{c_t^i\}$ is weakly preferable to the outside option $\{x_t^i\}$, which solves the rational expectation equilibrium with no transfers

$$E\left[\sum_{j=0}^{\infty} \beta^{t+j} u(c_{t+j}^i) | h_t^i\right] \geq E\left[\sum_{j=0}^{\infty} \beta^{t+j} u(x_{t+j}^i) | h_t^i\right], \tag{22}$$

(iii) and the transfers $\{\tau_t^i\}$ are resource-feasible

$$\int \tau_t^i(h_t^i) di = 0. \tag{23}$$

The key element of the information set in period t is the public signal on inflation provided by the monetary authority. The signal helps to resolve inflation uncertainty for the agents.

Definition 3 *A socially optimal arrangement under voluntary participation is a consumption allocation $\{c_t^i\}$ that provides the highest expected utility among the set of sustainable allocations.*

It is natural to compare the optimal arrangement under voluntary participation to an optimal arrangement under commitment. We define the *optimal commitment allocation* as a consumption allocation that provides the highest expected utility among the set of

[7] This precludes a lending element in the risk-sharing arrangements. A household that receives a transfer may be willing to "pay back" the donor by accepting a less favorable transfer agreement in the future. This in turn may induce a higher transfer from the donor today and may result in better risk sharing.

consumption-feasible allocations. An allocation is consumption-feasible if it solves the incomplete markets equilibrium with resource-feasible transfers $\{\tau_t^i\}$.

4 Negative social value of information

In this section we deliver our main result that policy announcements about future monetary policy can be detrimental to social welfare. We show that better precision of policy announcements is not desirable because it harms individual risk-sharing possibilities when rational participation incentives matter. In addition, we show that under more informative signals perfect risk sharing requires a higher degree of patience to be supported as a sustainable allocation.

To highlight the main effect we abstain in this section from the effect of public signals on optimal pricing decisions of firms. We avoid the pricing friction on the firm side by assuming in this section that all intermediate firms are flexible price firms. In the next section we extend the main result by illustrating a trade-off in public signal precision when a fraction of firms has to preset prices one period in advance: more precise information reduces the dispersion in relative prices between flexible and sticky-price firms and thereby leads to a better allocation of resources.

4.1 Optimal risk sharing under voluntary participation

In the following paragraphs we characterize the incomplete markets equilibrium under flexible prices, then proceed to state the problem to design the socially optimal arrangement in recursive form and derive general properties of the optimal solution.

As an initial point of our analysis we compute the incomplete markets equilibrium in the absence of transfers. Due to constant labor supply and since all firms are flexible in their price setting, the income of household i earned in period t depends only on productivity. From (16)-(19) the real income of a worker employed in sector f is equal to

$$w_t^f + \frac{d_t}{p_t} = \frac{1}{\mu}a^f + \frac{\mu-1}{\mu}\frac{a^h + a^l}{2},$$

where $\mu = 1/(1-\rho)$ is a fixed mark-up above real marginal costs. The first term is labor income and the second term is profit equally distributed among households. From the cash-in-advance constraint (15), equilibrium consumption in the absence of transfers –

the outside option – is given by

$$x_t^i = x^f(\pi_j) = \left[\frac{1}{\mu}a^f + \frac{\mu-1}{\mu}\frac{a^h+a^l}{2}\right]/\pi_j, \tag{24}$$

when inflation in period t is π_j and the worker was assigned to sector f in period $t-1$. Combining the goods' market clearing condition with the government budget constraint (21) and the cash-in-advance constraint (15), government expenditures are

$$g_t = y_t - y_{t-1}/\pi_j = \frac{a^h+a^l}{2}\frac{\pi_j-1}{\pi_j}. \tag{25}$$

It follows from (24) and (25) that the equilibrium consumption in the absence of transfers and the government expenditures is independent of the precision of the inflation target signal.

With risk-sharing transfers, from Definition 2 and Equation (24), period-t equilibrium consumption of household i is given by

$$c_t^i = c^f(\pi_j, s_k) = \left[\frac{1}{\mu}a^f + \frac{\mu-1}{\mu}\frac{a^h+a^l}{2}\right]/\pi_j + \tau(a^f, \pi_j, s_k),$$

when period-t signal of period-$t+1$ inflation is s_k, period-t inflation is π_j, and the worker of the household was assigned to production sector j in period $t-1$. With pure insurance transfers the equilibrium period-t consumption depends only on period-t direct purchases x_t^i, total resources available for consumption X_t, and the signal s_t on the period $t+1$ inflation target realized in period t. In particular, this implies that the current transfers prescribed by the arrangement do not hinge on the individual transfers received in the past. This allows us to write the optimal risk-sharing arrangement problem in a recursive form.

For two productivity states, two inflation states, and two signals on next period's inflation rate, the optimal contract problem given in Definitions 2 and 3 leads to the following recursive description

$$\max_{c^f(\pi_j,s_k)\geq 0} \frac{1}{1-\beta} E\left[u(c^f(\pi_j, s_k))\right] \tag{26}$$

subject to participation constraints for high and low signals

$$u(c^f(\pi_j, s_h)) + \beta\kappa V_{rs}(\pi_h) + \beta(1-\kappa)V_{rs}(\pi_l) + \frac{\beta^2}{1-\beta}V_{rs} \geq$$
$$u(x^f(\pi_j)) + \beta\kappa V_{at}(\pi_h) + \beta(1-\kappa)V_{at}(\pi_l) + \frac{\beta^2}{1-\beta}V_{at} \quad \forall f, j, \tag{27}$$

$$u(c^f(\pi_j, s_l)) + \beta\kappa V_{rs}(\pi_l) + \beta(1-\kappa)V_{rs}(\pi_h) + \frac{\beta^2}{1-\beta}V_{rs} \geq$$
$$u(x^f(\pi_j)) + \beta\kappa V_{at}(\pi_l) + \beta(1-\kappa)V_{at}(\pi_h) + \frac{\beta^2}{1-\beta}V_{at} \quad \forall f, j, \tag{28}$$

and consumption-feasibility constraints

$$\sum_f c^f(\pi_j, s_h) = \sum_f c^f(\pi_j, s_l) = \sum_f x^f(\pi_j) \quad \forall j, \tag{29}$$

with the period values of the arrangement

$$V_{rs}(\pi_j) \equiv E\left[u(c^f(\pi_j, s_k)) \middle| \pi_j\right], \qquad V_{rs} \equiv E\left[V_{rs}(\pi_j)\right],$$

and of the outside option

$$V_{at}(\pi_j) \equiv E\left[u(x^f(\pi_j)) \middle| \pi_j\right], \qquad V_{at} \equiv E\left[V_{at}(\pi_j)\right].$$

As the first point in characterizing socially optimal arrangements, we show that the optimal arrangement exists and is unique.

Lemma 1 *The socially optimal arrangement exists and is unique. The arrangement and the social welfare are continuous functions in the precision of the public signal.*

The proof provided in the technical appendix employs the Theorem of the Maximum, and relies on the convexity of the set of allocations that satisfy participation constraints.

Next, we highlight some valuable characteristics of the optimal risk-sharing arrangement. Among the participation constraints (27) and (28) only restrictions for high productivity agents can potentially be binding for the optimal arrangement. Households assigned to low productivity firms are never worse off under the optimal arrangement relative to their outside option because the arrangement prescribes transfers from high productivity households as stated in the following lemma.

Lemma 2 *The socially optimal arrangement satisfies*

$$x^l(\pi_j, s_k) \leq c^l(\pi_j, s_k) \leq c^h(\pi_j, s_k) \leq x^h(\pi_j, s_k).$$

The proof is provided in the technical appendix. First, we show that under the optimal arrangement in any state high income households consume at least as much as the low income households. Otherwise, if there are states such that low income households obtain more than the high income households, then an arrangement that prescribes perfect risk sharing in those states is sustainable and welfare improving. Second, we show that high income agents obtain not more than the outside option. By contradiction, either the participation constraint of some low productivity households is violated or a deviation can be constructed that yields higher social welfare.

As an immediate corollary from Lemma 2, the socially optimal arrangement satisfies $V_{rs}(\pi_j) - V_{at}(\pi_j) \geq 0$ for all inflation states π_j. In other words, in any inflation state the value of the optimal arrangement cannot be lower than the value of the allocation in the equilibrium without transfers.

4.2 Information, patience, and folk theorems

Before we proceed to our main result, we first pin down the cases when information precision does not affect social welfare, and then show that perfect risk sharing is less likely to be sustainable when the precision of public announcements increases. The following lemmas help to exclude the possibilities by characterizing the sustainability of the optimal commitment allocation and conditions when the outside option is the only sustainable allocation.

One potential candidate for the optimal risk-sharing arrangement is the optimal commitment allocation. Since all households are ax-ante the same, the optimal commitment allocation is perfect risk sharing $c_t^i = (x_t^h + x_t^l)/2$ for all households. Though voluntary participation imposes additional restrictions on the socially optimal arrangement, this does not mean that the optimal commitment allocation is never attainable. Indeed, perfect risk sharing may still be the socially optimal arrangement if the discount factor β is high enough. This result, commonly known as the folk theorem is established in the following lemma.

