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THE TWO FACES OF INFORMATION

Gaetano Gaballo
Guillermo Ordoñez

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ABSTRACT

In absence of insurance contracts to share risk, public information is a double-edged sword. On the one hand, it empowers self-insurance as agents better react to shocks, reducing risk. On the other hand, it weakens market-insurance as common knowledge of shocks restricts trading risk. We embody these two faces of information in a single general-equilibrium model. We characterize the conditions under which market-insurance is superior, and then public information – even though costless and precise – is socially undesirable. In the absence of information, however, market-insurance is still underprovided as individuals fail to internalize its general equilibrium benefits.

Gaetano Gaballo
HEC Paris
1 rue de la Liberation
Jouy-en-Josas, Fran 78350
France
gaballo@hec.fr

Guillermo Ordoñez
University of Pennsylvania
Department of Economics
PCPSE - Room 505
133 South 36th Street
Philadelphia, PA 19104
and NBER
ordonez@econ.upenn.edu

1 Introduction

There is ample evidence that insurance against idiosyncratic shocks (to labor, to capital, to health) is far from perfect.[1] Imperfect insurance emerges from the lack of contingent contracts to share risk that can be written before shocks materialize. One reason is that contingencies may not be observable or verifiable, in which case ex-post public information about these contingencies would be socially desirable. Other non-informational forces, however, can prevent the use of contingent contracts. These include limited commitment (agents can renege on contracts), enforcement frictions (courts are ineffective in assessing the legality of contracts), and restricted access to insurance markets.[2] In these cases, would public information still be insurance promoting? This question is particularly relevant when a policy maker can evaluate individual risks by pooling otherwise privately inaccessible information, such as the geographical incidence of a disease or the individual exposure of banks to systemic risk. Should this information be publicly disclosed?

In this paper we study the social value of information when contingent contracts cannot be written to *share risk* (that is, *contract-insurance* is absent), and agents need to rely on two alternatives: either exchanging non-contingent contracts to *trade risk* (what we denote as *market-insurance*) or relying on individual actions, without contracts, to *reduce risk* (what we denote as *self-insurance*).[3] On the one hand, information about the realization of idiosyncratic shocks allows for better individual reactions to these shocks. In our previous example, individuals can take actions to protect their health or banks can learn how to better hedge their portfolios. Self-insurance is at the center of recent developments in *macroeconomics* that focus

[1] Complete markets among households have strong implications for the correlation between individual and aggregate consumption growth and between individual consumption and income growth, which are not consistent with empirical counterparts from micro data, as shown by Hayashi, Altonji, and Kotlikoff (1996), Attanasio and Davis (1996), and many others more recently.

[2] The relevance of non-informational frictions for market incompleteness has been highlighted by Kehoe and Levine (1993), Kocherlakota (1996), Magill and Quinzii (2002), Krueger and Perri (2006) and Cole et al. (2021) among many others.

[3] For an excellent survey on specific examples of these insurance alternatives (such as changes in labor supply, human or physical capital accumulation, within-firm insurance, within-family insurance, participation in financial markets, etc.) see Heathcote, Storesletten, and Violante (2009).

on incomplete markets economies where individuals typically insure themselves by saving ex-ante or adjusting labor ex-post.[4] Information thus has a *positive face*, in that it - ceteris paribus - increases the set of responses available to an individual to reduce consumption risk. On the other hand, public information restricts the scope for exchanging risky assets for safe ones by trading non-contingent securities. In our example, individuals living in unhealthy locations may see a decline in the price of their properties and risky banks may face an increase in the cost of funding. Market-insurance has been emphasized by a *finance* tradition in the context of partial equilibrium exchange (or exogenous production) economies.[5] Information has then also a *negative face*, in that it restricts *trading* consumption risk.

Our contribution is providing a comprehensive analysis of the social value of information by developing a tractable general equilibrium model that captures on equal footing both faces of information, thus merging the two traditions. We combine the macroeconomics approach of self-insurance through production-labor choices with the finance approach of trading risk through non-contingent assets. In our model, (ex-ante) identical representative atomistic agents act in four roles: they are consumers and producers, as usual in macroeconomics, and also buyers and sellers, as usual in finance. We assume each agent faces an idiosyncratic shock to the productivity of an individually owned factor of production, which we denote as capital, which can be traded in a centralized competitive market. After trading, the agent can combine available capital with her own labor, through a standard Cobb-Douglas specification, to produce consumption goods.

Because of enforceability frictions, contingent contracts are absent in our economy. However, agents can trade capital to diversify productivity risk (market-insurance) or adjust labor to reduce the consumption implications of shocks (self-insurance). While market-insurance entails adjustments costs of working with others' capital, self-insurance is also costly in terms of labor disutility. These imperfect insurance alternatives shape how an individual's shock to capital maps into income

[4] For earlier contributions see Deaton (1991), Hugget (1993) and Aiyagari (1994). A more recent discussion is provided by Kaplan and Violante (2010).

[5] This tradition follows the seminal work of Hirshleifer (1971 and 1972), and more recent contributions discussed in Kurlat and Veldkamp (2015).

(from individual production) and then consumption.

We study the social value of information by comparing ex-ante welfare from market allocations in two extreme benchmarks: one where information about all idiosyncratic shocks is public, costless and perfectly informative and the other where information is not available to anyone. This way we abstract from any particular mechanism through which public information may be acquired, formed or disseminated, isolating the effects of it just being available. We then highlight underlying market failures by comparing market allocations with social planner solutions.

Information has a twofold impact. It enhances self-insurance because by learning about their own shock each agent can evaluate labor supply decisions with the actual cost and benefit in mind – if own capital is not very productive the agent can decide to either compensate by working more or cut back by working less, depending on whether substitution or income effects dominate, respectively. Information, however, comes at the cost of preventing market-insurance: once productivity is common knowledge, adjustment costs push buyers' reservation price below sellers', so no-trade obtains. In contrast, without information trade happens under the veil of ignorance, and capital is sold at a deterministic price equal to its ex-ante expected productivity reduced by adjustment costs. By selling capital agents *get rid* of their own productivity risk, *without transferring the risk* to buyers, who in a competitive equilibrium fully diversify their portfolio by buying capital from all sellers. Thus, when selling capital agents not only benefit individually by getting rid of idiosyncratic risk, but also benefit the rest of agents by providing inputs for the creation of safe assets in the form of perfectly diversified portfolios.

Hence, in absence of contingent contracts, insurance alternatives are determined by the availability of public information. With information, agents can self- but not market-insure. Without information, agents can market- but not self-insure. The social value of public information then depends on which insurance alternative is most relevant for welfare. We derive a simple parametric condition which shows that public information is socially undesirable when the *net benefit of adjusting labor* – the ratio of labor share to the Frisch elasticity – is small compared to the *net benefit of trading capital* – the ratio of capital share to the adjustment cost.

When public information is socially desirable, just disclosing such information is enough to implement the constrained social optimum, as agents always use it and do not affect others when adjusting their own labor supply – *self-insurance does not generate externalities*. In contrast, when public information is socially undesirable, individuals would still use it if disclosed. However, absconding information (so that agents cannot use it) would not be enough to implement the constrained social optimum. The reason is that, in their selling choices, individuals do not internalize the social benefit of increasing the amount of capital that buyers can use to diversify their portfolio – *market-insurance generates a positive externality on creating safe assets*. This externality leads to underprovision of market insurance, which could be fixed by a government, for instance by subsidizing the supply of capital, or by a financial intermediary, such as a competitive mutual fund owned by agents in shares proportional to their capital contributions.

Related Literature: To the best of our knowledge, this is the first paper providing an analysis of the social value of public information in the context of a general-equilibrium model with endogenous imperfect insurance. It show the interaction of the two opposing forces at play – the two faces of information – that other works have studied in isolation.

The *positive face* of public information is rooted in a long tradition in macroeconomics that either focuses on complete markets or on incomplete markets generated by asymmetric private information and/or hidden actions. In this tradition, the *potentially negative* social value of information may arise from the interaction of strategic complementarity and disperse information, as in the seminar works of Morris and Shin (2002) and Angeletos and Pavan (2007), but ultimately the socially optimal role of public information, when costless and perfect, is maintained.[6] Other papers have found that dispersed information about technological shocks may have perverse welfare effects because of externalities in learning from prices (Amador and Weill (2010), Gaballo (2016)) or because of costly information acquisition (Colombo,

[6] The insights from this literature, however, have been shown to be limited in the context of fully micro-founded macro models without consumption risk (Hellwig (2005), Walsh (2007), Baeriswyl and Cornand (2010), Lorenzoni (2010), Roca (2010)).

Femminis, and Pavan (2014), Llosa and Venkateswaran (2017)). Closer to our multi-faceted analysis, Angeletos, Iovino, and La'O (2016) shows that information about non-distortionary forces, such as technological shocks, cannot be welfare detrimental, whereas information about distortionary forces, such as markups shocks, can indeed be socially inferior. In contrast to these works, in our setting consumption risk cannot be shared with contingent contracts, but can be traded with non-contingent ones, showing that information about technological shocks (non-distortionary forces) that is public (no need to learn from prices), costless (no-information cost) and complete (no dispersed signals) may still be detrimental to welfare by eroding market-insurance.

The *negative face* of public information has gained more traction in finance, mainly in efforts to understand the relation between information and both the existence as well as the organization of financial intermediaries. Even though at its inception this literature focused on the beneficial role of information for reallocating resources and improving the quality of assets (such as the seminal papers of Leland and Pyle (1977), Bester (1985) and Diamond (1984 and 1991)) more recently it has highlighted information's detrimental effect on the value of liabilities (such as Gorton and Pennacchi (1990) and Dang et al. (2017), motivated by the original insights of Hirshleifer (1971)).[7]

There are, however, some recent notable attempts to accommodate information trade-offs in welfare analysis. Gottardi and Rahi (2014) combine the negative effect of information on insurance with the positive effect on portfolio optimization in the context of a two-period asset trading model, while Kurlat and Veldkamp (2015) explore the trade-off between risk and return that greater disclosure entails in the context of different types of assets. Our paper is close in spirit to these works, but we frame the trade-off in a general-equilibrium model with production. Eckwert and Zilcha (2001), also consider both production and risk-sharing in a two-period economy with heterogeneous agents (risk-averse consumers and risk-neutral producers);

[7]These contributions have been used for practical purposes, such as in arguments about the benefits of opacity on promoting liquidity in markets (Andolfatto, Berentsen, and Waller (2014), Chousakos, Gorton, and Ordoñez (2020)) or on improving government interventions (Nosal and Ordoñez (2016), Gorton and Ordoñez (2020a)).

in contrast, we use standard assumptions in macroeconomics and finance, in particular a representative agent who performs all roles (consumer, producer, buyer, and seller). Our approach allows for a tractable characterization of the social value of information and provides a setting that can be easily compared to traditional models in macroeconomics and finance.

Our work highlights the importance of the insurance contracting environment in an assessment of the social value of public information. A similar point has been made by Golosov and Iovino (2020), who show that, while full revelation of private information about employment possibilities is always desirable when governments can commit to social insurance, in general it is suboptimal without public commitment. Our setting shows instead that public information about idiosyncratic shocks is socially desirable when private markets are complete, but not necessarily when they are not - particularly when commitment is limited or enforcement is imperfect.

Finally, our work relates to the more recent literature that emphasizes studying origination and trading of assets in a single setting. Vanasco (2017) shows that information acquisition at origination deepens asymmetric information and may lead to a freeze in trading of assets with a collapse of liquidity. In our setting, lack of trading opportunities does not come from asymmetric information in decentralized secondary markets, but rather by common information in centralized secondary markets. Caramp (2017) also studies, but without focusing on information, the negative role of liquidity on the incentives to originate high quality assets. Our work strongly suggests that the positive face of information plays a more prominent role in the origination of assets, while the negative face is more relevant for trading assets.

The next section presents the model. Section 3 characterizes the equilibrium and computes the social value of public information, which is always individually preferred, but not necessarily socially desirable. Section 4 computes the social planner's solution: both constrained to respect market compensations, as well as unconstrained to redistribute capital at will. Section 5 extends the insights to different functional forms and shows that our specific earlier assumptions indeed lean towards making information socially desirable. Section 6 concludes.

