Public information and strategic interaction of policymakers

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Abstract

The social value of public information has been already well defined. Nevertheless, in existing studies this information always comes from a unique source. This assumption, undoubtedly, represents a huge simplification of the real information structure, when all the agents have an access to a number of public signals of different origins. The primary goal of our research is to investigate the information interaction of policymakers who have different objectives and can use public signals to influence private agents. For this purpose we built a model of two-region economy that is hit by two idiosyncratic shocks. Information structure is defined by two policymakers each of which maximizes welfare of one of the regions. First of all we found out that strategic complementarity at the level of private agents creates an additional strategic incentive for policymakers. Their goal is not only to assure that the private actions in their region fit economic fundamentals but also to achieve their superiority over foreigners. As a result, equilibrium information strategies are not effective from the social planner point of view: the head of a small region tends to be too transparent while the policymaker from the big region may be too opaque. Moreover, we showed that characteristics of social optimum in our model differ significantly from the standard for this literature field: transparency may be detrimental only if strategic complementarity is low, not high.

JEL: D82, E61, F42

1 Introduction

The influence that public information has on economic outcomes has been well studied. The paper that initiated a rapid development of this literature field was Morris and Shin (2002). They showed that more precise public signals may be detrimental for social welfare if there is a high strategic complementarity in private actions and if the quality of information available to policymaker is rather poor. Since then many authors confirmed this result (like James and Lawler (2011), Myatt and Wallace (2008) and Walsh (2013)) while a number of others did not (Svensson (2006), Angeletos and Pavan (2004) or Hellwig (2005)). It is worth to note that only few papers distinguish between socially optimal information policy and the real choice of

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signal precision by policymakers. For example, Hahn (2014) shows that an information policy of central bank can conflict with social interests.

Different studies make various assumptions about the public information structure. While some of them suppose that there is only one public signal (for example, Morris and Shin (2002) and James and Lawler (2011)), the others assume heterogeneity of public information. For example, Morris and Shin (2007) study a number of semi-public signals that are available to a certain part of population. Similar approaches are used in Myatt and Wallace (2008) and Cornand and Heinemann (2008). Nevertheless, to our knowledge, all this literature is based on the assumption of unique source of public information. But in reality agents have an access to a number of public signals that come from different sources. Moreover signal senders can differ by their goals. For example, policymakers from different parties or countries tend do have different objectives and their strategies in publishing information should be different.

The aim of this paper is relaxing this "one sender" assumption and establishing a framework for analysis of information interaction between different policymakers. Our model is based on Morris and Shin (2002). Contrary to their framework and similar to Angeletos and Pavan (2009) we assume that prior beliefs about economic fundamental are informative, because the variance of economic shocks is finite. Moreover, similar to several studies (for example, Angeletos and Pavan (2009)) we assume that agents are hit by idiosyncratic shocks. For simplicity we assume that there are two uncorrelated shocks each of which influences only a part of population. Contrary to previous studies in our model there are two policymakers associated with two different groups of agents. They can be considered as heads of two different regions or two lobbyists from different sectors. These policymakers can publish signals about shocks that are significant to their regions.

The paper is organized as follows. The model is presented in the next Section. Section 3 computes an equilibrium for given information policies while Section 4 determines the properties of socially optimal informational design. Section 5 compares the choice of policymakers to the social optimum. Section 6 concludes.

2 Model

Consider that population of an economy is divided between two regions: agents with index $i \in [0, n]$ belong to the first group, while agents with $i \in (n, 1]$ live in the second region. When convenient we will use notions $n_1 = n$ and $n_2 = 1 - n$ to define sizes of the regions. Regions are hit by idiosyncratic shocks θ_1 and θ_2 correspondingly. For simplicity we assume that these shocks are independently and normally distributed with zero mean and variance $\frac{1}{\varphi_j}$ $(j = \{1, 2\})$.