Lemma 3 *There exists a value $\bar{\beta}$ such that for any discount factor $\beta \geq \bar{\beta}$ the socially optimal arrangement for any signal precision is perfect risk sharing.*

Proof. Perfect risk sharing provides the highest ex-ante utility among the consumption-feasible allocations. The existence of $\bar{\beta}$ follows from monotonicity of participation constraints in β and $\bar{V}_{rs} > V_{at}$, where $\bar{V}_{rs}$ is the value of the perfect risk-sharing arrangement. In the participation constraints (27) and (28) a higher β increases the future value of perfect risk sharing relative to the allocation in the equilibrium without transfers, leaving the current incentives to deviate unaffected. Therefore, if the participation constraints are not binding for $\bar{\beta}$, they are not binding for any $\beta \geq \bar{\beta}$. ■

On the lower end of sustainable arrangements, if the level of patience is relatively low, the set of sustainable allocations may shrink to one point, which is the equilibrium allocation in the absence of transfers. If the equilibrium with no transfers is the only sustainable allocation for a certain level of patience then the socially optimal allocation is again the outside option if households are even less patient.

Lemma 4 *If for a certain discount factor $\underline{\beta}$ the equilibrium allocation in the absence of transfers is the socially optimal arrangement for any signal precision, then for any $\beta \leq \underline{\beta}$ the socially optimal arrangement is the equilibrium allocation in the absence of transfers.*

Proof. Assume that for some $\beta \leq \underline{\beta}$ there exists an optimal arrangement different from the equilibrium allocation with no transfers. The arrangement allocation is sustainable. By Lemma 2, the value of this arrangement is at least as high as the value of defecting into the outside option for any inflation state. Then for $\underline{\beta}$ the allocation is also sustainable since the value of the arrangement other than the outside option gets an even higher weight in the participation constraints. This contradicts that for $\underline{\beta}$ the optimal arrangement is the no-transfer equilibrium allocation. ■

In order to characterize the amount of consumption that high productivity households are willing to share with low productivity households it is useful to distinguish two opposite effects. The first effect is related to the increase in disposable resources available for consumption and therefore we refer to it as the *wealth effect*. Under low inflation, the disposable resources are higher, which tends to scale up the value of the arrangement, the value of the outside option, and the gain of the arrangement relative to the allocation of the no-transfer equilibrium. The second effect is related to the benefits of insurance, and we name the effect the *risk aversion effect*. Under high inflation consumers' disposable resources are lower, but this may lead to even higher benefits of risk sharing relative to the outside option if households' risk aversion is high enough.

In general, the wealth and the risk aversion effects lead households to value insurance differently in different inflation states. However, there is the degenerate possibility that these two effects exactly offset each other. This is the case when the relative gain of the optimal arrangement $V_{rs}(\pi_j) - V_{at}(\pi_j)$ is the same for all inflation states π_j.[8] Throughout the following analysis we exclude this possibility.

We can now analyze how informative policy announcements influence the outcome of the optimal insurance arrangement under voluntary participation. Signal precision plays an important role for the sustainability of perfect risk sharing. In the following proposition we show that the level of patience that is needed to sustain perfect risk sharing increases in the precision of the signal.

Proposition 1 *Let $\bar{\beta}(\kappa)$ be the cutoff point such that for each $\beta \geq \bar{\beta}(\kappa)$ perfect risk sharing is the socially optimal arrangement. The cutoff point $\bar{\beta}(\kappa)$ is strictly increasing in the precision of the public signal.*

The proof is provided in Appendix A.1. The cutoff point is determined by a participation constraint for high productivity households that imposes the tightest restriction. Which particular constraint is the tightest depends on the gains the perfect risk-sharing arrangement offers relative to the equilibrium in the absence of transfers as can be seen from (27) and (28). The gain can be higher either under low or under high inflation. This depends on whether the wealth or risk aversion effect is dominant. However, in both cases the tightest constraint imposes a stronger restriction under informative signals than under uninformative signals. Suppose without loss of generality that the risk aversion effect dominates, i.e. the perfect risk sharing arrangement provides higher value relative to the equilibrium allocation without transfers under high inflation than under low inflation. While for high productivity agents the current period loss of staying in the arrangement is independent of signal precision, under the low next period inflation signal the expected future gain of insurance is lower for informative signals than for uninformative signals. Therefore, the level of patience needed to sustain the perfect risk sharing allocation is higher under an informative signal.

4.3 Information and welfare under partial risk sharing

A number of studies indicate that the more realistic case is when risk sharing is neither perfect nor absent, but partial.[9] This case is analyzed below. We show that the transfers prescribed by the arrangement depend on signal precision, and the signal can shape the resulting consumption allocation significantly. As our main result, we provide conditions

[8] The relative gain of the insurance arrangement for homogenous preferences vanishes when the degree of homogeneity converges to zero. The risk aversion effect (the wealth effect) dominates for a degree of homogeneity smaller (larger) than zero.

[9] See e.g. Townsend (1994) or more recently Ligon, Thomas, and Worrall (2002).

for social welfare to be decreasing in the precision of the public signal. We exclude the cases when the optimal arrangement is either perfect risk sharing or the outside option and signal precision does not directly affect the arrangement and social welfare. Lemmas 5 and 6 provide sufficient conditions for a socially optimal arrangement that is neither perfect risk sharing nor the outside option.

If perfect risk sharing is not sustainable, a number of participation constraints of high productivity agents are binding. Which constraints are binding depends on the current loss relative to the outside option and the future value of the arrangement. We focus on the case when all constraints are binding and state below sufficient conditions for this case to apply.

Lemma 5 *If all participation constraints for high productivity agents are violated under an arrangement that prescribes perfect risk sharing in all states then all the constraints are binding under the optimal arrangement.*

The proof of this lemma is provided in the technical appendix. First, under the conditions of the lemma, we show that for all states the optimal arrangement satisfies strict inequalities $c^l(\pi_j, s_k) < c^h(\pi_j, s_k)$. Second, by contradiction we show that a Lagrangian multiplier on any participation constraint of a high productivity agent cannot be zero, since otherwise the inequalities do not hold.

Binding participation constraints imply that perfect risk sharing is not optimal, however on the other hand, the optimal arrangement may be given by another extreme, which is the outside option. In the following lemma we provide conditions under which there exists a socially optimal arrangement different from the consumption allocation in the absence of transfers. In particular, we consider a situation when the signal is uninformative.

Lemma 6 *Consider the case of an uninformative public signal with all participation constraints for high productivity agents binding in the optimal arrangement. If and only if*

$$\frac{1}{2}\left(\frac{u'(x^l(\pi_h))}{u'(x^h(\pi_h))} + \frac{u'(x^l(\pi_l))}{u'(x^h(\pi_l))}\right) > \frac{2-\beta}{\beta}, \tag{30}$$

then the socially optimal arrangement is not the consumption allocation of the equilibrium in the absence of transfers.

The proof is provided in the technical appendix. Under binding participation constraints the optimal arrangement problem can be written as a fixed point problem in terms of the value of the risk-sharing arrangement. The outside option is always a solution to the fixed point problem. The condition stated in the lemma guarantees that for an uninformative signal there exists another solution to the fixed point problem, which is a sustainable arrangement and is strictly preferable to the outside option.

From the perspective of an agent with a high current period income, risk-sharing in future periods is attractive if the agent values the future significantly enough and if the agent is subject to high enough consumption risk in the equilibrium without transfers. Both aspects are reflected in condition (30) of Lemma 6. Taking it to one extreme, if future consumption is worthless for agents (i.e. $\beta = 0$), then the outside option is the only sustainable arrangement. Therefore, the threshold for β implied by condition (30) is strictly positive. On the other hand, if the consumption risk in the equilibrium without transfers is significant, the marginal utility for consuming the low income relative to the high income, $u'(x^l(\pi_j))/u'(x^h(\pi_j))$, may become substantial, and thus the required level of patience for engaging in social insurance is low.

In the following theorem we establish our main result that social welfare is strictly decreasing in the precision of the public signal.

Theorem 2 *If all participation constraints for high productivity agents are binding and the equilibrium allocation in the absence of transfers is not the only sustainable arrangement, then social welfare is strictly decreasing in precision of the public signal on future inflation.*

The proof is provided in Appendix A.2. For any two values of signal precision $\kappa_1 < \kappa_2$, we construct a consumption allocation for κ_1 based for on the optimal allocation for κ_2 as follows. The allocation is constructed to satisfy participation constraints for κ_1 with equality while the value of the arrangement in future periods corresponds to the optimal arrangement for κ_2. We show that this allocation delivers strictly higher welfare than the optimal allocation for κ_2, and is also sustainable for signal precision κ_1. Thus, since the optimal allocation for κ_1 must be at least as good as the one constructed, welfare is strictly higher for lower signal precision.