2 Model

In this section we present a general equilibrium model of production and trade with imperfectly insurable idiosyncratic risk. Markets are incomplete in that contingent contracts are unfeasible, preventing agents from sharing risks. However, imperfect insurance is possible as agents can trade risk by exchanging non-contingent assets and reduce risk by individually adjusting production to shocks. Our objective is to study how the availability of public information generates a trade-off in these two insurance alternatives.

Utility and technology. There is a single period with a continuum of agents of mass one indexed by $i \in (0,1)$. Agent i has utility function

$$\mathbb{U}(C_i, L_i) \equiv \frac{C_i^{1-\sigma}}{1-\sigma} - \frac{1}{\gamma} L_i^{\gamma}, \tag{1}$$

where C_i and L_i are consumption and labor specific to agent i, $\sigma > 0$ is a constant relative risk-aversion parameter and $\gamma > 1$ controls the convexity of labor disutility.

Each agent produces a quantity Y_i of consumption goods according to the following production function:

$$Y_i = L_i^{\alpha} \hat{K}_i^{1-\alpha}, \tag{2}$$

where $\alpha \in (0,1)$ is the labor share in production and $\hat{K}_i$ denotes the quantity of capital available for production to agent i, given by

$$\hat{K}_i = e^{k_i} \tag{3}$$

where k_i denotes a quantity of homogeneous *intermediate capital* that is obtained by transforming *raw capital*. We describe next how this transformation operates.

Production of capital Agents are ex-ante identical. Ex-post, each agent is endowed with one unit of *raw capital* whose type is determined by a stochastic productivity $\overline{\theta}+\theta_i \sim N\left(\overline{\theta}, 1\right)$, independently distributed across agents, with $\overline{\theta}$ assumed large enough to guarantee productivity is positive almost surely[8]. Agent i can transform her own or others' raw capital into a quantity of intermediate capital, y, according to a linear technology:

$$y(\beta_i(j)) = (\overline{\theta} + \theta_j)\beta_i(j) - \frac{\varphi_{ij}}{2}\beta_i^2(j), \tag{4}$$

where $\beta_i(j) \in [0,1]$ is the mass of raw capital from agent $j \in (0,1)$ used by agent i. We define φ_{ih} to be the adjustment cost (an "iceberg cost") in terms of intermediate capital production that agent i incurs for using raw capital from agent j. Further, we assume adjustment costs are symmetric and only exist when agents produce with raw capital of others,

$$\varphi_{ij} = \begin{cases} \varphi > 0 & \text{if } j \neq i, \\ 0 & \text{if } j = i. \end{cases}$$

Every agent chooses a fraction $\beta_i(i)$ of her own raw capital (from here onwards simply β_i) to use in the production of intermediate capital, selling the rest to other agents; inversely, each agent chooses how much of others' raw capital to buy: $\beta_i(j)$ from all $j \neq i$.

Trading contracts. Agents can exchange raw capital for uncontingent claims on intermediate capital. In particular, raw capital is traded in a centralized Walrasian market according the following protocol: each agent $h \in H(i) \equiv (0,1)/\{i\}$ can sign a contract with agent i to buy raw capital at a unit price R_i, where the price R_i represents an enforceable claim on agent h's future production of intermediate capital. In other words, agent h can produce with raw capital from agent i in exchange of a repayment promise backed by agent h's subsequent production of intermediate capital.

We will assume throughout that intermediate capital is the only pledgeable asset in the economy, and then these transactions cannot be written in terms of consumption goods. The implication of this assumption is that each agent consumes what

[8]More precisely, such that $\Pr\left(\bar{\theta} + \theta_i < 0\right) \approx 0$.

produces, $C_i = Y_i$. This is useful to introduce consumption risk in a tractable way but it is not critical for the results as it does not entail any departure from complete markets. Indeed, we show later in section 4.2 that a social planner could implement the unconstrained first-best allocation by operating *contingent transfers* in intermediate capital only. Next we discuss the assumptions that do generate incompleteness.

Market incompleteness. In our economy markets are incomplete as we assume restrictions on the ability of agents to write contingent contracts, i.e. enforceable agreements to make transfers contingent to the verifiable realizations of uncertain events. First, we assume enforceability only holds for contracts written after agents are endowed with raw capital, meaning that agents cannot write contracts based on assets for which they do not yet hold property rights. Second, we assume that verifiability obtains only with public information, meaning that contracts cannot condition on realizations for which there will not be common knowledge.

Information benchmarks. We focus on two extreme information benchmarks. In the *full-information benchmark*, public, costless and infinitely precise information about the type of raw capital is *available to all* agents in the economy as soon as endowments are distributed and property right are assigned. In this benchmark, contingent contracts are not written before shocks realize because of the absence of property right, and not after because there are no uncertain contingencies to share risk. In the *no-information* benchmark, instead, no one has any information about idiosyncratic productivities until production occurs. In this case contingent contracts cannot be written due to lack of public verifiability.

Timing and Equilibrium. The timing is as follows: first, raw capital of idiosyncratic productivity is assigned to agents $\Theta \equiv \{\theta_i\}_{i\in(0,1)}$, second - based on available information - agents set their trading positions $\{\beta_i(h)\}_{(i,h)\in(0,1)}$ and choose labor supply $\{L_i\}_{i\in(0,1)}$, finally, raw capital is exchanged, production of intermediate capital takes place, intermediate capital payments are made, production of the consumption good takes places, and agents consume their output. Given this sequence of events, for a given information benchmark, a market equilibrium is defined as follows:

Definition 1 (Market Equilibrium). *For given productivity realizations Θ and an information set $\Omega = \{\emptyset, \Theta\}$, a market equilibrium is the cross-sectional allocation of capital $\{\hat{K}_i\}_{i\in(0,1)}$ and consumption $\{C_i\}_{i\in(0,1)}$ induced by trading of raw capital $\{\beta_i(j)\}_{j\in(0,1)}$ and labor choices L_i that maximize $E[\mathbb{U}(C_i, L_i)|\Omega]$ for each agent $i \in (0, 1)$.*

Discussion. Before moving on, it is useful to highlight three key features of our model. First, this is a general equilibrium setting: any agent in the economy is at the same time a buyer, a seller, a producer and a consumer. Agents only differ in the productivity of the endowed raw capital - they are otherwise ex-ante identical.

Second, our specification of market incompleteness allows a tractable model in which consumption risk cannot be insured away with contingent contracts, but can be managed with labor choices and trading choices. While the first do not induce externalities, the second are subject to general equilibrium forces, which will induce a failure to internalize the effects of trading decisions on consumption risk.

Third, while we model preferences and consumption good production with standard forms (CRRA utility and a Cobb-Douglas technology) the assumption that production of capital follows an exponential function (equation 3) - increasing returns to scale with respect to raw capital - is not. As it will become clear, this assumption is extremely convenient for tractability. We will generalize this benchmark assumption in section 5 and show that not only do the main insights go through for generic production functions of capital, but also that this assumption is conservative in that it tends to favor public information desirability.

3 Market Equilibrium

In this section, we characterize the equilibrium in three steps. In each of the information benchmark, we, first, solve for the agent's optimum labor supply, and express ex-ante individual utility purely as a function of the conditionally expected amount of intermediate capital. We then solve for the optimal individual demand and supply of raw capital. Finally, we obtain the equilibrium for raw capital trade under the two information benchmarks. A comparative analysis of the equilibria follows in which we obtain simple conditions, based on the model's parameters, that dictate when public information is socially undesirable.

3.1 Optimal Individual Labor Choice

The next Lemma shows the amount of labor that agent i chooses given her expected (conditional on available information) distribution of intermediate capital,

Lemma 1. *Agent i supplies labor optimally according to*

$$L_i = E_i[K_i]^{\frac{\phi}{\gamma}}. \tag{5}$$

with

$$\phi \equiv \frac{1}{1 - \frac{\alpha}{\gamma}(1-\sigma)} \tag{6}$$

where $K_i \equiv \alpha e^{k_i(1-\alpha)(1-\sigma)}$.

Proof. This results follows from maximizing expected equation (1) subject to (2). □

Note that labor is increasing in intermediate capital k_i when $\sigma < 1$, and decreasing when $\sigma > 1$. These comparative statics come from standard trade-offs between income and substitution effects. When $\sigma < 1$ a substitution effect dominates: as capital becomes abundant, labor is more productive and agents work more - the additional variance of consumption is not punished as heavily because risk aversion is relatively low. In contrast, when $\sigma > 1$ the income effect dominates: as capital becomes abundant agents work less because they are comparatively more sensitive to variance. When $\sigma = 1$, these two forces exactly offset each other and labor supply does not depend on the amount of intermediate capital.

The role of information on optimal labor choices is captured through the expectation operator. Without information agents can only choose labor based on expected capital, not on each possible realization, as could be done with full-information. This conveys the *positive face* of information: information allows for labor choices to better react to idiosyncratic shocks to capital.

Characterization of ex-ante individual utility. We can replace the optimal choice of labor (5) into the production function (2) and take the expectation of utility (1) to express the individual's ex-ante utility, just in terms of expected capital under each of the information benchmarks.[9]

$$E[\mathbb{U}(E_i[K_i])] \equiv E\left[\frac{K_i\, E_i[K_i]^{\frac{\phi}{\gamma}\alpha(1-\sigma)}}{\alpha(1-\sigma)} - \frac{1}{\gamma}E_i[K_i]^{\phi}\right],$$

where $E[\cdot]$ denotes the unconditional expectation operator and $E_i[\cdot] = E[\cdot|\Omega]$ denotes the expectation operator conditional to the information set of agent i (note, $E[\cdot] = E[\cdot|\emptyset]$). Manipulating this equation, the next Lemma characterizes in simpler form the ex-ante expected utility of agent i in each of the extreme information benchmarks we are considering,

Lemma 2. *For given trading choices* $\{\beta_i(j)\}_{(i,j)\in(0,1)^2}$*,*

- *In the full-information benchmark* $E_i[K_i] = K_i$ *and*

$$E[\mathbb{U}(E_i[K_i])] = E[\mathbb{U}(K_i)] = \Phi E[K_i^{\phi}]; \tag{7}$$

- *In the no-information benchmark* $E_i[K_i] = E[K_i]$ *and*

$$E[\mathbb{U}(E_i[K_i])] = \mathbb{U}(E[K_i]) = \Phi E\left[K_i\right]^{\phi}; \tag{8}$$

with $\Phi \equiv \frac{\gamma-\alpha(1-\sigma)}{\gamma\alpha(1-\sigma)}$ *(i.e. positive for* $\sigma < 1$ *and negative for* $\sigma > 1$*).*

[9]This represents the utility that an agent expects to obtain anticipating her knowledge at the time of making labor choices. Equivalently this is the ex-post average utility obtained across all agents, given their information set.

Our characterization unveils the relation between the quantity of capital available and the ex-ante utility through the optimal choice of labor. In particular, it allows for a straight interpretation of the key parameter ϕ, from equation 6 depending on the information benchmark.

Under no-information, ϕ measures the *elasticity of ex-ante utility to expected capital* $E[K_i]$. When the substitution effect dominates, i.e. $\sigma < 1$, ϕ is larger than one, meaning that an increase in expected capital is *amplified* in terms of ex-ante utility because agents react by working more. When the income effect dominates instead, i.e. $\sigma > 1$, ϕ is positive but smaller than one, meaning that an increase in expected capital productivity is *weakened* in terms of ex-ante utility because agents react by working less. Note that the elasticity ϕ not only depends on σ but also on α/γ – the labor elasticity of production relative to the labor elasticity of utility: the higher this ratio, the cheaper it is for agents to adjust labor, which magnifies these amplification/weakening effects of labor choices on ex-ante utility.

For the full-information benchmark, ϕ measures the *elasticity of ex-post utility to capital* K_i. The same economic insights carry over, but instead of holding on average (in ex-ante terms), they hold for each realization of capital (in ex-post terms).

It is straightforward to see that, *ceteris paribus*, the difference between equations (8) and (7) that characterizes the two benchmarks, relies on the wedge created by Jensen's inequality. In particular, for a *given* ex-ante distribution of K_i realizations, when $\phi > 1$ the wedge associated with full-information is positive, whereas for $\phi \in (0, 1)$ the wedge is negative, but that since in this case $\Phi < 0$, this is an improvement that generates a "less negative" expected utility. As a consequence, *given trading of raw capital, ex-ante utility is always higher in the full-information benchmark*; this is intuitive as there are no externalities in labor choices and so information is always efficiently used by individuals in making these decisions.

Equipped with this characterization we can now solve for the optimal demand and supply of raw capital in the trading stage. As we will see, trading affects the ex-ante distribution of K_i realizations, so our assessment of the benefits of information has to be reconsidered in light of the possibly different ex-ante distributions of K_i that arise in *general equilibrium* under the two benchmarks.

3.2 Optimal Individual Demand of Raw Capital

Since the production of consumption goods is increasing in the amount of available intermediate capital (from equations 2 and 3), each agent seeks to maximize the total quantity of intermediate capital to operate, partly by trading raw capital in centralized markets; in these markets, buyers compete for the raw capital supplied by other agents. The equilibrium per unit price of agent i's raw capital, which we denote by R_i, is determined competitively by equalizing the total demand from agents $h \neq i$ with the supply from agent i. That is,

$$\int_{H(i)} \beta_h(i) dh = 1 - \beta_i. \tag{9}$$

After selling a fraction β_i of her own raw capital at a price R_i, buying $\beta_i(h)$ raw capital from agents $h \in H(i)$ at prices R_h and covering adjustment costs $\frac{\psi}{2}\beta_i^2(h)$, the amount of intermediate capital available to agent i to produce consumption goods is

$$k_i = \left(\bar{\theta} + \theta_i\right) \beta_i + (1 - \beta_i) R_i + \int_{H(i)} \Pi_i(h) dh, \tag{10}$$

where $\Pi_i(h)$ is agent i's profit from buying agent h's raw capital and given by

$$\Pi_i(h) = \left(\bar{\theta} + \theta_h\right) \beta_i(h) - \frac{\varphi}{2}\beta_i^2(h) - R_h \beta_i(h), \tag{11}$$

for any $h \in H(i)$. In words, an agent will operate with intermediate capital that comes from three sources: that proceeding from i) transforming a fraction β_i of her own raw capital into intermediate capital with productivity θ_i, ii) selling a fraction $(1 - \beta_i)$ of own her raw capital to other agents in exchange for $(1 - \beta_i)R_i$ units of intermediate capital, and iii) buying raw capital $\beta_i(h)$ from other agents and obtaining a profit $\Pi_i(h)$, in terms of intermediate capital, after repayment.

The objects R_i and $\Pi_i(h)$ are endogenous and depend on the availability of public information. In what follows, we characterize these objects and also the implied quantity of intermediate capital available to agent i after participation in the market for raw capital, as function of all agents' demand for own capital $\{\beta_i\}_{i\in(0,1)}$. We will focus our analysis on equilibria where, for a given information benchmark, the optimal supply of assets is equal across agents and later prove that this feature, in fact, is generically true.

Proposition 1 (Demand and equilibrium price of raw capital)**.** *Agent i's utility-maximizing demand of agent h's raw capital is*

$$\beta_i^*(h) = \frac{\bar{\theta} + E_i[\theta_h] - R_h}{\varphi}, \tag{12}$$

which also maximizes profits (33). Given a uniform supply of raw capital $(1-\beta_h) = (1-\beta) \in (0,1)$*, since* $E_i(\theta_h)$ *is the same for all agents, market clearing (9) implies that the price of agent h's raw capital satisfies*

$$R_h = \bar{\theta} + E_i[\theta_h] - \varphi(1-\beta), \tag{13}$$

Proof. Postponed to Appendix A.1. □

This proposition shows that the optimal individual demand for raw capital equates expected marginal return, $\bar{\theta} + E_i[\theta_h]$, and marginal cost, $R_h + \varphi\beta_i(h)$, of operating with others' capital. It boils down to a linear schedule, decreasing in price and increasing in expected productivity, whereas higher marginal adjustment costs produce downward shifts. It is instructive to notice that demand only depends on the expected productivity of raw capital - not on its conditional variance. The reason for this is that traders simultaneously demand a continuum of capital goods, each with an i.i.d. productivity shock, which allows them to achieve perfect diversification.

Because of market forces, perfect diversification is indeed the only possible equilibrium outcome when there is trade of raw capital (even if $\sigma < 1$ and agents like volatility of intermediate capital). Four features combine in our setting to obtain this convenient result: i) perfect competition among traders, ii) *capital-specific*, rather than *portfolio-specific*, adjustment costs φ iii) CRRA utility in consumption (by (2)), but constant absolute risk aversion (CARA) in portfolio returns (by (2) and

(3) jointly), and iv) quadratic adjustment costs which allow asset investments to be "self-financed." The last two features ensure that h's demand of i's raw capital is independent from the expected returns of h's raw capital, i.e. from the only potential source of individual heterogeneity[10]; combined with capital-specific adjustment costs, this implies that agents have common asset valuations irrespectively of their differences as buyers. Perfect competition requires that the marginal benefit be equalized across all buyers for each type of raw capital, so that, in equilibrium, each buyer must absorb an equal (infinitesimal) amount of raw capital supply. Finally, since per unit adjustment costs are homogeneous across all raw capital types, the distribution of optimal individual demand across types within a portfolio must also be symmetric.

In short, as long as the supply of raw capital is uniform across sellers (which we prove in the next section), buyers perfectly diversify their portfolio as a result of perfect competition. Thus, portfolio profits are deterministic and known by agents in any information benchmark, leading to the following result,

Corollary 1. *Suppose supply of raw capital is uniform across agents other than i, i.e. $(1-\beta_h) = (1-\beta) \in (0,1)$ for any $h \in H(i)$. Agent i's portfolio profits are deterministic,*

$$\int_{H(i)} \Pi_i(h)dh = \frac{\varphi}{2}(1-\beta)^2. \tag{14}$$

and agent i's quantity of intermediate capital available for production, from (10), is

$$k_i = \bar{\theta} + \beta_i\theta_i + (1-\beta_i)\, E_h[\theta_i] - \varphi \int (1-\beta_i)^2 di + \frac{\varphi}{2}(1-\beta)^2, \tag{15}$$

which depends on both agent i's supply $(1-\beta_i)$ and other agents' supply $(1-\beta)$.

Proof. Postponed to Appendix A.1. □

The corollary leads to two important insights. First, even though information affects the selling price of an agent's raw capital, it does not affect the portfolio profits

[10]In particular, CARA with self-financing ensure respectively that the marginal utility of portfolio returns and the spending in others' capital does depend on one's own wealth, which in our model is determined by the price at which the agent can sell her own raw capital in the market and, ultimately, on the expected productivity of said capital.

from buying others' raw capital. By the law of large numbers, the sum of profits obtained from buying a basket of raw capital from other agents is deterministic, so its ex-ante and ex-post evaluations coincide. Thus, information availability is irrelevant to agents in their role as buyers. As we will see next, it is however relevant in their role as sellers. Second, the choices of an agent as a seller do not affect the profits that the agent obtains as a buyer: this is key to understand the potential sub-optimal provision of diversification possibilities by the market. The reason is that buying others' capital is expected to be self-financed by the production of that purchase ($E_i[\Pi_i(h)] = \frac{\varphi}{2}(1-\beta)^2 > 0$). Expected profits are positive because the purchase unit price is $\varphi(1-\beta)$ lower than expected productivity, while average unit adjustment cost is only $\frac{\varphi}{2}(1-\beta)$.

3.3 Optimal Individual Supply of Raw Capital

When agent i chooses how much raw capital to sell, $1-\beta_i$, she understands that public information affects the selling price. Thus, in contrast to the problem of agents as buyers, the optimal supply of raw capital does depend on the information environment, which we characterize below for each information benchmark.

3.3.1 Supply of raw capital with no-information.

Exploiting the property of exponential functions and the definition of K_i from Lemma 1, we expand the expression of ex-ante expected utility from Lemma 2 as a function of expectation and variance of intermediate capital as follows,

$$\begin{aligned} \Phi E[K_i(\theta_i)]^\phi &= \Phi\alpha E[e^{(1-\alpha)(1-\sigma)k_i}]^\phi \\ &= \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi E[k_i]+\frac{1}{2}((1-\alpha)(1-\sigma))^2\phi V(k_i)}. \end{aligned} \tag{16}$$

The utility value of supplying raw capital depends on how the ex-ante expected quantity of intermediate capital $E[k_i]$ and its ex-ante variance $V(k_i)$ affect utility: while selling raw capital (reducing β_i) reduces expected intermediate capital, it also reduces its variance. To see this, taking unconditional expectations of equation (15),

$$E[k_i] = \bar{\theta} - \varphi(1-\beta_i)^2 + \frac{\varphi}{2}(1-\beta)^2. \tag{17}$$

which increases with β_i. While taking the variance of equation (15) yields,

$$V(k_i) = \beta_i^2. \tag{18}$$

which also increases in β_i. In short, agents want to sell raw capital to reduce the variance of intermediate capital, but it comes at a cost in terms of reducing the expected amount of intermediate capital available to produce.

Now we can map these results about intermediate capital to consumption goods. First, while the variance of intermediate capital $V(k_i)$ increases consumption variance, it also increases average consumption (through the exponential production function that transforms intermediate capital into capital for producing consumption goods). The first effect becomes less relevant in utility terms as σ declines: when $\sigma > 1$ the variance of intermediate capital decreases ex-ante utility (recall $\Phi < 0$, in this case), whereas the variance of intermediate capital increases ex-ante utility when $\sigma < 1$ (recall $\Phi > 0$, in this case).

This implies that in the absence of information, when $\sigma < 1$ agents want to maximize both $E(k_i)$ and $V(k_i)$, which is achieved by not selling any raw capital. In contrast, when $\sigma > 1$, agents want to maximize $E(k_i)$ but minimize $V(k_i)$, facing a trade-off that is formally captured by the first order condition of ex-ante utility with respect to the supply of raw capital, β_i. Evaluating (16) with (17) and (18), we have

$$\frac{\partial \Phi E[K_i(\theta_i)]^{\phi}}{\partial \beta_i} = [2\varphi(1-\beta_i) + (1-\alpha)(1-\sigma)\beta_i](1-\alpha)(1-\sigma)\phi\Phi E[K_i(\theta_i)]^{\phi},$$

which determines the optimal value of β_i. Combining these results, the following proposition characterizes the result.

Proposition 2 (Supply of raw capital with no-information)**.** *With no-information,* *agent i's optimal individual supply of raw capital is such that,*

$$\beta^*_{i,NI} = \begin{cases} 1 & \text{if } \sigma < 1, \\ \frac{1}{1-\frac{1-\alpha}{2\varphi}(1-\sigma)} & \text{if } \sigma \geq 1. \end{cases} \tag{19}$$

This proposition clarifies that the discussed trade-off only arises when variance of intermediate capital reduces expected utility - that is when $\sigma > 1$. In this case, the agent sells more raw capital when the production function is more elastic to capital – i.e. $1 - \alpha$ is large, adjustment cost φ is small, and/or risk aversion σ is high. When $\sigma < 1$ agents do not sell raw capital, as variance of intermediate capital increases expected utility, and then agents prefer to work with own raw capital: both maximizing the variance and saving on adjustment costs. In addition, notice that one agent's profits in her role as buyers do not enter in her supply choice.

3.3.2 Supply of raw capital with full-information.

In the full-information benchmark, sellers choose how much to sell once productivity is publicly known. In this case, sellers maximize ex-post utility for any possible realization of their raw capital productivity,

$$\Phi K_i(\theta_i)^\phi \quad = \quad \Phi \alpha e^{(1-\alpha)(1-\sigma)\phi k_i} \tag{20}$$

where k_i is given by (15) with $E_h[\theta_i] = \theta_i$. Taking derivative of ex-post utility with respect to β_i

$$\frac{\partial \Phi K_i(\theta_i)^\phi}{\partial \beta_i} = [2\varphi(1-\beta_i)(1-\alpha)(1-\sigma)\phi]\Phi K_i(\theta_i)^\phi,$$

which is positive for all σ and any β_i. This reasoning implies,

Proposition 3 (Supply of raw capital with full-information)**.** *With full-information agent i never sells, this is,* $\beta^*_{i,FI} = 1$.

The intuition here is clear, as selling raw capital just decreases available intermediate capital - given that the selling price perfectly reflects productivity net of adjustment costs - and there is no variance reduction benefit.

3.4 The Social Value of Information

In this section we show that public, perfect and costless information is not always desirable from a social standpoint.[11] We compare expected utility in the full-and no-information benchmarks, as stated in Lemma 2, evaluated at the optimal labor and optimal supply of raw capital β_i^* from Propositions 2 and 3 respectively. After simple manipulations, we get a clear characterization of welfare in each case.