The negative influence of informative signals on social welfare can be illustrated as follows. Assume that the risk aversion dominates the wealth effect. Suppose further that the realized signal indicates that the next period inflation is more likely to be low. From the signal households infer that the future value of the arrangement relative to the outside option is lower, which is an unfavorable outcome for all households. Therefore the high productivity agents require higher current period consumption. In contrast, under the high inflation signal, which indicates a higher value of the arrangement relative to the outside option, the high productivity agents can be satisfied with lower current period consumption. Compared to uninformative signals, the consumption allocation prescribed by the optimal arrangement diverges as precision increases, i.e. the consumption allocation of high income agents becomes riskier ex-ante. Binding participation constraints imply that the expected utility of high income agents before the signal realization is independent of signal precision. Since households are risk-averse, high income agents are less willing to share their good fortune with low income agents when information gets more precise. Correspondingly, from the resource constraint it follows that low income households are better off under imperfect information. Therefore, ex-ante risk averse agents prefer uninformative policy announcements.

The negative value of information does not depend on whether the wealth effect or the risk aversion effect is dominant. If the wealth effect dominates, the high productivity agents require lower current period consumption following a low inflation signal, and demand higher current period consumption following a high signal. Nonetheless, from an ex-ante perspective such divergences are still welfare decreasing for risk-averse agents.

We prove that social welfare is strictly decreasing in precision when all participation constraints for high productivity agents are binding. This is a sufficient condition. Our numerical computations reveal that as long as perfect risk sharing is not sustainable for uninformative signals, social welfare is strictly decreasing in precision no matter how many constraints are binding at the optimal arrangement. Evidently, if perfect risk sharing is sustainable under uninformative signals but not under informative signals – which can occur since the minimum level of patience needed to sustain perfect risk sharing is increasing in precision (see Proposition 1) – less information is still preferable.

The strongest effect of information on welfare is observed – measured as the difference in social welfare between uninformative and perfectly informative signals – when all participation constraints for high productivity agents are binding. The effect is weaker when in some inflation states the optimal allocation exhibits perfect risk sharing, which is the case when participation constraints are not binding in those states. Intuitively, in such a case the influence of information on risk sharing is limited to states with binding constraints, and the overall effect on the consumption allocation is smaller.

The result in Theorem 2 is robust with respect to the value of the outside option. The assumption of agents living forever in the equilibrium without transfers when a given risk-sharing arrangement is declined constitutes a harsh penalty. The main result stays valid qualitatively if this assumption is relaxed. Suppose the penalty were weaker, for example, if agents were allowed to reengage in social insurance. Then under the optimal arrangement the high income agents would be less willing to share the risk with the low income agents. In this case, since the marginal utility of low income households is higher, public information plays an even more significant role than under harsher punishment.

In this section we have characterized how the precision of public signals on future inflation affects optimal insurance under voluntary participation when prices are flexible. If the optimal arrangement is partial risk sharing, the precision of the signal effectively influences the distribution of consumption in the risk-sharing arrangement. We show that higher precision in signals is socially undesirable because this decreases the willingness of high income households to transfer resources to less fortunate households. In addition, we find that the level of patience needed to sustain the perfect risk sharing allocation is strictly increasing in the precision of the signal. The reason for this is that the public information provided by the monetary authority does not help agents to make better decisions for the future. In the next section we extend our framework to allow for a beneficial role of public information, and thereby to assess the importance of the detrimental effect of policy announcements on risk sharing.

5 Assessment of risk-sharing distortions

The main purpose of this section is to evaluate the risk-sharing effect by comparing it to a widely known positive effect of public information. We introduce the positive effect by considering imperfectly flexible prices. In particular, we assume that a positive fraction of intermediate good producers preset their prices one period in advance (Woodford 2003), which results in increasing aggregate resources with better public information. We find that the negative effect of information prevails when the model is calibrated to the U.S. economy. Furthermore, the increase in the U.S. income inequality over the last decades tends to amplify the negative role of public information about aggregate risk on social welfare.

When some monopolistically competitive firms have to preset prices, firms' problems become non-trivial. Solving first the cost minimization problem of the perfectly competitive final good firms (18) we get the demand for each of the variety goods

$$y_t^{fj} = \left(\frac{p_t^{fj}}{p_t} \right)^{-1/\rho} y_t^f, \tag{31}$$

where the aggregate price level is defined by

$$p_t = \left(\int_0^1 (p_t^{fj})^{1-1/\rho} dj \right)^{1/(1-1/\rho)}. \tag{32}$$

Using the production technology (17), the final good firm demand (31), and integrating over all monopolistically competitive firms within a sector, production per worker in sector f is given by

$$y_t^f = \frac{a^f}{\Delta_t^f}, \tag{33}$$

where price dispersion $\Delta_t^f \equiv \int \left(\frac{p_t^{fj}}{p_t}\right)^{-1/\rho} dj$ satisfies $\Delta_t^f \geq 1$ by Jensen's inequality. The highest level of production is achieved when all differentiated goods firms are flexible in their pricing decision and all firms set the same price $p_t^{fj} = p_t$.

When there is a positive measure of sticky price firms, aggregate resources are not longer determined by productivity alone. Instead, current period production depends in addition on the accuracy of pricing decisions of firms, which had to set their prices in the previous period. To illustrate a possible social value of information, we show that aggregate resources are increasing in the precision of the public signal.

Proposition 2 *There exists a neighborhood for prices set by differentiated good firms, in which expected aggregate resources are strictly increasing in the precision of the public signal.*

The proof provided in the technical appendix relies on a second order approximation to the price dispersion term in (33) employing the aggregate price level as the expansion point. The intuition for this result is the following. The less precise the signal the larger is the inflation prediction error by sticky price firms. As a result, the prices set by these firms differ more from the prices set by flexible price firms. The resulting dispersion in relative prices of differentiated goods diminishes resources available for consumption, as can be seen from (33).

Signal precision under imperfectly flexible prices affects the outcome of the optimal insurance arrangement in two different ways. First, it influences the willingness of high productivity households to share with low productivity households, as highlighted in the previous section. Second, it affects the amount of resources that can be shared among the households. The influence of the latter effect can be illustrated by a particular participation constraint. With a fraction of prices preset and for price dispersion, which is symmetric in predicted and realized inflation,[10] the constraint for a high inflation signal (27) is modified to

$$\begin{aligned} u(c^f(\Delta_{-1}^f, \pi_j, s_h)) + \beta\kappa V_{rs}(\Delta^f, \pi_h) + \beta(1-\kappa)V_{rs}(\Delta^f, \pi_l) + \frac{\beta^2}{1-\beta}V_{rs} \geq \\ u(x^f(\Delta_{-1}^f, \pi_j)) + \beta\kappa V_{at}(\Delta^f, \pi_h) + \beta(1-\kappa)V_{at}(\Delta^f, \pi_l) + \frac{\beta^2}{1-\beta}V_{at}, \end{aligned} \tag{34}$$

[10] Symmetry implies that price dispersion for any signal realization depends on the precision of the signal but not on the signal itself.

where Δ^f_{-1} is the previous period price dispersion, π_j is the current period inflation, and V_{rs} and V_{at} are the value of arrangement and the value of the outside option accordingly. An increase in precision distorts risk-sharing opportunities, but on the other hand it allows sticky price firms to set their prices correctly, thereby resulting in less price distortions and a better allocation of resources. Taking it to the extreme, if the socially optimal arrangement is either the outside option or perfect risk sharing, then the expected utility of households is increasing in precision, unless households are too risk averse. We state this result in the following proposition.

Proposition 3 *Let perfect risk sharing or the outside option be the socially optimal arrangement for any public signal precision, and preferences be characterized by a relative risk aversion of less or equal than 2. There exists a neighborhood for prices set by flexible price firms and sticky price firms, in which social welfare is strictly increasing in the precision of the public signal.*

In the proof provided in the technical appendix we employ the second order approximation for the price dispersion term. We specify conditions under which the expected increase of resources under higher precision is welfare-improving.

Proposition 3 provides sufficient conditions for better information to be socially valued. By assuming that either perfect risk sharing or outside option is the socially optimal arrangement for any precision, we exclusively consider the pricing mechanism. There are two effects on welfare when signal precision increases. First, sticky price firms put a larger weight on the signal, which results in larger spread in output. Relative risk aversion of 2 or less is sufficient for this effect not to be welfare decreasing. Second, the probability that the signal and the realized inflation differ is decreasing in signal precision. This effect always increases welfare, and thus, the assumption on risk-aversion in Proposition 3 is likely to be too restrictive.[11]

When either perfect risk sharing or the outside option characterize the socially optimal arrangement, Proposition 3 indicates that the positive effect of information on social welfare is guaranteed to be valid in a neighborhood of perfectly flexible prices. Furthermore, our numerical example (specified below) indicates that the positive value of information is a global phenomenon.

Under partial risk sharing there are two opposite effects of information. First, there is a negative effect due to the destruction of insurance possibilities. Second, there is a positive effect due to smaller distortions of relative prices. In our numerical example both

[11] In fact, in our numerical example (see description below) social welfare is still increasing in information precision even for degrees of relative risk aversion higher than 50 – given that either the outside option or perfect risk sharing is the socially optimal arrangement.

effects are of second order, and the optimal announcements are either no announcement ($\kappa = 1/2$) or perfect announcements ($\kappa = 1$).