Proposition 4 (The two faces of information)**.** *Market allocations generate the following ex-ante utility:*

- *In the full-information benchmark*

$$\Phi E[K_i(\theta_i)^\phi] = \Phi \bar{K} E[e^{(1-\alpha)(1-\sigma)\theta_i}]^{\phi^2} \qquad \forall\, \sigma \tag{21}$$

- *In the no-information benchmark*

$$\Phi E[K_i(\theta_i)]^\phi = \begin{cases} \Phi \bar{K} E[e^{(1-\alpha)(1-\sigma)\theta_i}]^{\phi} & \text{for } \sigma < 1 \\ \Phi \bar{K} E[e^{(1-\alpha)(1-\sigma)\theta_i}]^{\phi \beta^M} & \text{for } \sigma \geq 1 \end{cases} \tag{22}$$

where $\bar{K} = \alpha e^{\phi(1-\alpha)(1-\sigma)\bar{\theta}}$ *and*

$$\beta^M = \frac{1}{1 - \chi \frac{1-\alpha}{\varphi}(1-\sigma)} \tag{23}$$

with

$$\chi \equiv \frac{3\varphi + (1-\alpha)(\sigma-1)}{4\varphi + (1-\alpha)(\sigma-1)} \in (3/4, 1)\,. \tag{24}$$

Proof. Postponed to Appendix A.2. □

[11] Our welfare criterion is based on each identical individual agent from an ex-ante perspective, not the representative agent which is normatively unrepresentative, as explained by Schlee (2001).

This proposition helps contrasting (almost visually from comparing the exponents of 21 and 22) the two opposite faces of information.

Information induces *self-insurance* by allowing agents to optimally react to fluctuations of available capital, which is captured by an exponent ϕ from adjusting labor in response to realized productivity in addition to the single ϕ in (22) from adjusting labor in response to expected productivity. Information, however, prevents *market-insurance* as prices perfectly reflect realized productivity with a discount for adjustment costs, which discourages agents to sell. Public information then discourages the use of raw capital markets and the possibility of insurance by diversification.

No-information allows *market-insurance*, when agents are sufficiently risk-averse ($\sigma > 1$), by creating scope for raw capital trade which effectively reduces the volatility of labor productivity; this shows up as β^M in (22), which ameliorates the relative inferiority of an uncontingent labor response (again captured by ϕ). Naturally, the absence of information deters *self-insurance*, so diversification from the market comes at the cost of preventing contingent labor responses.

Note how β^M in (23) is the mirror image of ϕ in (6). This analogy is instructive about the similar impact of *market-insurance* and *self-insurance* on expected utility. The trade-off that sellers face of lowering variance at a trading cost, which is typically studied in the finance literature, is essentially the same as the trade-off that households face when adjusting labor to reduce variance at a disutility labor cost, which is typically studied in the macro literature. The next proposition exploits this analogy to characterize the social value of public information by directly comparing the strength of market- and self-insurance.

As we've discussed, when $\sigma < 1$, information is never socially inferior: agents prefer to maximize the variance of intermediate capital and save on adjustment costs, so market-insurance is not desired at all, yet adjusting their labor response allows them to do strictly better by working most when their effort is most productive (substitution effect dominates). The next proposition characterizes the condition under which information is socially inferior in the other, more interesting case, in which $\sigma > 1$ and agents are risk averse to intermediate capital.

Proposition 5 (The social value of information)**.** *The market allocation attained with full-information is socially inferior to the one attained with no-information if and only if $\sigma > 1$ and $\beta^M < \phi$, that is*

$$\frac{\alpha}{\gamma} < \chi \frac{1-\alpha}{\varphi}. \tag{25}$$

Proof. With $\sigma > 1$ we have that $\Phi < 0$ (from Lemma 2) and $0 < \phi < 1$ (from equation 6). The proposition is a direct implication of 21 and 22. □

This proposition can also be explained intuitively from comparing the two channels through which individuals can reduce the variance of consumption.

One channel is *self-insurance*. When agents know productivity realizations, the raw capital market does not provide insurance, but individuals can self-insure by allocating labor optimally. This reduction of variance is proportional to ϕ, which increases in α/γ. In words, self-insurance is more powerful to reduce variance when labor is more important in the production function (higher α) and when the Frisch elasticity (the elasticity of labor disutility to labor supply) is low such that it is less costly to adjust labor to compensate for lower stochastic productivity (lower γ).

The other channel is *market-insurance*. When individuals do not know shocks, they cannot self-insure for the own capital not sold (this is for $\beta^*_{i,NI}$), but the market can provide insurance for the rest, at an adjustment cost φ. In the absence of information, agents get more market-insurance (decrease $\beta^*_{i,NI}$) when $(1-\alpha)/\varphi$ increases by (19). In words, market-insurance is more powerful to reduce variance when capital is more important in the production function and when adjustment costs are smaller; the former increasing the utility cost of productivity fluctuations and the latter reducing the cost of both trade as well as working with others' capital.

The relative benefit of market-insurance is adjusted by χ, which monotonically increases in σ. Intuitively, a larger σ increases the relevance of market-insurance and decreases the social benefits of information. This result comes from agents not internalizing that, by selling raw capital they effectively increase the amount of raw capital that other agents can use to build safe assets, in the form of perfectly diversified portfolios, when acting as buyers. The role of this externality will be better appreciated in the next section, when we explicitily solve the social planners' problem.

Let us conclude this section by discussing the source of the discrepancy between the social and individual evaluation of information in our setting. Public information, even if perfect and costless, can be socially undesirable and yet still used by individuals because of a coordination failure. The reason is that agents would never ignore information about own and others' raw capital, if available. Intuitively, if nobody else has information in the economy, an agent can always (at least weakly) exploit such information in the market, when buying raw capital from others[12]. In this sense, the availability of socially inferior information generates a coordination failure among agents, who would be better off by coordinating not to use public information. How does this lack of coordination manifest itself? As the variance of raw capital prices. No agent internalizes the fact that, by buying conditional on public information, prices react, introducing uninsurable ex-ante consumption variance to the seller. This is why the availability of information to agents that cannot commit to buy without using the information creates an externality to sellers that can only be negative.

4 Social Planning

In this section, we define the problem of a social planner that maximizes the ex-ante expected utility of the representative consumer. First, we solve a *constrained social optimum*, in which the planner is constrained by the same trading restrictions that agents face, i.e. compensation implied by market prices. Even though the planner does not trade in a market, she has to respect the mapping between information and allocations imposed by the market, such that agents with raw capital of known high

[12] The strength of incentives to have information individually depends on how expectations are formed in the market. In one extreme, when other agents learn perfectly from prices, information gains from trading are strictly positive only when no other agent is informed. In the other extreme, when agents do not learn from prices, information gains from trading are always strictly positive.

productivity receive high intermediate capital in exchange. We show that the planner would like agents to supply more raw capital than in equilibrium, highlighting the nature of a typical externality in the provision of market-insurance.

Second, we solve an *unconstrained social optimum*, thus, replicating the allocation with *complete markets* - a situation in which public information is always socially desirable. We endow the planner with full-information about productivity shocks and allow her to implement contingent transfers in intermediate capital freely, without being subject to the allocations implied by market prices. We show that, while markets use information to allocate intermediate capital "regressively" (more intermediate capital to agents with raw capital of higher productivity), a planner would use information to allocate it "progressively" so as to equalize intermediate capital across agents (more intermediate capital to agents with raw capital of lower productivity).

4.1 Constrained Social Optimum

We analyze the fraction of raw capital that the planner would like each agent to trade in the market. The planner's problem is the same as that of any individual agent, but internalizes that marginally increasing the supply of raw capital of an agent increases the possibilities of diversification and improves insurance for other agents. Individual sellers are not compensated for these "pooling gains" by the market.

With public information, the planner chooses β_i to maximize equation (20), with the result being the same as in Proposition 3. This means the planner's solution coincides with the equilibrium allocation in which all agents work with their own raw capital and do not interact with each other. Intuitively, as the planner has to respect the market's compensations, agents with high productivity raw capital end up working with more intermediate capital - with or without the market - and, as individuals in equilibrium, the planner prefers not to waste on adjustment costs by trading. In other words, by trading the planner does not eliminate conditionally expected variance of intermediate capital, but loses on adjustment costs.

Without public information, the planner chooses β_i to maximize equation (16), where expected intermediate capital is as in equation (17), but with $\beta_i = \beta$, so that the planner internalizes the effect of supplying more raw capital on increasing other agents' insurance via diversification. Then, equation (17) becomes

$$E[k_i] = \bar{\theta} - \frac{\varphi}{2}(1-\beta)^2,$$

and taking the derivative of ex-ante utility with respect to β leads to the planner's optimal supply of raw capital, which is characterized in a "planner-version" of Proposition 2 as follows,

Proposition 6 (Social supply of raw capital with no-information). *With no-information the planner's optimal supply of raw capital is such that,*

$$\beta^P_{i,NI} = \begin{cases} 1 & \text{if } \sigma < 1 \\ \frac{1}{1-\frac{1-\alpha}{\varphi}(1-\sigma)} & \text{if } \sigma \geq 1 \end{cases}$$

Notice, comparing Propositions 2 and 6 that the planner would like agents to supply more raw capital (lower β_i), than they do in equilibrium. Intuitively, in equilibrium, individuals only internalize the role of selling raw capital for own insurance, not for the insurance of others as they are not compensated for it. The market fails to compensate each individual for the "insurance value" of selling raw capital because buying a single type raw capital of idiosyncratic productivity does not provide insurance unless combined with additional purchases of many other units of raw capital of different idiosyncratic productivity, but transactions are bilateral. This complementarity that is not priced-in induces an under-supply of raw capital. The planner fixes this failure of *coordination*.

Now, we obtain the set of parameters under which information is socially undesirable. We evaluate welfare in Proposition 4 at the socially optimal supply of raw capital in Proposition 6, which delivers the next "Ramsey-version" of Proposition 5,

Proposition 7 (Socially Undesirable Information). *The planner's allocation attained with full-information is inferior to the one attained with no-information if and only* *if $\sigma > 1$ and $\beta^P_{i,NI} < \phi$, that is,*

$$\frac{\alpha}{\gamma} < \frac{1-\alpha}{\varphi}. \tag{26}$$

Proof. With $\sigma > 1$ we have that $\Phi < 0$ (from Lemma 2) and $0 < \phi < 1$ (from equation 6). The proposition is a direct implication of comparing 21 and 22 evaluated at $\beta^M = \beta^P_{i,NI}$ from Proposition 6. □

The extent of the wedge between the planner's solution and the market equilibrium is captured by the difference between the conditions in Propositions (25) and (26), which is given by χ from equation (24). Since $\chi < 1$, the region of parameters under which information is undesirable is larger for the planning problem, as the planner can operate market-insurance more efficiently than the agents and information denies this avenue. Furthermore, since χ increases with σ, the wedge declines with risk aversion. Intuitively, as risk aversion increases, the supply choices of agents in equilibrium becomes more similar to those of the planner: both converging to perfect diversification (in the limit, $\lim_{\sigma\to\infty}\chi = 1$, and $\lim_{\sigma\to\infty}\beta^*_{i,NI} \to \beta^P_{i,NI} \to 0$). As market-insurance becomes more desirable (when risk aversion increases), the speed at which the planner and agents' decisions converge depends on the extent of adjustment costs; seen by examining (24).

Interestingly, condition (26) does not depend on the level of risk-aversion - just on the benefits and costs of self-insurance (the left-hand side) and market-insurance (the right-hand side). In our setting, both sources of insurance are equally effective at reducing consumption variance, so the decision regarding whether to exploit one or the other (and the social desirability of public information) only depends on the net benefit of each.

A note on implementation with a financial intermediary. A competitive (zero-profit) mutual fund could induce the coordination that sellers cannot achieve in a decentralized market and allow them to reach the constrained socially optimal raw capital allocations. Each agent "invests" in the mutual fund $1-\beta_i$ units of raw capital, the mutual fund pools all the raw capital, and produces intermediate capital subject to identical adjustment costs. Given perfect diversification, the agent receives back $\bar{\theta}(1-\beta_i) - \frac{\varphi}{2}(1-\beta_i)^2$. This implies that the agents' return in terms of expected intermediate capital is lower in expectation, but deterministic. A mutual fund effectively sells insurance at a "fee", $\frac{\varphi}{2}(1-\beta_i)^2$, thereby turning an agent's expected amount of intermediate capital, from equation (17), into $E[k_i] = \bar{\theta} - \frac{\varphi}{2}(1-\beta)^2$, which makes the agent's objective function mathematically identical to that of the constrained social planner; thus, agents optimally contribute to the mutual fund the socially optimal amount from Proposition 6. Being that all agents contribute the same amount $1-\beta$, the mutual fund produces in total $\bar{\theta}(1-\beta) - \frac{\varphi}{2}(1-\beta)^2$, which is what it repays to investors, making zero profits. This potential implementation suggests the importance of financial intermediation in increasing the supply of "safe assets" in the economy, for instance, by securitization which indeed follows the logic of an originator pooling assets with idiosyncratic quality and, at a cost, generating a "new asset" of lower variance, as discussed in Gorton and Ordoñez (2020b).