We set up a numerical example to assess quantitatively the effect of public announcements. The baseline is constructed to match stylized facts for the U.S. economy on an annual basis. We calibrate the inflation process to the postwar U.S. consumer price index that results in two states with 1.2 and 5.7 percent inflation rates. We set the variance of the productivity process to 0.1, which is the average of the variance for the transitory component of income within-groups for the U.S. between 1980 and 2003 as estimated by Krueger and Perri (2006).[12] Throughout the example we employ standard preferences that feature constant relative risk aversion. We calibrate the elasticity of substitution between differentiated goods to a value of 6 following Woodford (2003). The fraction of sticky price firms is set to 13 percent, which is the value found by Bils and Klenow (2004) using U.S. data collected by the Bureau of Labor Statistics (BLS). We keep the discount factor at the highest value such that all participation constraints are violated under perfect risk sharing (the condition of Lemma 5) for any precision.

We measure the social value of policy announcements as the percentage difference in certainty equivalent consumption between uninformative and perfectly informative signals. In other words, this measure captures the percentage amount of annual consumption agents are willing to give up until they are indifferent between perfectly informative announcements and no announcements at all.

The negative effect of information dominates when the fraction of firms that have to preset prices is small enough or alternatively, when agents are sufficiently risk-averse. In Figure 3 the social value of information is displayed as a function of risk aversion. The value is provided for three different fractions of preset prices, $1 - \lambda$, including 13%, which is the baseline value reported by Bils and Klenow (2004). For this value we find that the social value of information is negative for any relative risk aversion that exceeds 4.66. This can be interpreted as even if risk aversion is not unreasonably high the negative effect of information may dominate.[13] When a larger fraction of prices is adjusted more frequently then the social value of information becomes negative for even lower degrees of risk aversion (see the dotted line for $1 - \lambda = 0.05$ in Figure 3).

It is a well-documented fact the U.S. have experienced a substantial increase in income inequality over the last decades (see Gottschalk and Moffitt 2002; Krueger and Perri 2006).

[12] Violante (2002) provides similar numbers for wage inequality.

[13] There is quite a controversy about the magnitude of the constant risk aversion coefficient (see Campbell 2003; Kocherlakota 1996b; Mehra and Prescott 1985). Kocherlakota (1996b) summarized the prevailing view "... that a vast majority of economists believe that values for [the coefficient of relative risk aversion] above ten (or, for that matter above five) imply highly implausible behavior on part of the individuals."

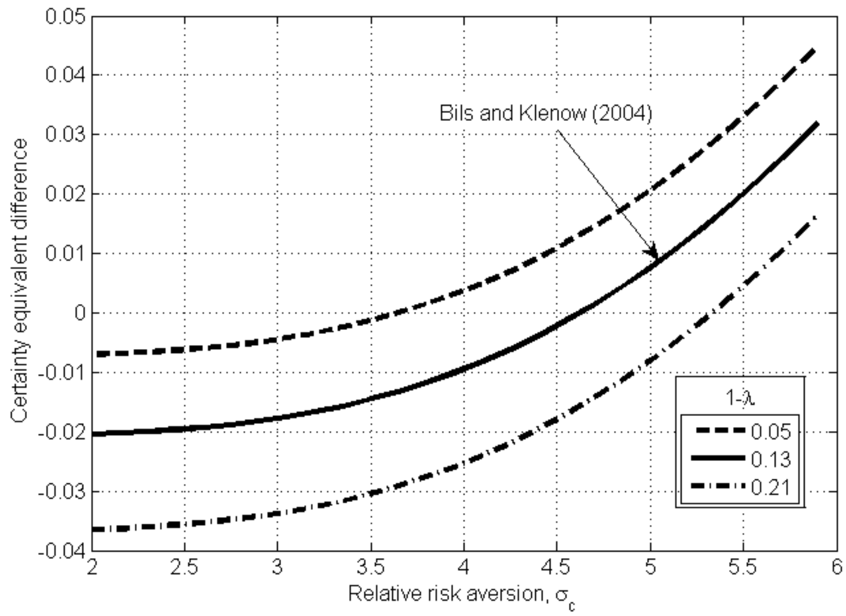

Figure 3: The welfare gain of uninformative signals relative to perfectly informative signals expressed in percentage certainty equivalent consumption as a function of risk aversion.

We capture the evidence by an increase in the variance of the idiosyncratic income that results from the random assignment of workers to sectors of different productivity. How does this increase in income inequality affect the trade-off between the destruction of insurance possibilities on one hand and the better allocation of resources on the other hand, when policy announcements become more precise? For this exercise we set the coefficient of relative risk aversion to 4.66 – implying that the positive and negative effect of more precise information cancel out for the average of the idiosyncratic variance in the U.S. between 1980 and 2003. Employing our baseline calibration we obtain that for the variance of the idiosyncratic component of within-group income observed in 1980, the social value of information was positive. From 1980 to 2003 the variance increased from 8 percent to 12 percent (Krueger and Perri 2006). This renders the social value of information negative. This result is illustrated in Figure 4. For the income inequality observed in 2003, a secretive inflation target is desirable unless the fraction of prices preset for one year were exceeding 16 percent.

The negative effect of information on social welfare is amplified when the penalty for default, i.e. the value of the outside option, is decreased. To illustrate this property, we compute the social value of information when households are allowed to reengage

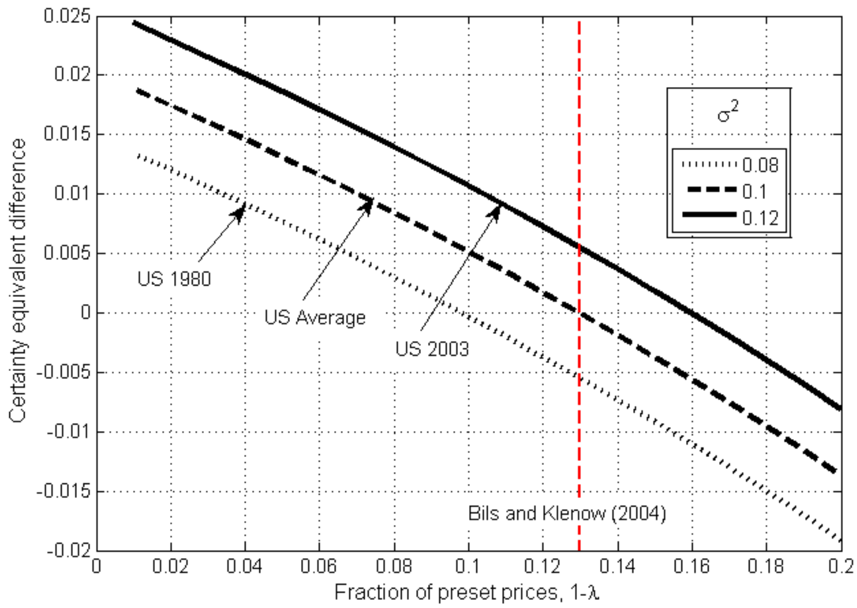

Figure 4: The welfare gain of uninformative signals relative to perfectly informative signals expressed in percentage certainty equivalent consumption as a function of the fraction of prices preset.

in social insurance after one period instead of living in the equilibrium without transfers forever. The corresponding participation constraint for a high inflation signal (34) is modified to

$$u(c^f(\Delta_{-1}^f, \pi_j, s_h)) + \beta\kappa V_{rs}(\Delta^f, \pi_h) + \beta(1-\kappa)V_{rs}(\Delta^f, \pi_l) \geq \\ u(x^f(\Delta_{-1}^f, \pi_j)) + \beta\kappa V_{at}(\Delta^f, \pi_h) + \beta(1-\kappa)V_{at}(\Delta^f, \pi_l).$$

Though qualitatively similar to our standard case in which agents are not allowed to reengage in risk sharing arrangements, the results differ quantitatively. Under a lower penalty for default, the negative aspect of information dominates the positive one for even lower degrees of risk aversion and even when idiosyncratic income uncertainty is lower (see Figures 5 and 6 in the technical appendix. For example, when the fraction of preset prices equals the value found by Bils and Klenow (2004), the negative effect of information outperforms the positive effect for degrees of risk aversion higher than 3.5. Moreover, even for an idiosyncratic income variance from 1980, the social value of policy announcements becomes negative in this scenario.

The negative effect of policy announcements can be also measured relative to the well studied welfare gain from completely removing all aggregate fluctuations (Lucas 2003). For our baseline example with flexible price firms, we calculate the gain from inflation stabilization at a constant inflation equal to average U.S. postwar consumer price inflation. We find that the welfare gain of completely uninformative signals relative to perfectly informative signals measured in certainty equivalent consumption is in the range of 9 to 53 percent of the welfare gain under inflation stabilization (see Table 1).

Coefficient of relative risk aversion, σ_c	2	5	10	20	50
Welfare gain, %	9.1	17.6	35.3	44.2	53.3

Table 1: Welfare gain of uninformative signals relative to perfectly informative signals as a percentage of welfare gain from inflation stabilization measured in certainty equivalent consumption.

Even for reasonable degrees of relative risk aversion below five, the relative welfare gain of uninformative signals on aggregate fluctuations accounts for up to approximately 17 percent, which can be referred to as sizeable.

6 Conclusion

In this paper we studied the welfare effects of policy announcements about future aggregate risk in the presence of idiosyncratic risk. We developed a general equilibrium model that integrates optimal insurance arrangements for idiosyncratic risk under voluntary participation into a monetary production economy. In this environment, we analyzed how the precision of signals on future inflation targets affects social welfare.