A note on implementation with subsidies. Which tax scheme could a government use to implement the constrained socially optimal supply of raw capital? As we noted, agents' failure to internalize the positive effect of supplying raw capital for other agents' insurance stems from market prices' under-compensation. A government could therefore subsidize the sale of raw capital by an amount $s(\beta_i)$; financing the subsidies with lump-sum taxes T, in terms of intermediate capital. Given this subsidy scheme, the expected amount of intermediate capital from equation (17) becomes $E[k_i] = \bar{\theta} - \varphi(1-\beta_i)^2 + \frac{\varphi}{2}(1-\beta)^2 + s(\beta_i) - T$ and the socially optimal supply of raw capital from Proposition 6 can be implemented by setting $s(\beta_i) = \frac{\varphi}{2}(1-\beta_i)^2$. Note this scheme does not require information on productivity, just on actual supply. In the previously mentioned example of asset backed securities, policymakers should thus not only tax information, to encourage the origination of these safe assets (encourage the trade of certain assets that are used as inputs of private safe assets, such as mortgages for MBS, or bonds for CDOs), but also to subsidize such trading.

4.2 Unconstrained Social Optimum

Now, we study a planner that has full-information about the idiosyncratic productivity of all raw capital, seeks to maximizes the ex-ante utility of a representative agent, and can freely redistribute intermediate capital. Individuals could implement this allocation if they were able to write ex-ante contracts which specify transfers of intermediate capital contingent on productivity realizations.

In particular, the planner can choose both the proportion of in-house production of intermediate capital β_i and the exchange of intermediate capital after production τ_i. Given that, in this benchmark, the planner's hands are not tied by market compensations, her problem becomes,

$$\max_{\{\beta_i(h),\tau_i\}_{(i,h)\in(0,1)^2}} E[\mathbb{U}(K_i(\theta_i))] = \Phi E[K_i(\theta_i)^{\phi}]$$

subject to

$$\begin{aligned} k_i &= (\bar{\theta}+\theta_i)\beta_i + \tau_i + \int_{H(i)} \left[(\bar{\theta}+\theta_h)\beta_i(h) - \frac{\varphi}{2}\beta_i^2(h)\right] dh\,, \\ \int \tau_i di &= 0\,, \\ 1-\beta_i &= \int_{H(i)} \beta_h(i)\, dh \end{aligned}$$

In other words, the planner maximizes ex-ante utility by controlling the production of intermediate capital, through β_i, and its distribution, through τ_i.

Proposition 8 (Unconstrained planner's solution)**.** *The unconstrained planner allocation is characterized by no-trade in raw capital (that is $\beta_i = 1$ for all i) and redistribution of intermediate capital as follows,*

$$\tau_i = \begin{cases} 0 & \text{if } \sigma < 1 \\ -\theta_i & \text{if } \sigma \geq 1 \end{cases}$$

Proof. Postponed to Appendix A.3. □

Intuitively, an unconstrained planner wants to employ raw capital where it is most productive - with the original owners who don't face adjustment costs - and, having maximized aggregate intermediate capital, go on to achieve perfect insurance, when market-insurance is desired ($\sigma > 1$), by equalizing allocations via redistribution. Further, in stark contrast to the market, which allocates more intermediate capital to the agents with higher productivity (*regressive redistribution*), the unconstrained planner allocates more intermediate capital to agents with lower raw capital productivity (*progressive redistribution*).

For the unconstrained planner, it is always optimal to have full-information, as this allows her to make transfers contingent on productivity (more transfers to less productive agents when $\sigma > 1$) which equalize labor efforts and consumption. In other words, when the planner is not constrained to redistribute, information is unequivocally beneficial as the planner will use it to both increase production and equalize consumption. This is not the case in equilibrium because the market uses information in a way that increases production but prevents risk sharing; indeed, when the planner is constrained by the limitations imposed by the market there are situations in which she would prefer no-information (Proposition 7).

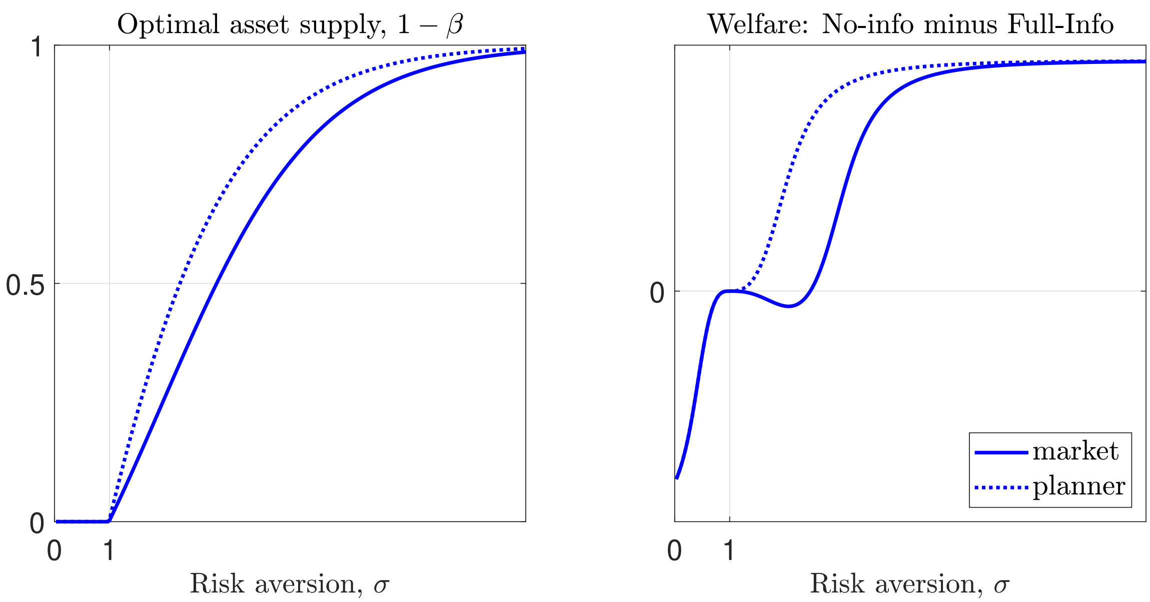
A note on an implementation by a government. With incomplete markets, a government could implement the planner's desired allocation by imposing taxes and subsidies that achieved zero-trade along with redistribution as per $\tau_i(\theta_i)$. Naturally, the feasibility of such transfers would critically depend on observability, pledgeability, and verifiability of raw capital productivity by the government. This result stresses once more an important assumption of the standard view that information is important for insurance to work properly by facilitating the fulfillment of contingent contracts.[13]

[13] Notice that the optimal set of taxes and subsidies (*public insurance*) eliminates the need of (*private insurance*), an extreme version of a rich literature that claims that public insurance may crowd out private insurance (such as Golosov and Tsyvinski (2007), Krueger and Perri (2011) and Park (2014)).

4.3 An Illustration: Market vs. Planner Allocations

In this section, we illustrate the difference between the market equilibrium and the constrained planner solutions with a numerical example. Being that the constrained planner and the market allocations coincide under full-information, the first panel of Figure 1 shows the origin of differences in the alternative benchmark: no public information. We plot how $1-\beta$ (the fraction traded) changes in both cases with the risk-aversion parameter σ. When $\sigma \leq 1$, both in equilibrium and in the planning solution there is no trade so $1-\beta=0$. When $\sigma > 1$, there is a strictly positive supply of raw capital (identical for all agents under no-information), increasing in risk-aversion and converging to trading all own raw capital as $\sigma \to \infty$. For all $\sigma > 1$, however, the planner (dashed line) would trade more than agents in equilibrium (solid line). With information (not plotted), there is never trade.

Figure 1: Information Social (Un)desirability



Note: We assume $\alpha = 0.66$, $\varphi = 1$ and $\gamma = 2.4$. For the sake of graphical clarity the axes display monotonic transformations of σ and $E[\mathbb{U}(E_i[\theta_i])]$. More precisely, on the x-axis $e^{2\sigma}-1$, whereas on the y-axis the arctang$(\cdot)$ of $(E[\mathbb{U}(E[\theta_i])] - E[\mathbb{U}(\theta_i)])/E[\mathbb{U}(\theta_i)]$.

The second panel of Figure 1 shows the welfare implications of this difference.

We plot the difference in welfare between no-information and full-information benchmarks for both the constrained planner and market outcomes. When $\sigma < 1$, these allocations coincide, and welfare under full-information is superior (the difference between no-information and full-information welfare is negative when $\sigma < 1$), as the productivity variance increases the level of consumption more than the variance of consumption. When $\sigma = 1$, both information benchmarks yield identical welfare outcomes as labor does not respond to information about capital productivity.

When $\sigma > 1$, the difference in the supply of raw capital from the first panel critically affects the desirability of information. For the planner, the desirability of information depends purely on parameters, as described in Proposition 7. In this particular example, we have assumed parameters such that the planner prefers market- to self-insurance for all $\sigma > 1$, thus welfare under no-information, which privilege market-insurance, is higher than welfare under full-information, which privilege self-insurance, i.e. the dashed line takes on strictly positive values. In equilibrium, however, agents inefficiently underprovide market-insurance. This deficiency is particularly egregious when risk-aversion is relatively low, so for these levels of σ full-information welfare is, in fact, higher than no-information welfare, hence the dip in the solid line. Information becomes socially undesirable in equilibrium (solid line becomes positive) once σ is large enough: in these cases, individuals preferentially value market-insurance, which are only able to use it effectively by engaging in robust trade in the absence of public information. Formally, this condition is expressed in Proposition 5, where it is made clear that the relative bite of this externality on welfare, as measured by χ, diminishes as σ increases.

5 Generalizing Results

Even though the previous results are mostly based on a set of standard functional-form assumptions in macroeconomics and finance, we have also resorted to specifications that enhanced tractability and expositional clarity. First, the production function of capital is special: exponential on intermediate capital, which implies that individuals are risk lovers on intermediate capital (even though being risk averse on consumption goods), when $\sigma < 1$. Second, the production function of intermediate goods is also special: linear in the productivity of raw capital.

An unattractive implication of combining these two features is that the unconditional distribution of capital is not mean invariant (expected capital production is not the same as the capital production of expected intermediate capital), that is

$$E[\hat{K}_i(\theta_i)] = e^{E[k_i]+\frac{1}{2}V(k_i)} \neq \hat{K}_i(E[\theta_i]) = e^{E[k_i]}\,.$$

This means that the expected capital available to produce consumption goods increases with the variance of intermediate capital and always exceeds the capital obtained by using the average amount of intermediate capital.

One may wonder to which extent our result about the social undesirability of free and perfect public information could be an artifact of these assumptions. In fact, it is the opposite. The exponential shape of capital production function implies that average production increases with variance, and as information induces more variance, information is more, not less, desirable. Intuitively, when public information is available prices are volatile. On the one hand, the uncertain amount of capital to produce generates utility losses from consumption uncertainty: the negative face of information. On the other hand, the uncertain amount of capital to produce generates and increase in expected consumption, and utility gains. This gain from intermediate capital variance is purely mechanical when compared to the more relevant conceptual gain of information that comes from correlating labor to productivity shocks: our positive face of information. Thus, our functional forms overestimate the social benefits of information.

Once we relax this mechanical effect of variance increasing expected capital production from our functional forms, we can show that *there is always a low enough adjustment cost φ under which free and perfect public information is socially undesirable*. We defer the formal proof of this result to Appendix B, but illustrate the pattern with a version of our model that employs an ad-hoc formulation of production functions which maintains the tractability of the exponential specification and makes expected capital production a function of only average intermediate capital (i.e. mean preserving production of capital).

5.1 A tractable setting with mean-preserving production

Let production of capital remain exponential on intermediate capital and the production of intermediate capital linear in raw capital, but adjusted such that the unconditional distribution of consumption goods is mean invariant. Formally, we modify (3) and assume instead that $\tilde{K}_i(\theta_i) \equiv e^{\tilde{k}_i}$ where

$$\tilde{k}_i = k_i - \frac{1}{2}V(k_i), \tag{27}$$

with k_i given by (15) and $V(k_i)$ by (18).

The additional term $-\frac{1}{2}V(k_i)$ corrects for the effect of a change in unconditional variance $V(k_i)$ via the unconditional mean $E[\tilde{k}_i] = E[k_i] - \frac{1}{2}V(k_i)$, so that $E[\tilde{K}_i(\theta_i)] = e^{E[k_i]} = \tilde{K}_i(E[\theta_i])$. This additional term is deterministic, because $V(E[k_i(\theta_i)]) = 0$, which makes extending previous results simple: only requiring a downward adjustment of the unconditional expectation by the (scaled) variance of intermediate capital. This term does depend on information however.

Take the no-information case. The variance of $\tilde{k}_i$ is the same as in the main text benchmark $V(\tilde{k}_i) = V(k_i) = \beta_i^2$ by equation (18). Nevertheless, its unconditional expectation is different,

$$E[\tilde{k}_i] = \bar{\theta} - \varphi(1-\beta_i)^2 + \frac{\varphi}{2}(1-\beta)^2 - \frac{1}{2}\beta_i^2,$$

which is smaller than the main text benchmark from equation (17) precisely because of the downward adjustment entailed by subtracting the variance. The ex-ante utility equation (16) for the no-information case still holds, but evaluated at the revised expectation and variance. The next Proposition, which combines a version of Propositions 2 (for the market) and 6 (for the planner), shows that this adjustment increases trading of raw capital compared to the main text environment.

Proposition 2' and 6' (Adjusted propositions 2 and 6 with mean-preserved production of capital). *With no-information, agent i's and planner's optimal supply of raw capital are, respectively, such that:*

$$\tilde{\beta}^*_{i,NI} = \frac{1}{1 - \frac{(1-\alpha)(1-\sigma)-1}{2\varphi}} < \beta^*_{i,NI} \qquad \textit{and} \qquad \tilde{\beta}^P_{i,NI} = \frac{1}{1 - \frac{(1-\alpha)(1-\sigma)-1}{\varphi}} < \beta^P_{i,NI} \qquad \forall\sigma.$$

Proof. Postponed to Appendix A.4. □

In words, when expected capital production is not increasing in intermediate capital variance, both the agents and the planner choose to sell raw capital more aggressively than in the main text benchmark. Importantly, in contrast to that benchmark, in which there is no trading for low values of risk aversion ($\sigma < 1$), here there is trading for all levels beyond risk neutrality ($\sigma > 0$). Hence, market-insurance becomes relatively more desirable when fluctuations in productivity don't have a built in expected production upside. This, naturally, makes a setting which negates the possibility of obtaining market-insurance even less socially desirable; so much, in fact, that when there is sufficient trade (as we shall see) even under $\sigma < 1$, it is possible for full-information to be the inferior benchmark.

So, consider the full-information case. The variance of $\tilde{k}_i$ is the same as in the main text, $V(\tilde{k}_i) = V(k_i) = 1$, while the unconditional expectation is equal to,

$$E[\tilde{k}_i] = \bar{\theta} - \varphi(1-\beta_i)^2 + \frac{\varphi}{2}(1-\beta)^2 - \frac{1}{2},$$

also smaller by the variance adjustment. Similarly, the ex-ante utility equation (20) for the full-information case continue to hold, but evaluated at these expectation and variance values. Since trading of raw capital does not reduce conditionally expected variance but working with the raw capital of others continues to have adjustment costs, there is no trading ($\tilde{\beta}^M_{i,FI} = \tilde{\beta}^P_{i,FI} = 1$); replicating the result of Proposition 3.

We can now compare the ex-ante utilities in the two information benchmarks under these alternative production specifications. Formally, the analogous version of Proposition 4 reads follows,

Proposition 4' (Adjusted proposition 4 with mean-preserving production of capital). *Ex-ante utility takes the following values:*

- *In the full-information benchmark*

$$\Phi E[\tilde{K}_i(\theta_i)^{\phi}] = \Phi \bar{K} E\left[e^{(1-\alpha)(1-\sigma)\theta_i}\right]^{\phi^2} R \tag{28}$$

- *In the no-information benchmark:*

$$\Phi E[\tilde{K}_i\left(\theta_i\right)]^{\phi} = \Phi \bar{K} E\left[e^{(1-\alpha)(1-\sigma)\theta_i}\right]^{\phi\tilde{\beta}^M} R^{\tilde{\beta}^M} \tag{29}$$

where $R = e^{-\frac{1}{2}(1-\alpha)(1-\sigma)\phi}$ *and*

$$\tilde{\beta}^M = \frac{1}{1-\tilde{\chi}\frac{(1-\alpha)(1-\sigma)-1}{\varphi}} < \beta^M \tag{30}$$

since

$$\tilde{\chi} = \frac{3\varphi + (1-\alpha)(\sigma-1)+1}{4\varphi + (1-\alpha)(\sigma-1)+1} \in (3/4, 1) \qquad \textit{and} \quad \tilde{\chi} > \chi \tag{31}$$

Proof. Postponed to Appendix A.4. □

Note that equations (28) and (29) differ from the corresponding ones in the previous setting (equations 21 and 22), in part, by the deterministic term R, which is greater than 1 for $\sigma > 1$ and smaller than one for $\sigma < 1$. Comparing equations (28) through (31) leads to a result, analogous to a combination of Propositions 5 and 7, that identifies a sufficient condition for the undesirability of public information.

Proposition 5' and 7' (Adjusted propositions 5 and 7 with mean-preserved production of capital). *When $\sigma > 1$, information is socially undesirable for a larger set of parameters than those implied by condition (25). When $\sigma < 1$, there is always a low enough transaction cost for which information is socially undesirable, with the sufficient condition,*

$$\varphi < \frac{\alpha(\gamma-1)}{1-\alpha}. \tag{32}$$

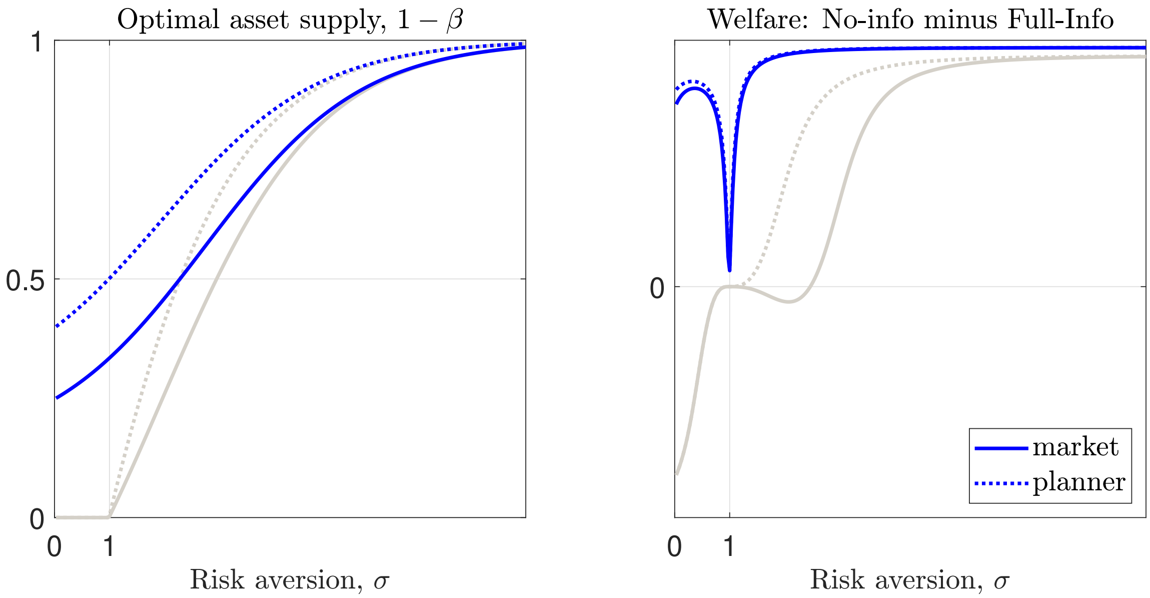
Proof. Postponed to Appendix A.5. □

This adjusted proposition establishes that with an exponential mean-preserving production of capital, information is less likely to be desirable for all σ. Take the case $\sigma > 1$, in which $\Phi < 0$ and public information is undesirable when equation (28) is greater than equation (29) in absolute value. In our baseline setting, the condition corresponding to (25) is simply given by $\phi > \beta^M$. When comparing equations (28) and (29), however, not only is $\tilde{\beta}^M < \beta^M$, but also $R^{\tilde{\beta}^M} < R$ (given that $R > 1$ when $\sigma > 1$), thus enlarging the set of parameters for which information is undesirable.

More interestingly, when $\sigma < 1$, and $\Phi > 0$, there is no trading in the baseline model and public information is undesirable when equation (28) is smaller than equation (29) in absolute value. With a mean-preserving adjustment, there are two countervailing effects. On the one hand, $\tilde{\beta}^M < 1$, which increases the gains of information. On the other hand, $R^{\tilde{\beta}^M} > R$ given that $R < 1$ when $\sigma < 1$, which reduces the gains of information. We show that, while the first effect is bounded, the second effect dominates when φ is low enough. To see this, notice that equation (28) is smaller than $\Phi\bar{K}$, as $E\left[e^{(1-\alpha)(1-\sigma)\theta_i}\right]^{\phi^2} R = R^{[1-(1-\alpha)(1-\sigma)\phi]} < 1$, (since $1 > (1-\alpha)(1-\sigma)\phi$ and $R < 1$). While equation (28) does not depend on φ, equation (29) does: as $\varphi \to 0$, $\tilde{\beta}^*_{i,NI} \to 0$ so agents choose to trade all raw capital and $\tilde{\beta}^M \to 0$. In the limit then, equation (29) is $\Phi\bar{K}$ and greater than equation (28) for φ small.

We summarize these findings graphically in Figure 2 using the same parameters as in Figure 1, but under exponential mean-preserving production of capital. We report in light gray the corresponding curves of Figure 1 so that it is easy to contrast the two cases. In the first panel, as Proposition 2' and 6' states, the supply of raw capital is higher both for the market and for the planner under the current production technology (blue lines); being also positive in the range $\sigma < 1$. The second panel displays the welfare consequences, illustrating that, as stated in Proposition 5' and 7' and consistent with condition (32), (i) for all σ, public information is always socially inferior (blue lines taking on strictly positive values) and (ii) since $\tilde{\chi} > \chi$, the strength of externalities that generate a gap between planner and market outcomes is smaller.

Figure 2: Information Social (Un)desirability: mean-preserving production



Note: We assume $\alpha = 0.66$, $\varphi = 1$ and $\gamma = 2.4$. For the sake of graphical clarity the axes display monotonic transformations of σ and $E[\mathbb{U}(E_i[\theta_i])]$. More precisely, on the x-axis $e^{2\sigma} - 1$, whereas on the y-axis the arctang$(\cdot)$ of $(E[\mathbb{U}(E[\theta_i])] - E[\mathbb{U}(\theta_i)])/E[\mathbb{U}(\theta_i)]$.

6 Final remarks

What is the social value of public, costless, and perfect information about agents' idiosyncratic shocks? An immediate intuition suggests that such information is always socially desirable. We show that in an economy with restrictions for individuals to share risks, the role of information is more nuanced. It has a positive face, by permitting self-insurance, as it improves how agents reallocate their resources (labor, for instance) to face idiosyncratic shocks that affect their consumption. It also has a negative face however, by constraining market-insurance, as it weakens how agents can trade resources (selling volatile assets and buying safe ones) to reduce their exposure to idiosyncratic shocks. We show that this trade off between ex-post optimal labor allocation and ex-ante creation of safe assets makes public information socially desirable only if welfare reacts more to self-insurance than to market-insurance.

When is self-insurance superior? This is the case when consumption depends heavily on resources that can be cheaply adjusted upon idiosyncratic shocks. When is market-insurance superior? This is the case when consumption is heavily exposed to idiosyncratic shocks that can be hedged by buying safe assets that can be cheaply originated and traded. While information is always desirable in the presence of insurance markets, it may be undesirable in their absence, as it improves one insurance alternative at the expense of the other.