The main message of the paper is that more precise announcements on future monetary policy can be detrimental to social welfare. By revealing information on future realizations of the aggregate risk, the policymaker distorts households' insurance incentives and thereby increases the riskiness of the optimal consumption allocation that is consistent with rational participation incentives.

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A Appendix

A.1 Proof of Proposition 1

The cutoff point for β is characterized by the tightest participation constraint, which is the one that becomes binding for any level of patience below the cutoff point. Among the participation constraints only constraints for high productivity agents can be binding, which limits consideration to four cases.

There are two independent factors that determine the tightest participation constraint: the relative gain of deviation from perfect risk sharing to the outside option for high income households, and the expected future gain of perfect risk-sharing arrangement relative to the outside option. Without loss of generality, consider a case such that

$$u(x^h(\pi_l)) - u(\bar{x}(\pi_l)) \leq u(x^h(\pi_h)) - u(\bar{x}(\pi_h)) \tag{A.1}$$

$$u(\bar{x}(\pi_l)) - \frac{1}{2}(u(x^h(\pi_l)) + u(x^l(\pi_l))) < u(\bar{x}(\pi_h)) - \frac{1}{2}(u(x^h(\pi_h)) + u(x^l(\pi_h))), \tag{A.2}$$

where $\bar{x}(\pi_j) \equiv (x^h(\pi_j) + x^l(\pi_j))/2$ is the perfect risk-sharing allocation. The first inequality (A.1) states that the current period deviation for a high income household is more attractive in the high inflation state. The second inequality (A.2) implies that for the perfect risk-sharing arrangement the risk aversion effect dominates, i.e. the perfect risk-sharing arrangement provides higher value in comparison to the outside option under high inflation. Therefore, for any precision of the signal, the participation constraint of high productivity agents under high current inflation and a low future inflation signal is the one that imposes the tightest restriction. This constraint holds with equality at the cutoff point

$$\begin{aligned} u(\bar{x}(\pi_h)) - u(x^h(\pi_h)) + \bar{\beta}\kappa(\bar{V}_{rs}(\pi_l) - V_{at}(\pi_l)) \\ + \bar{\beta}(1-\kappa)(\bar{V}_{rs}(\pi_h) - V_{at}(\pi_h)) + \frac{\bar{\beta}^2}{1-\bar{\beta}}(\bar{V}_{rs} - V_{at}) = 0, \end{aligned} \tag{A.3}$$

where $\bar{V}_{rs}(\pi_j) = u(\bar{x}(\pi_j))$ and $\bar{V}_{rs} = (u(\bar{x}(\pi_h)) + u(\bar{x}(\pi_l)))/2$.

Solving (A.3), there exists a unique solution for $\bar{\beta}$ in $(0,1)$ due to $u(x^h(\pi_h)) - u(\bar{x}(\pi_h)) > 0$. Employing the implicit function theorem from (A.3) we get

$$\frac{d\bar{\beta}}{d\kappa} = \frac{\bar{\beta}(1-\bar{\beta})(\bar{V}_{rs}(\pi_h) - V_{at}(\pi_h) - \bar{V}_{rs}(\pi_l) + V_{at}(\pi_l))}{u(x^h(\pi_h)) - u(\bar{x}(\pi_h)) + dV(\kappa) + 2\bar{\beta}(dV(1/2) - dV(\kappa))} > 0,$$

where $dV(\kappa) \equiv \kappa(\bar{V}_{rs}(\pi_l) - V_{at}(\pi_l)) + (1-\kappa)(\bar{V}_{rs}(\pi_h) - V_{at}(\pi_h))$ and satisfies $0 \leq dV(\kappa) \leq dV(1/2)$.

A.2 Proof of Theorem 2

Suppose $V_{rs}(\kappa_1) \leq V_{rs}(\kappa_2)$ for some $\kappa_1 < \kappa_2$. Consider an alternative consumption allocation $\{\tilde{c}^i(\pi_j, s_k, \kappa_1)\}$ for signal precision κ_1 constructed on the basis of the optimal allocation $\{c^i(\pi_j, s_k, \kappa_2)\}$ for κ_2 according to

$$u(\tilde{c}^h(\pi_j, s_h, \kappa)) = -\beta\left(\kappa(V_{rs}(\pi_h, \kappa_2) - V_{at}(\pi_h)) + (1-\kappa)(V_{rs}(\pi_l, \kappa_2) - V_{at}(\pi_l))\right) + u(x^h(\pi_j)) - \frac{\beta^2}{1-\beta}(V_{rs}(\kappa_2) - V_{at}) \quad \text{(A.4)}$$

$$u(\tilde{c}^h(\pi_j, s_l, \kappa)) = -\beta\left((1-\kappa)(V_{rs}(\pi_h, \kappa_2) - V_{at}(\pi_h)) + \kappa(V_{rs}(\pi_l, \kappa_2) - V_{at}(\pi_l))\right) + u(x^h(\pi_j)) - \frac{\beta^2}{1-\beta}(V_{rs}(\kappa_2) - V_{at}) \quad \text{(A.5)}$$

and the corresponding allocation for low productivity agents given by consumption feasibility. $V_{rs}(\pi_j, \kappa_2)$ and $V_{rs}(\kappa_2)$ characterize the optimal allocation for κ_2.

First, the alternative allocation $\{\tilde{c}^i(\pi_j, s_k, \kappa_1)\}$ is consumption-feasible by construction.

Second, the alternative allocation $\{\tilde{c}^i(\pi_j, s_k, \kappa_1)\}$ delivers strictly higher expected utility than the optimal allocation for signal precision κ_2, i.e. $\tilde{V}_{rs}(\kappa_1) > V_{rs}(\kappa_2)$, where $\tilde{V}_{rs}(\kappa) \equiv \frac{1}{8}\sum_{f,j,k} u(\tilde{c}^f(\pi_j, s_k, \kappa))$. We prove this result by showing that high productivity agents are indifferent between the optimal allocation and the alternative allocation, and low productivity agents strictly prefer the alternative allocation.

For signal precision κ_2 by assumption the risk aversion and wealth effects do not offset each other and the outside option is not the only sustainable arrangement. Without loss of generality, suppose that the risk aversion effect dominates, i.e. $V_{rs}(\pi_l, \kappa_2) - V_{at}(\pi_l) < V_{rs}(\pi_h, \kappa_2) - V_{at}(\pi_h)$. Subtracting (A.5) from (A.4) we get

$$u(\tilde{c}^h(\pi_j, s_h, \kappa)) - u(\tilde{c}^h(\pi_j, s_l, \kappa)) = (2\kappa - 1)\beta((V_{rs}(\pi_l, \kappa_2) - V_{at}(\pi_l)) - (V_{rs}(\pi_h, \kappa_2) - V_{at}(\pi_h))).$$

Therefore, for any $\kappa < \kappa_2$

$$u(c^h(\pi_j, s_h, \kappa_2)) < u(\tilde{c}^h(\pi_j, s_h, \kappa)) \leq u(\tilde{c}^h(\pi_j, s_l, \kappa)) < u(c^h(\pi_j, s_l, \kappa_2)). \quad \text{(A.6)}$$

For high productivity agents, the alternative allocation for κ_1 and the optimal allocation for κ_2 deliver the same expected utility in any state π_j, as can be seen from adding (A.4) and (A.5).

For low productivity agents, the expected utility in state π_j, defined by

$$W^l(\pi_j, \kappa) \equiv \frac{1}{2} \sum_k u(\tilde{c}^l(\pi_j, s_k, \kappa))$$

is strictly decreasing in precision over $\kappa \leq \kappa_2$. This result follows from (A.4)-(A.6), consumption feasibility, and risk-aversion of agents:

$$\frac{\partial W^l(\pi_j, \kappa)}{\partial \kappa} = -\frac{1}{2} \left(\frac{u'(\tilde{c}^l(\pi_j, s_h, \kappa))}{u'(\tilde{c}^h(\pi_j, s_h, \kappa))} - \frac{u'(\tilde{c}^l(\pi_j, s_l, \kappa))}{u'(\tilde{c}^h(\pi_j, s_l, \kappa))} \right) \times \\ (V_{rs}(\pi_l, \kappa_2) - V_{at}(\pi_l)) - (V_{rs}(\pi_h, \kappa_2) - V_{at}(\pi_h)) < 0 \quad \forall \kappa > 1/2,$$

and $\partial W^l(\pi_j, 1/2)/\partial \kappa = 0$. In particular, this implies that $\tilde{V}_{rs}(\pi_j, \kappa_1) > V_{rs}(\pi_j, \kappa_2)$, and therefore $\tilde{V}_{rs}(\kappa_1) > V_{rs}(\kappa_2)$.

Third, the alternative allocation $\{\tilde{c}^i(\pi_j, s_k, \kappa_1)\}$ satisfies the participation constraints for signal precision κ_1. This results follows immediately from construction of the alternative allocation, and from the finding in the previous step that the alternative allocation for $\kappa_1 < \kappa_2$ provides strictly higher utility in all inflation states than the optimal allocation for κ_2.

Finally, the social value of the optimal allocation for κ_1 is at least as large as for any other feasible allocation compatible with participation constraints $V_{rs}(\kappa_1) \geq \tilde{V}_{rs}(\kappa_1)$. Therefore, $\tilde{V}_{rs}(\kappa_1) > V_{rs}(\kappa_2)$ is a contradiction to $V_{rs}(\kappa_1) \leq V_{rs}(\kappa_2)$.

B Technical appendix

B.1 Additional details for the proof of Theorem 1

First, we consider the perfect information environment. The Lagrangian of the optimal risk-sharing problem can be written as

$$
\begin{aligned}
\mathcal{L} = \frac{1}{4}\left(u(c_{1g}^{h}) + u(y - c_{1g}^{h}) + u(y^{h}) + u(y^{l})\right) \\
+ \frac{\beta}{8}\left(u(c_{2g}^{hh}) + u(c_{2g}^{hl}) + u(y - c_{2g}^{hl}) + u(y - c_{2g}^{hh}) + 4u(0)\right) \\
+ \lambda\left(u(c_{1g}^{h}) + \frac{\beta}{2}\left(u(c_{2g}^{hh}) + u(c_{2g}^{hl})\right) - u(y^{h}) - \frac{\beta}{2}\left(u(y^{h}) + u(y^{l})\right)\right),
\end{aligned}
$$

with resource constraints and consumption under type-b policy already substituted in, and where $y \equiv y^h + y^l$.

The first order conditions with respect to c_{1g}^h, c_{2g}^{hh}, and c_{2g}^{hl} are

$$
\frac{1}{4}\left(u'(c_{1g}^{h}) - u'(y - c_{1g}^{h})\right) + \lambda u'(c_{1g}^{h}) = 0,
$$

$$
\begin{aligned}
\frac{\beta}{8}\left(u'(c_{2g}^{hh}) - u'(y - c_{2g}^{hh})\right) + \lambda\frac{\beta}{2}u'(c_{2g}^{hh}) = 0, \\
\frac{\beta}{8}\left(u'(c_{2g}^{hl}) - u'(y - c_{2g}^{hl})\right) + \lambda\frac{\beta}{2}u'(c_{2g}^{hl}) = 0.
\end{aligned}
$$

This implies that the socially optimal consumption of the high endowment agents is constant over time

$$
c_{1g}^{h} = c_{2g}^{hh} = c_{2g}^{hl},
$$

except for the type-b policy when all goods are taxed away. When the high endowment agent participation constraints (2) and (3) are binding, then

$$
\begin{aligned}
u(c_{1g}^{h}) &= \frac{1}{1+\beta}\left(u(y^{h}) + \frac{\beta}{2}\left(u(y^{h}) + u(y^{l})\right)\right) \\
&= \frac{1+\beta/2}{1+\beta}u(y^{h}) + \frac{\beta/2}{1+\beta}u(y^{l}). \qquad \text{(B.1)}
\end{aligned}
$$

Second, in the imperfect information environment the Lagrangian is

$$\begin{aligned}\mathcal{L} = \frac{1}{2}\left(u(c_1^h) + u(y - c_1^h)\right) \\ + \frac{\beta}{8}\left(u(c_{2g}^{hh}) + u(c_{2g}^{hl}) + u(y - c_{2g}^{hl}) + u(y - c_{2g}^{hh}) + 4u(0)\right) \\ + \lambda\left(u(c_1^h) + \frac{\beta}{4}\left(u(c_{2g}^{hh}) + u(c_{2g}^{hl}) + 2u(0)\right) - u(y^h) - \frac{\beta}{4}\left(u(y^h) + u(y^l) + 2u(0)\right)\right).\end{aligned}$$

Similarly to perfect information, it follows from the first order conditions that

$$c_1^h = c_{2g}^{hh} = c_{2g}^{hl},$$

and when participation constraint (7) is binding

$$\begin{aligned}u(c_1^h) &= \frac{1}{1+\beta/2}\left(u(y^h) + \frac{\beta}{4}(u(y^h) + u(y^l))\right) \\ &= \frac{1+\beta/4}{1+\beta/2}u(y^h) + \frac{\beta/4}{1+\beta/2}u(y^l). \qquad \text{(B.2)}\end{aligned}$$

Comparing (B.1) and (B.2) reveals that $u(c_{1g}^h) < u(c_1^h) < u(y^h)$, and taking into account $c_{1b}^h = y^h$ we obtain $c_{1g}^h < c_1^h < c_{1b}^h$.

B.2 Proof of Lemma 1

Let $S(\kappa)$ be the set of sustainable allocations. The outside option is always in the set of sustainable allocations, and the restrictions imposed by the participation constraints (27), (28) and consumption feasibility (29) define a bounded and closed set. Therefore, for any precision of the public signal, $S(\kappa)$ is nonempty and compact-valued. Furthermore, it can be shown that the correspondence $\varphi : [1/2; 1] \rightarrow \mathbb{R}_+^8$, which maps $\kappa \mapsto S(\kappa)$ is continuous. Given that the objective function (26) is also continuous, by the Theorem of the Maximum (Bergé 1963) there exists a solution to the optimal arrangement problem for any public signal precision, and the expected utility of the socially optimal arrangement is continuous in signal precision.

In addition, the set of sustainable allocations is convex-valued due to the concavity of the utility function, and the objective function is strictly concave. By the Maximum Theorem under Convexity the optimal arrangement is unique and continuous in signal precision.

B.3 Proof of Lemma 2

Let $\{c^i(\pi_j, s_k)\}$ be the optimal arrangement. First, we show that for any state (π_j, s_k) in the optimal arrangement the high income agents obtain at least as much as the low income agents, i.e. $c^h(\pi_j, s_k) \geq c^l(\pi_j, s_k)$. By contradiction, assume there exist inflation π_j and signal s_j such $c^h(\pi_j, s_k) < c^l(\pi_j, s_k)$. Let the perfect risk sharing allocation be defined as $\bar{x}(\pi_j) \equiv (x^h(\pi_j) + x^l(\pi_j))/2$, and consider an arrangement $\{\tilde{c}^i(\pi_j, s_k)\}$ given by

$$\tilde{c}^h(\pi_j, s_k) = \tilde{c}^l(\pi_j, s_k) = \bar{x}(\pi_j), \quad \tilde{c}^i(\tilde{H}) = c^i(\tilde{H}),$$

with $\tilde{H}$ as the set of all possible states, excluding (π_j, s_k). By construction the arrangement provides strictly higher utility for risk-averse households than $\{c^i(\pi_j, s_k)\}$. We are left to prove that the arrangement $\{\tilde{c}^i(\pi_j, s_k)\}$ is sustainable. High income households undoubtedly accept the arrangement because it delivers both higher current period consumption and higher future arrangement utility. Low income households in state (π_j, s_k) obtain the same utility as the high income households. Given that the outside option is worse for low income households and the high income households accept the arrangement, the low income households must also accept the arrangement. Summing up, the arrangement $\{\tilde{c}^i(\pi_j, s_k)\}$ is sustainable and socially preferable over $\{c^i(\pi_j, s_k)\}$. This contradicts that $\{c^i(\pi_j, s_k)\}$ is the socially optimal arrangement.

Second, we show that for any state $c^h(\pi_j, s_k) \leq x^h(\pi_j, s_k)$. Again, by contradiction, assume that there is a state such that $c^h(\pi_j, s_k) > x^h(\pi_j, s_k)$. If the participation constraint for the high productivity agent under π_j inflation and s_k signal holds with equality then the future value of the arrangement is lower than the outside option value, and taking into account that for the low productivity agent from the resource constraint $c^l(\pi_j, s_k) < x^l(\pi_j, s_k)$ the participation constraint for the low productivity agent is violated. Therefore, the considered participation constraint for the high productivity agent can only hold with a strict inequality. Then, consider a consumption allocation $\{\tilde{\tilde{c}}^i(\pi_j, s_k)\}$ given by

$$\tilde{\tilde{c}}^h(\pi_j, s_k) = c^h(\pi_j, s_k) - \varepsilon, \quad \tilde{\tilde{c}}^l(\pi_j, s_k) = c^l(\pi_j, s_k) + \varepsilon, \quad \tilde{\tilde{c}}^i(\tilde{H}) = c^i(\tilde{H}).$$

By continuity there exists $\varepsilon > 0$ such that the consumption allocation $\{\tilde{\tilde{c}}^i(\pi_j, s_k)\}$ is sustainable, and by concavity the constructed allocation provides higher utility then the allocation $\{c^i(\pi_j, s_k)\}$, which contradicts that $\{c^i(\pi_j, s_k)\}$ is the socially optimal arrangement.