This insight shows that a reduction in the cost of originating and trading safe assets should (optimally) be accompanied with steps that discourage the availability of information about idiosyncratic shocks. This is in stark contrast with the information disclosure implication that arises when insurance markets are complete, in which case it would be better to encourage information if it is free, public, and perfect. The application of this insight is relevant, for instance, in the discussion about the design of financial regulations, or the disclosure of information about lending programs.

The trade-off we explore in general equilibrium can also be applied in partial equilibrium to inform recent regulatory reforms. Take the case of banking stress tests, for instance. When regulators reveal to a bank results about stress scenarios, they reveal pieces of information (mostly about sources of systemic risk) that are useful for the bank to rebalance its own portfolio (the positive face of improving self-insurance). Those pieces of information, however, also become available to other banks, who may revise their own beliefs about the bank's individual portfolio and its market valuation, introducing additional volatility and inhibiting the functioning of interbank markets (the negative face of weakening market-insurance). This trade-off is critical in designing information disclosure of stress tests once regulators weight the relevance of portfolio rebalancing vs. interbank market operations.

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A Proofs

A.1 Proof of Proposition 1 and Corollary 1

Proof. Our first step is deriving the first order condition relative to asset demand in the two information benchmarks. By the discussion preceding Lemma 2, for a given $\beta_i \in (0,1)$, the first order conditions relative to $\beta_h(i)$ are:

- In the full-information benchmark $E_h[K_h(\beta_h(i))] = K_h(\beta_h(i))$, agent h maximizes $\mathbb{U}(K_h(\beta_h(i))) = \Phi K_h(\beta_h(i))^\phi$ choosing $\beta_h(i)$ such that, for all i,

  $\Phi\phi(1-\alpha)(1-\sigma)\frac{\partial \int_{H(h)} \Pi_h(i)di}{\partial \beta_h(i)} e^{\phi k_h} = 0.$

- In the no-information benchmark $E_h[K_h(\beta_h(i))] = E[K_h(\beta_h(i))]$, agent h maximizes $\mathbb{U}(E[K_h(\beta_h(i))]) = \Phi E[K_h(\beta_h(i))]^\phi$ choosing $\beta_h(i)$ such that, for all i,

  $\Phi\phi\left((1-\alpha)(1-\sigma)\frac{\partial E[\int \Pi_h(i)di]}{\partial \beta_h(i)} + \frac{1}{2}(1-\alpha)^2(1-\sigma)^2\frac{\partial V(\int \Pi_h(i)di)}{\partial \beta_h(i)}\right) e^{\phi E[k_h] + \frac{\phi}{2}V(k_h)} = 0$

Since portfolio returns enter exponentially in the utility function, constant absolute risk aversion obtains, and the optimal individual asset demand is invariant in the expected value of the rest of the portfolio (total amount of intermediate capital) - as in standard CARA asset pricing models.

In what follows we solve for the profit-maximizing demand of raw capital and then show that it is also the utility-maximizing demand of raw capital satisfying the first order conditions above. Suppose instead agent h chooses the quantity $\beta_h(i)$ of raw capital to demand from agent i to maximize her expected profits (which are given by agent h's version of equation (33)); then, an interior $\beta_h(i)$ demand (required by $\beta_i \in (0,1)$ and agent homogeneity) must satisfy,

$$\frac{\partial E_h[\Pi_h(i)]}{\partial \beta_h(i)} = \frac{\partial E_h\left[\left(\bar{\theta} + \theta_i\right)\beta_h(i) - \frac{\varphi}{2}\beta_h^2(i) - R_i\beta_h(i)\right]}{\partial \beta_h(i)} = 0 \quad (33)$$

$$\implies \quad \beta_h^*(i) = \frac{\bar{\theta} + E_h[\theta_i] - R_i}{\varphi}$$

Since the supply of agent i's raw capital is $1-\beta_i$, market clearing implies,

$$\int_{H(i)} \beta_h^*(i)dh = 1 - \beta_i,$$

and the equilibrium price in the market of agent i's raw capital would be

$$R_i = \bar{\theta} + E_h[\theta_i] - \varphi(1 - \beta_i), \tag{34}$$

where agents have identical information under both benchmarks so $E_h[\theta_i]$ is the same for all h.

The actual profit of agent h as a buyer of agent i's raw capital can then be rewritten as

$$\Pi_h(i) = (\theta_i - E_h[\theta_i])(1 - \beta_i) + \frac{\varphi}{2}(1 - \beta_i)^2.$$

Under full-information, $E_h[\theta_i] = \theta_i$; meanwhile, under no-information, $E_h[\theta_i] = E[\theta_i] = 0$ and by a law of large numbers with a continuum of iid random variables $\int_{(0,1)} \theta_i di = 0$ almost surely.[14] As such, aggregate portfolio profits,

$$\int_{H(i)} \Pi_h(i) di = \frac{\varphi}{2} \int_{H(i)} (1 - \beta_i)^2 di$$

are deterministic, agents attain perfect diversification, and (since this quantity is strictly positive) agent's total demand for raw capital can be "self-financed".

Now, we prove the conjecture that profit-maximizing demand is the same as utility-maximizing demand. Since portfolio profits are deterministic, $V\left(\int_{H(i)} \Pi_h(i) di\right) = 0$ and,

$$\frac{\partial V(\int_{H(i)} \Pi_h(i) di)}{\partial \beta_h(i)} = 2E\left[\frac{\partial \Pi_h(i)}{\partial \beta_h(i)} \left(\int_{H(i)} \Pi_h(i) di - E\left[\int_{H(i)} \Pi_h(i) di\right]\right)\right] = 0$$

which shows, jointly with (33), that $\beta_h^*(i)$ also satisfies utility-maximizing first-order conditions.

Finally, the expression for the quantity of intermediate capital available to agents at the end of the period (15), as stated in the Corollary 1, comes from substituting the price received from selling raw capital (equation (34)) and the profits from buying raw capital (equation (14)) into (10). □

[14] Sun, Yeneng and Yongchao Zhang (2009), "Individual risk and Lebesgue extension without aggregate uncertainty", *Journal of Economic Theory* 144, 432-443.

A.2 Proof of Proposition 4

In the full-information benchmark, there is never trade so $\beta^*_{i,FI} = 1$ for all i from Proposition 3. Further, given that $V(k_i) = 1$, according to (20) we have,

$$\begin{aligned}
\Phi E[K_i(\theta_i)^\phi] &= \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi\bar{\theta}+\frac{1}{2}((1-\alpha)(1-\sigma))^2\phi^2} = \\
&= \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi\bar{\theta}} E\big[e^{(1-\alpha)(1-\sigma)\theta_i}\big]^{\phi^2}
\end{aligned}$$

In the no-information benchmark, trade is possible, as characterized by $\beta^*_{i,NI}$ in proposition 2. In this case, $V(k_i) = \beta^{*,2}_{i,NI}$ so (16), (17), and the fact that $\beta^*_{i,NI}$ is identical for all i imply,

$$\begin{aligned}
\Phi E[K_i(\theta_i)]^\phi &= \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi\left(\bar{\theta}-\frac{\varphi}{2}(1-\beta^{*,2}_{i,NI})^2\right)+\frac{1}{2}((1-\alpha)(1-\sigma))^2\phi\beta^{*,2}_{i,NI}} = \\
&= \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi\bar{\theta}} e^{\frac{1}{2}(1-\alpha)^2(1-\sigma)^2\phi\left(\beta^{*,2}_{i,NI}-\frac{\varphi}{(1-\alpha)(1-\sigma)}(1-\beta^{*,2}_{i,NI})^2\right)} \\
&= \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi\bar{\theta}} E\big[e^{(1-\alpha)(1-\sigma)\theta_i}\big]^{\phi\left(\beta^{*,2}_{i,NI}-\frac{\varphi}{(1-\alpha)(1-\sigma)}(1-\beta^{*,2}_{i,NI})^2\right)}
\end{aligned}$$

where we define

$$\beta^M \equiv \beta^{*,2}_{i,NI} - \frac{\varphi}{(1-\alpha)(1-\sigma)}(1-\beta^*_{i,NI})^2 = \frac{1}{1-\frac{3\varphi+(1-\alpha)(\sigma-1)}{4\varphi+(1-\alpha)(\sigma-1)}\frac{1-\alpha}{\varphi}(1-\sigma)}$$

A.3 Proof of Proposition 8

Proof. Substituting for $E[\mathbb{U}(K_i(\theta_i))]$ with (20), we can rewrite the problem as,

$$max_{\{\hat{\beta}_i(h),\tau_i\}_{(i,h)\in(0,1)^2}} \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi E[k_i]+\frac{1}{2}((1-\alpha)(1-\sigma)\phi)^2 V(k_i)} \tag{35}$$

where

$$k_i = \bar{\theta} + \beta_i\theta_i - \tau_i + \int_{H(i)} \beta_i(h)\theta_h\, dh - \int_{H(i)} \frac{\varphi}{2}\beta_i^2(h)\, dh\,,$$

subject to the resource and balance-budget constraints,

$$1-\beta_i = \int_{H(i)} \beta_h(i)dh$$

$$0 = \int \tau_i di$$

The first observation is that necessarily in any equilibrium $1-\beta_i = \beta_h(i) = \beta_j(i)$ for any $h, j \in H(i)$. If this condition were violated, let us say $\beta_h(i) < \beta_j(i)$, the planner could save on quadratic costs without loosing on expected production by moving raw capital type i from agent j to agent h. The result of this observation is that by a law of large numbers result, as in the proof of Proposition 1, and using the constraints,

$$\begin{aligned} E[k_i] &= \bar{\theta} + \int \beta_i \theta_i \, di - \int \tau_i di - \int \int_{H(i)} (1-\beta_h)\theta_h \, dh \, di - \frac{\varphi}{2} \int \int_{H(i)} (1-\beta_h)^2 \, dh \, di \\ &= \bar{\theta} - \frac{\varphi}{2} \int (1-\beta_i)^2 \, di \, , \\ V(k_i) &= \int \left(\beta_i \theta_i - \tau_i - \int \beta_i \theta_i \, di \right)^2 di. \end{aligned}$$

where we used $E[\theta_i] = \int \theta_i di = 0$ and,

$$\int_{H(i)} (1-\beta_h)\theta_h \, dh = \int (1-\beta_h)\theta_h \, dh \quad \text{and} \quad \int_{H(i)} (1-\beta_h)^2 \, dh = \int (1-\beta_h)^2 \, dh$$

As such,

$$\begin{aligned} \frac{\partial E[k_i]}{\partial \beta_i} &= \varphi(1-\beta_i) \\ \frac{\partial V(k_i)}{\partial \beta_i} &= 2\theta_i \left(\beta_i \theta_i - \tau_i - \int \beta_i \theta_i \, di \right) \\ \frac{\partial V(k_i)}{\partial \tau_i} &= 2 \left(\beta_i \theta_i - \tau_i - \int \beta_i \theta_i \, di \right) \end{aligned}$$

all of which are equal to zero at $\beta_i = 1, \tau_i = -\theta_i$ and therefore imply that all the necessary first order conditions of problem (35) (factoring in the constraints) for optimality are also satisfied. □

A.4 Proof of Propositions 2', 6', and 4'

Ex-ante utility in the no-information benchmark is given by

$$\Phi E[\tilde{K}_i(\theta_i)]^\phi = \Phi \alpha e^{(1-\alpha)(1-\sigma)\phi\left(\bar{\theta} - \varphi(1-\beta_i)^2 + \frac{\varphi}{2}(1-\beta)^2 - \frac{1}{2}\beta_i^2\right) + \frac{1}{2}((1-\alpha)(1-\sigma))^2 \phi \beta_i^2}.$$

The optimal individual supply of raw capital is given by the first order condition

$$\frac{\partial \left((1-\alpha)(1-\sigma)\phi \left(-\varphi(1-\beta_i)^2 + \frac{\varphi}{2}(1-\beta)^2 - \frac{1}{2}\beta_i^2 \right) + \frac{1}{2}\left((1-\alpha)(1-\sigma)\right)^2 \phi \beta_i^2 \right)}{\partial \beta_i} = 0$$

which yields:

$$\tilde{\beta}^{*}=\frac{1}{1-\frac{(1-\alpha)(1-\sigma)-1}{2\varphi}}$$

By evaluating $\Phi E[\tilde{K}_i\left(\theta_i\right)]^{\phi}$ at this expression, we get

$$\begin{aligned}\Phi E[\tilde{K}_i\left(\theta_i\right)]^{\phi} &= \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi\bar{\theta}}e^{\frac{1}{2}\phi(1-\alpha)(1-\sigma)((1-\alpha)(1-\sigma)-1)\tilde{\beta}^{M}} \\ \Phi E[\tilde{K}_i\left(\theta_i\right)]^{\phi} &= \Phi\bar{K}\left[e^{(1-\alpha)(1-\sigma)\theta_i}\right]^{\phi\tilde{\beta}^{M}}e^{-\frac{1}{2}(1-\alpha)(1-\sigma)\phi\tilde{\beta}^{M}}\end{aligned}$$

where

$$\tilde{\beta}^{M}=\frac{1}{1-\tilde{\chi}\frac{(1-\alpha)(1-\sigma)-1}{\varphi}}$$

with

$$\tilde{\chi}=\frac{3\varphi+(1-\alpha)(\sigma-1)+1}{4\varphi+(1-\alpha)(\sigma-1)+1}$$

and $\frac{3}{4}<\tilde{\chi}<1$.