B.4 Proof of Lemma 5

First, we show that if participation constraints are violated under perfect risk sharing for any state then the optimal consumption allocation satisfies

$$c^h(\pi_j, s_k) > \bar{x}(\pi_j) > c^l(\pi_j, s_k), \tag{B.3}$$

where $\bar{x}(\pi_j)$ again is the perfect risk sharing allocation in inflation state π_j. Without loss of generality, consider the participation constraint for households of high productivity in the previous period under currently high inflation that receive a high signal on future inflation. The constraint holds for the socially optimal arrangement

$$\begin{aligned} u(c^h(\pi_h, s_h)) + \beta(\kappa V_{rs}(\pi_h) + (1-\kappa)V_{rs}(\pi_l)) + \frac{\beta^2}{1-\beta}V_{rs} \geq \\ u(x^h(\pi_h)) + \beta(\kappa V_{at}(\pi_h) + (1-\kappa)V_{at}(\pi_l)) + \frac{\beta^2}{1-\beta}V_{at}, \end{aligned} \tag{B.4}$$

but is violated by assumption under perfect risk sharing

$$\begin{aligned} u(\bar{x}(\pi_h)) + \beta(\kappa u(\bar{x}(\pi_h)) + (1-\kappa)u(\bar{x}(\pi_l))) + \frac{\beta^2}{1-\beta}\bar{V}_{rs} < \\ u(x^h(\pi_h)) + \beta(\kappa V_{at}(\pi_h) + (1-\kappa)V_{at}(\pi_l)) + \frac{\beta^2}{1-\beta}V_{at}, \end{aligned} \tag{B.5}$$

where $\bar{V}_{rs} \equiv u(\bar{x}(\pi_h)) + u(\bar{x}(\pi_l))/2$ denotes the value of the perfect risk-sharing arrangement. The right hand side of (B.4) or (B.5) represents the total value of the outside option. Combining (B.4) and (B.5) we get

$$\begin{aligned} u(c^h(\pi_h, s_h)) + \beta(\kappa V_{rs}(\pi_h) + (1-\kappa)V_{rs}(\pi_l)) + \frac{\beta^2}{1-\beta}V_{rs} > \\ u(\bar{x}(\pi_h)) + \beta(\kappa u(\bar{x}(\pi_h)) + (1-\kappa)u(\bar{x}(\pi_l))) + \frac{\beta^2}{1-\beta}\bar{V}_{rs} \end{aligned} \tag{B.6}$$

Taking into account that the optimal contract delivers a value no larger than the value of perfect risk sharing $V_{rs}(\pi_j) \leq u(\bar{x}(\pi_j))$, and $V_{rs} \leq \bar{V}_{rs}$, from (B.6) we get

$$u(c^h(\pi_h, s_h)) > u(\bar{x}(\pi_h))$$

or, combining with resource feasibility

$$c^h(\pi_h, s_h) > \bar{x}(\pi_h) > c^l(\pi_h, s_h).$$

Similarly we can show that the same inequalities hold for the other public states.

Second, by contradiction, assume that there is one participation constraint for high productivity agents that is not binding. The Lagrangian of the optimal contract problem (26)-(29) can be written as

$$\mathcal{L} = (1 + \sum_{(\pi_j, s_k) \in \tilde{H}} \lambda^i(\pi_j, s_k))(u(c^h(\pi_j, s_k)) + u(c^l(\pi_j, s_k))) \\ + \mu(\pi_j, s_k)(c^h(\pi_j, s_k) + c^l(\pi_j, s_k) - 2\bar{x}(\pi_j)) + \xi(\tilde{H}), \quad \text{(B.7)}$$

where (π_j, s_k) is the state for which the participation constraint is not binding, $\tilde{H}$ is the set of all possible states, excluding (π_j, s_k), $\lambda^i(\pi_j, s_k)$ are the normalized Lagrange multipliers for the participation constraints, $\mu(\pi_j, s_k)$ are the Lagrange multipliers for resource constraints, and $\xi(\tilde{H})$ collects consumption and resources for states in $\tilde{H}$, and respective multipliers. The Lagrange multiplier for the participation constraint for state (π_j, s_k) is zero and is explicitly excluded from the Lagrangian.

Solving the optimal arrangement problem (B.7) we get

$$c^h(\pi_j, s_k) = c^l(\pi_j, s_k) = \bar{x}(\pi_j)$$

for the state (π_j, s_k), which contradicts the partial risk-sharing condition (B.3) stated above.

B.5 Proof of Lemma 6

The socially optimal risk sharing arrangement under uninformative signals can be analyzed as a fixed point problem in terms of the period value of the arrangement. When signals are uninformative, the optimal arrangement is conditional only on current inflation, and the number of binding participation constraints of high productivity households reduces to two.

The fixed point problem is constructed as follows. Let w be the future one-period value of an arrangement. We restrict attention to $w \in [V_{at}, \bar{w})$, since per assumption all participation constraints for high productivity agents are binding. The two binding participation constraints can be written as

$$u(c^h(\pi_j)) + \frac{\beta}{1-\beta} w = u(x^h(\pi_j)) + \frac{\beta}{1-\beta} V_{at} \quad \forall j, \tag{B.8}$$

and consumption feasibility is given by

$$c^h(\pi_j) + c^l(\pi_j) = x^h(\pi_h) + x^l(\pi_h) \quad \forall j. \tag{B.9}$$

The objective function of the optimal arrangement problem is

$$V(w) \equiv \frac{1}{4} \sum_{f,j} u(c^f(\pi_j)).$$

The optimal arrangement should necessary solve the fixed point problem $w = V(w)$.

We show that $V(w)$ is strictly increasing and strictly concave, therefore there exist at most two solutions to the fixed problem. From the participation constraints (B.8) and consumption feasibility constraints (B.9) it follows that $V(w)$ is strictly increasing

$$V'(w) = \frac{1}{4} \frac{\beta}{1-\beta} \left(-2 + \frac{u'(c^l(\pi_h))}{u'(c^h(\pi_h))} + \frac{u'(c^l(\pi_l))}{u'(c^h(\pi_l))} \right) > 0,$$

since perfect risk sharing is not sustainable per assumption. Strict concavity of $V(w)$ is implied by

$$\frac{d}{dw} \left(\frac{u'(c^l(\pi_j))}{u'(c^h(\pi_j))} \right) = \frac{\beta}{1-\beta} \frac{1}{\left(u'(c^h(\pi_j))\right)^2} \left(u''(c^l(\pi_j)) + u''(c^h(\pi_j)) \frac{u'(c^l(\pi_j))}{u'(c^h(\pi_j))} \right) < 0.$$

By construction, one solution to the fixed point problem is V_{at}. The concavity of $V(w)$ implies that the derivative of $V(w)$ at V_{at} is higher than at any partial risk-sharing allocation. Therefore, the derivative of $V'(w)$ at V_{at} must be greater than 1, which implies

$$\frac{1}{2} \left(\frac{u'(x^l(\pi_h))}{u'(x^h(\pi_h))} + \frac{u'(x^l(\pi_l))}{u'(x^h(\pi_l))} \right) > \frac{2-\beta}{\beta}$$

in order for the optimal arrangement to be different from the outside option.

From the other end, suppose there exists a socially optimal arrangement different from the allocation in the absence of transfers and participation constraints are binding. Then the value of this arrangement must be a solution to the fixed point problem. This requires that the slope of $V(w)$ at V_{at} must be necessarily larger than unity, due to the concavity of

$V(w)$ and because the allocation in the absence of transfers must always be one solution of the constructed fixed point problem.

B.6 Proof of Proposition 2

Log-linear second order approximations around $p_t^{fj} = p_t$ of the integrands in (32) and (33) are given by

$$\left(\frac{p_t^{fj}}{p_t}\right)^{1-1/\rho} = 1 + \left(1 - \frac{1}{\rho}\right)\hat{z}_t^{fj} + \left(1 - \frac{1}{\rho}\right)^2 \frac{(\hat{z}_t^{fj})^2}{2} + \mathcal{O}(\|\hat{z}_t^{fj}\|^3) \tag{B.10}$$

$$\left(\frac{p_t^{fj}}{p_t}\right)^{-1/\rho} = 1 - \frac{1}{\rho}\hat{z}_t^{fj} + \left(\frac{1}{\rho}\right)^2 \frac{(\hat{z}_t^{fj})^2}{2} + \mathcal{O}(\|\hat{z}_t^{fj}\|^3) \tag{B.11}$$

where $\hat{z}_t^{fj} = \log p_t^{fj} - \log p_t$.

Substituting the approximation (B.10) into the identity for the aggregate price level (32) we get

$$\int \hat{z}_t^{fj} dj + \left(1 - \frac{1}{\rho}\right) \int \frac{(\hat{z}_t^{fj})^2}{2} dj = \mathcal{O}(\|\hat{z}_t^{fj}\|^3),$$

and combining the expression with the approximation (B.11) we can write the price distortion term in (33) as

$$\int \left(\frac{p_t^{fj}}{p_t}\right)^{-1/\rho} dj = 1 + \frac{1}{2\rho} var_j \log p_t^{fj} + \mathcal{O}(\|p_t^{fj}\|^3).$$

Next, we compute the cross-variance of prices $var_j \log p_t^{fj}$ from the optimal price setting. Solving the profit maximization problem for sticky price firms (20), up to a first order approximation $\log p_{2t}^f = E_{t-1}\left[\log p_{1t}^f | s_{t-1}\right]$. From (32) up to a first order approximation, it follows that the aggregate price can be written as $\log p_t = \lambda \log p_{1t}^f + (1-\lambda) p_{2t}^f$, where p_{1t}^f is the flexible firm price and p_{2t}^f is the sticky firm price. Then, the prediction error can be written as $\pi_t - E_{t-1}[\pi_t | s_{t-1}] = \lambda(\log p_{1t} - \log p_{2t})$, and therefore $var_j \log p_t^j = \lambda(1-\lambda)(\log p_{1t} - \log p_{2t})^2 = \frac{1-\lambda}{\lambda}(\pi_t - E_{t-1}[\pi_t | s_{t-1}])^2$. This implies

$$\int \left(\frac{p_t^{fj}}{p_t}\right)^{-1/\rho} dj = 1 + \varphi(\pi_t - E_{t-1}[\pi_t | s_{t-1}])^2 + \mathcal{O}(\|p_t^{fj}\|^3),$$

with $\varphi = (1-\lambda)/(2\rho\lambda)$.