The planner's optimal supply of raw capital is given by the first order condition

$$\frac{\partial\left((1-\alpha)(1-\sigma)\phi\left(-\varphi(1-\beta)^2+\frac{\varphi}{2}(1-\beta)^2-\frac{1}{2}\beta^2\right)+\frac{1}{2}\left(\left((1-\alpha)(1-\sigma)\right)^2\phi\beta^2\right)\right)}{\partial\beta}=0$$

which yields

$$\tilde{\beta}^{P}=\frac{1}{1-\frac{(1-\alpha)(1-\sigma)-1}{\varphi}}.$$

By evaluating $\Phi E[\tilde{K}_i\left(\theta_i\right)]^{\phi}$ at this expression, we get

$$\begin{aligned}\Phi E[\tilde{K}_i\left(\theta_i\right)]^{\phi} &= \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi\bar{\theta}}e^{\frac{1}{2}\phi(1-\alpha)(1-\sigma)((1-\alpha)(1-\sigma)-1)\frac{1}{1-\frac{(1-\alpha)(1-\sigma)-1}{\varphi}}} \\ \Phi E[\tilde{K}_i\left(\theta_i\right)]^{\phi} &= \Phi\bar{K}\left[e^{(1-\alpha)(1-\sigma)\theta_i}\right]^{\phi\tilde{\beta}^{P}}e^{-\frac{1}{2}(1-\alpha)(1-\sigma)\phi\tilde{\beta}^{P}}\end{aligned}$$

Ex-ante utility in the full-information benchmark is given by

$$\Phi E[\tilde{K}_i\left(\theta_i\right)^{\phi}]=\Phi\alpha e^{(1-\alpha)(1-\sigma)\phi\left(\bar{\theta}-\varphi(1-\beta)^2+\frac{\varphi}{2}(1-\beta)^2-\frac{1}{2}\right)+\frac{1}{2}((1-\alpha)(1-\sigma))^2\phi^2}$$

Both individual and planner optimal supply of raw capital gives a corner solution with no trading, (this is $\beta=1$), so that

$$\begin{aligned}\Phi E[\tilde{K}_i\left(\theta_i\right)^{\phi}] &= \Phi\alpha e^{(1-\alpha)(1-\sigma)\phi\left(\bar{\theta}-\frac{1}{2}\right)+\frac{1}{2}((1-\alpha)(1-\sigma))^2\phi^2} \\ \Phi E[\tilde{K}_i\left(\theta_i\right)^{\phi}] &= \Phi\bar{K}\left[e^{(1-\alpha)(1-\sigma)\theta_i}\right]^{\phi^2}e^{-\frac{1}{2}(1-\alpha)(1-\sigma)\phi}\end{aligned}$$

A.5 Proof of Proposition 5' and 7'

Compare the expressions in Proposition 4'. First, consider the case $\sigma > 1$ (so that $\Phi < 0$). Ex-ante utility under no-information is greater than under full-information in the market and constrained planner solutions respectively, if and only if,

$$(1-\alpha)(1-\sigma)((1-\alpha)(1-\sigma)\phi - 1)\phi > \phi(1-\alpha)(1-\sigma)((1-\alpha)(1-\sigma)-1)\tilde{\beta}^A$$

with $A \in \{M, P\}$ depending on comparing market allocations or planner solutions. This inequality becomes

$$(1-\alpha)(1-\sigma)\phi - 1 \quad < \quad ((1-\alpha)(1-\sigma)-1)\tilde{\beta}^A$$

and so,

$$\phi \quad > \quad \tilde{\beta}^A + \frac{1}{(1-\alpha)(1-\sigma)}\left(1-\tilde{\beta}^A\right).$$

To see that this condition necessarily holds whenever (25) holds, it is sufficient to observe that $\tilde{\beta}^A < \beta^A$, but also that the extra term $(1-\tilde{\beta}^A_{i,NI})/(1-\alpha)(1-\sigma)$ is negative.

Consider now the other case, $\sigma < 1$ (so that $\Phi > 0$ and $\phi > 1$). Then, no-information ex-ante utility is greater if and only if,

$$(1-\alpha)(1-\sigma)((1-\alpha)(1-\sigma)\phi - 1)\phi < \phi(1-\alpha)(1-\sigma)((1-\alpha)(1-\sigma)-1)\tilde{\beta}^A$$

with $A \in \{M, P\}$. This inequality becomes

$$(1-\alpha)(1-\sigma)\phi - 1 \quad < \quad ((1-\alpha)(1-\sigma)-1)\tilde{\beta}^A$$

and so,

$$\phi \quad < \quad \tilde{\beta}^A + \frac{1}{(1-\alpha)(1-\sigma)}\left(1-\tilde{\beta}^A\right).$$

given that $\phi > 1$ and $\tilde{\beta}^A < 1$, there exists a sufficiently high σ such that the inequality holds. Furthermore note that,

$$\frac{\partial\left(\tilde{\beta}^M + \frac{1}{(1-\alpha)(1-\sigma)}\left(1-\tilde{\beta}^M\right)\right)}{\partial\sigma} =$$

$$\frac{\chi}{(1-\alpha)(\sigma-1)^2}\frac{\alpha+\sigma-\alpha\sigma}{(\varphi+\alpha\chi+\sigma\chi-\alpha\sigma\chi)^2}(2\varphi-\alpha\varphi-\sigma\varphi+\alpha\sigma+\varphi\alpha\chi+\sigma\chi-\alpha\sigma\chi) > 0$$

meaning that the right-hand side of the inequality is always satisfied for $\sigma = 0$. Evaluating the inequality at $\sigma = 0$ for the case $A = M$ we get,

$$\frac{1}{1-\frac{\alpha}{\gamma}} \;<\; \frac{1}{1+\frac{\alpha}{\tilde{\chi}^{-1}\varphi}} + \frac{1}{1-\alpha}\frac{\frac{\alpha}{\tilde{\chi}^{-1}\varphi}}{1+\frac{\alpha}{\tilde{\chi}^{-1}\varphi}},$$

that is, any value of φ satisfying,

$$\varphi \;<\; \chi\,(\gamma-1)\,\frac{\alpha}{1-\alpha}.$$

also satisfies the inequality for any σ.

B General results for given supply choice

In this section we discuss the robustness of our results by evaluating how the value of information changes with an exogenous supply $1-\beta$ of raw capital. Intuitively, for a given β, the benefit of information comes from setting contingent labor supply (proportional to β), while the cost is inducing a higher volatility of capital (proportional to $1-\beta$): when β is low the cost dominates, whereas when β is high the opposite occurs. The following proposition establishes that our intuition generally holds true for the generic class of mean preserving production functions (even if not-exponential).

Proposition 9. *Given a generic $\tilde{K}_i(\cdot)$ production function such that,*

1. *information increases ex-ante uncertainty of labor productivity, i.e. for any $\beta_i = \beta \in (0,1)$,*
$$V(\tilde{K}_i(\beta\theta_i)) < V(\tilde{K}_i(\theta_i)) \tag{36}$$
2. *the unconditional median coincides with the unconditional mean,*
$$E[\tilde{K}_i(\theta_i)] = \tilde{K}_i(E[\theta_i])\,, \tag{37}$$
which implies $E[\tilde{K}_i(\theta_i)] = E[\tilde{K}_i(\beta\theta_i)]$.

Then, in the limit of $\varphi \to 0$ for which $\lim_{\varphi\to 0}\beta^A_{i,NI} = 0$ information is always inferior to no-information.

Proof. We repeat the logic of lemma 2 for $\beta_i \in [0,1]$ and the new production function. In the benchmark case of complete information, i.e. when $E_i[\tilde{K}_i(\theta_i)^{(1-\sigma)(1-\alpha)}] = \tilde{K}_i(\theta_i)^{(1-\sigma)(1-\alpha)}$, we get that

$$E[\mathbb{U}(\tilde{K}_i(\theta_i)^{(1-\sigma)(1-\alpha)})] = \Phi E[\tilde{K}_i(\theta_i)^{(1-\alpha)(1-\sigma)\phi}]$$

whereas in the extreme case of no-information, i.e. when $E_i[\tilde{K}_i(\beta_i\theta_i)^{(1-\sigma)(1-\alpha)}] = E[\tilde{K}_i(\beta_i\theta_i)^{(1-\sigma)(1-\alpha)}]$, we have instead

$$\mathbb{U}(E[\tilde{K}_i(\beta_i\theta_i)^{(1-\sigma)(1-\alpha)}]) = \Phi E[\tilde{K}_i(\beta_i\theta_i)^{(1-\sigma)(1-\alpha)}]^{\phi},$$

where $\Phi > 0$ and $\phi > 1$ if and only if $\sigma < 1$.

Now we can study the role of information in the limiting supply of raw capital.

- The limit at $\beta = 1$: With $\sigma > 1$ we have $\Phi < 0$ and $\phi < 1$. Because of Jensen:

  $$\lim_{\beta\to 1} E[\tilde{K}_i(\beta\theta_i)^{(1-\sigma)(1-\alpha)}]^{\phi} = E[\tilde{K}_i(\theta_i)^{(1-\sigma)(1-\alpha)}]^{\phi} > E[\tilde{K}_i(\theta_i)^{(1-\sigma)(1-\alpha)\phi}],$$

  with $\sigma < 1$ we have $\Phi > 0$ and $\phi > 1$ and because of Jensen:

  $$\lim_{\beta\to 1} E[\tilde{K}_i(\beta\theta_i)^{(1-\sigma)(1-\alpha)}]^{\phi} = E[\tilde{K}_i(\theta_i)^{(1-\sigma)(1-\alpha)}]^{\phi} < E[\tilde{K}_i(\theta_i)^{(1-\sigma)(1-\alpha)\phi}],$$

  Then information is preferred.

- The limit at $\beta = 0$: As the variance of $\tilde{K}_i(\beta_i\theta_i)^{(1-\alpha)(1-\sigma)}$ is degenerate, then

  $$E[\tilde{K}_i(\beta_i\theta_i)^{(1-\sigma)(1-\alpha)}]^{\phi} = \tilde{K}_i(E[\theta_i])^{(1-\sigma)(1-\alpha)\phi}.$$

  With $\sigma < 1$, we have with $(1-\sigma)(1-\alpha)\phi \in (0,1)$ since

  $$\sigma > 0 > -\frac{\alpha(\gamma-1)}{\gamma(1-\alpha)+\alpha},$$

  and because of Jensen's inequality,

  $$\tilde{K}_i(E[\theta_i])^{(1-\sigma)(1-\alpha)\phi} > E[\tilde{K}_i(\theta_i)^{(1-\sigma)(1-\alpha)\phi}],$$

  that is, no-information is preferred as $\Phi > 0$.

  With $\sigma > 1$, we have with $(1-\sigma)(1-\alpha)\phi < 0$, in which case, due to Jensen's inequality once again,

  $$\tilde{K}_i(E[\theta_i])^{(1-\sigma)(1-\alpha)\phi} < E[\tilde{K}_i(\theta_i)^{(1-\sigma)(1-\alpha)\phi}],$$

  that is, no-information is preferred as $\Phi < 0$.

□

This proposition shows that, under the generic requirement of a mean preserving production function, there is always a sufficiently low β for which no-information is socially preferred, since for the same expected production agents can completely eliminate any production risk.