With two inflation states, the second order approximation to expected per capita production in each sector (33) is

$$E[y_t^f] = \kappa \left(\frac{a^f}{1+\phi(1-\kappa)^2} \right) + (1-\kappa) \left(\frac{a^f}{1+\phi\kappa^2} \right),$$

where $\phi \equiv \frac{1}{2\rho}\frac{1-\lambda}{\lambda}(\pi_h - \pi_l)^2$.

Differentiating with respect to signal precision gives

$$\begin{aligned} \frac{\partial E[y_t^f]}{\partial \kappa} = a^f & \left(\frac{1}{1+\phi(1-\kappa)^2} - \frac{1}{1+\phi\kappa^2} \right) \\ & + 2a^f \phi\kappa(1-\kappa) \left(\frac{1}{(1+\phi(1-\kappa)^2)^2} - \frac{1}{(1+\phi\kappa^2)^2} \right) > 0 \\ & \qquad \forall \quad 1/2 < \kappa \leq 1. \end{aligned}$$

Since the resources increase with better signals in each sector, aggregate resources (in per capita terms and in total) are also an increasing function in signal precision.

B.7 Proof of Proposition 3

We consider the case when perfect risk sharing is the socially optimal arrangement. In this case each household consumes the deflated average income across sectors, $\bar{x} \equiv (x_t^h + x_t^l)/2$. Building on results derived in Proposition 2, up to the second order approximation average deflated income reads

$$\bar{x} = \frac{\bar{a}}{1 + \frac{1-\lambda}{\lambda}(\pi_t - E_{t-1}[\pi_t | s_{t-1}])^2},$$

where $\bar{a} = (a^h + a^l)/2$. The period social welfare is given by the following expression

$$\begin{aligned} E[u(\bar{x})] = \frac{\kappa}{2} u \left(\frac{\bar{a}}{1+\phi(1-\kappa)^2} \frac{1}{\pi_h} \right) + \frac{1-\kappa}{2} u \left(\frac{\bar{a}}{1+\phi\kappa^2} \frac{1}{\pi_h} \right) & \\ + \frac{\kappa}{2} u \left(\frac{\bar{a}}{1+\phi(1-\kappa)^2} \frac{1}{\pi_l} \right) + \frac{1-\kappa}{2} u \left(\frac{\bar{a}}{1+\phi\kappa^2} \frac{1}{\pi_l} \right). & \quad \text{(B.12)} \end{aligned}$$

Differentiating (B.12) with respect to signal precision results in

$$\begin{aligned}\frac{\partial E[u(\bar{x})]}{\partial \kappa} &= \frac{1}{2}\left[u\left(\frac{\bar{a}}{1+\phi(1-\kappa)^2}\frac{1}{\pi_h}\right) - u\left(\frac{\bar{a}}{1+\phi\kappa^2}\frac{1}{\pi_h}\right)\right] \\ &\quad + \frac{1}{2}\left[u\left(\frac{\bar{a}}{1+\phi(1-\kappa)^2}\frac{1}{\pi_l}\right) - u\left(\frac{\bar{a}}{1+\phi\kappa^2}\frac{1}{\pi_l}\right)\right] + \Psi(\kappa,\pi_h) + \Psi(\kappa,\pi_l), \end{aligned} \quad \text{(B.13)}$$

where

$$\begin{aligned}\Psi(\kappa,\pi_i) \equiv \frac{\kappa}{2}u'\left(\frac{\bar{a}}{1+\phi(1-\kappa)^2}\frac{1}{\pi_i}\right)\frac{2\phi\bar{a}(1-\kappa)}{(1+\phi(1-\kappa)^2)^2}\frac{1}{\pi_i} \\ - \frac{1-\kappa}{2}u'\left(\frac{\bar{a}}{1+\phi\kappa^2}\frac{1}{\pi_i}\right)\frac{2\phi\bar{a}\kappa}{(1+\phi\kappa^2)^2}\frac{1}{\pi_i}.\end{aligned}$$

While the first two terms in the derivative (B.13) are non-negative for $\kappa \geq 1/2$, the signs for the latter two are ambiguous in general. Taking into account the condition imposed in the proposition on risk aversion, the function $f(c) \equiv c^2 u'(c)$ is increasing, and therefore we get

$$\Psi(\kappa,\pi_i) = \phi\kappa(1-\kappa)\frac{\pi_i}{\bar{a}}\left(f\left(\frac{\bar{a}}{1+\phi(1-\kappa)^2}\frac{1}{\pi_i}\right) - f\left(\frac{\bar{a}}{1+\phi\kappa^2}\frac{1}{\pi_i}\right)\right) > 0 \quad \forall \quad 1/2 < \kappa \leq 1.$$

The case when outside option is the socially optimal arrangement is similar.

B.8 Figures in case of reengagement in social insurance

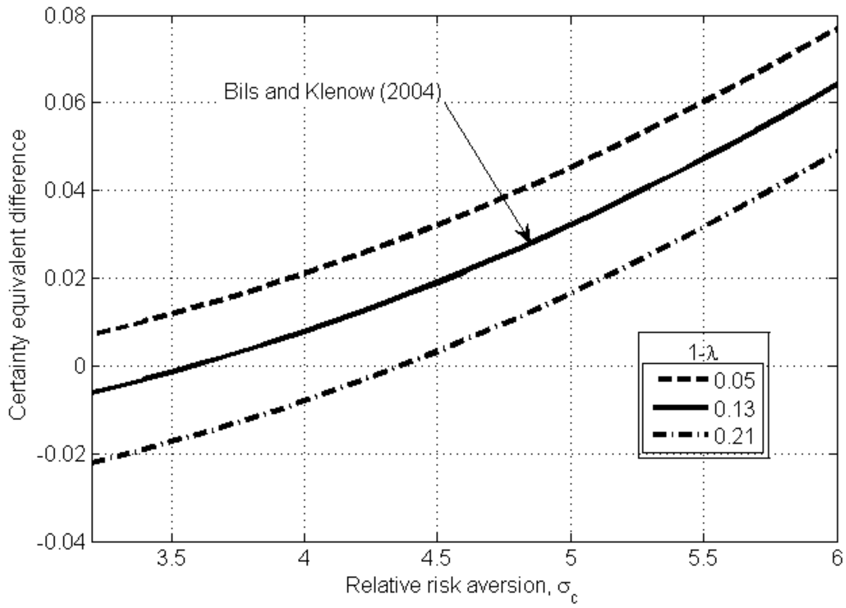

Figure 5: The welfare gain of uninformative signals relative to perfectly informative signals as a function risk aversion when households are allowed to reengage in social insurance after one period.

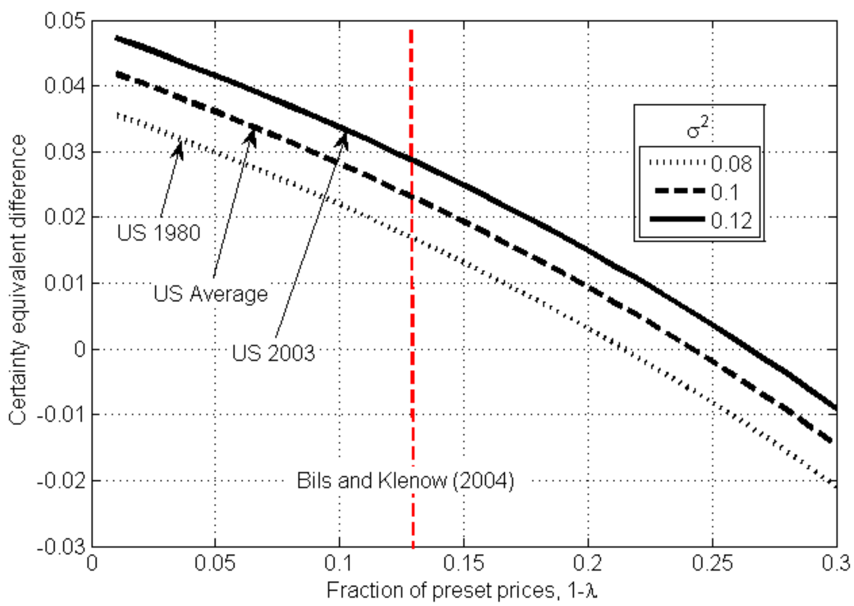

Figure 6: The welfare gain of uninformative signals relative to perfectly informative signals as a function the fraction of prices preset when households are allowed to reengage in social insurance after one period.