A private agent i chooses an action a_i in order to minimize his losses l_i. Losses of the agent are defined by the distance between his action and value of corresponding economic shock and by the distance between his own performance and the performance of all other private players:

$$l_i = (1-r)(a_i - \theta_j)^2 + r(L_i - \bar{L}) \ , \tag{1}$$

where $j = 1 \ \forall i \in [0,n]$ and $j = 2 \ \forall i \in (n,1]$. Parameter $r \in [0,1]$ characterizes an extent of strategic complementarity in private actions, $L_i = \int\limits_0^1 (a_k - a_i)^2 dk$ stands for the losses arisen due to strategic complementarity and $\bar{L} = \int_0^1 L_k dk$ is an average strategic loss. When there is no strategic complementarity ($r = 0$) the only goal of a private agent is to follow a fundamental economic variable θ_j. To the contrary when $r = 1$ private agent does not worry about economic shock itself. Then the only incentive is "to do as others do". For intermediate values for strategic complementarity an agent has to balance both objectives.

For example, losses (1) may represent an objective function of one of monopolistically competitive firms. These firms have a strategic incentive to mimic the behavior of others: when an average price goes down, a firm also has to lower its price in order to be competitive. In addition to this strategic goal the firm has to take into account fundamental economic factors of its home region. These factors can differ from economic conditions abroad due to different tax policies, trade unions behavior or, for example, specific weather phenomena or whatever. So, an optimal action of agent i is a weighted sum of expected values of the relevant economic shock and of average private actions in the whole economy $E_i(\bar{a})$:

$$a_i = (1-r)E_i(\theta_j) + rE_i(\bar{a}) \tag{2}$$

Each private agent observes one private signal about the true value of the home economic shock $x_i = \theta_j + \varepsilon_i$, where $\varepsilon_i \sim i.i.d.N(0, \frac{1}{\beta})$ is the noise of this signal and β stands for its precision. We suppose that agents have no private information about the shocks that affect another region. In addition to their private information all agents observe two public signals.

We assume that P_j, $j \in \{1,2\}$ is a policymaker who tries to maximize welfare of the region j ($j \in \{1,2\}$). P_j receives a noisy signal y_j about the economic shock θ_j: $y_j = \theta_j + \eta_j$, where $\eta_j \sim N(0, \frac{1}{\alpha_j})$ and α_j is precision of this signal. The signal can be resent by policymaker to other agents with (probably) some additional noise. Public signal s_j sent by P_j equals to the sum of received signal y_j and additional noise $v_j \sim N(0, \frac{1}{\gamma_j})$: $s_j = y_j + v_j = \theta_j + \eta_j + v_j$. By choosing different values of additional noise, γ_j, policymaker can influence precision of his public signal: $\mu_j = \frac{1}{Var(\eta_j + v_j)} = \frac{\alpha_j \gamma_j}{\alpha_j + \gamma_j} \in [0, \alpha_j]$. When the policymaker is transparent and does not add any noise at all ($\gamma_j \to \infty$), precision of the signal sent coincides with precision of the signal received by the policymaker: $\mu_j = \alpha_j$. When the policymaker is opaque ($\gamma_j \to 0$) the precision of his signal goes to zero. This means that policymaker does not disclose any information at all.

Policymaker P_j chooses precision of his signal that minimizes average losses of agents that belong to his region. These losses, L_j^P, are defined by an average distance between actions of private agents who belong to j and economic shock θ_j and by relative performance of this group in comparison to the whole economy:

$$L_1^P \equiv \int_0^n l_i\,di = (1-r)\int_0^n (a_i-\theta_1)^2 di + r(\overline{L}_1 - n\overline{L}) \tag{3}$$

$$L_2^P \equiv \int_n^1 l_i\,di = (1-r)\int_n^1 (a_i-\theta_2)^2 di + r(\overline{L}_2 - (1-n)\overline{L}) \tag{4}$$

where $\overline{L}_1 = \int_0^n L_i di$ and $\overline{L}_2 = \int_n^1 L_i di$. As we can see from (3-4) the policy is driven by two incentives. First of all the policymaker is interested to guide his region as close to home economic shock as possible. Then there is also strategic complementarity at the level of policymakers: each policymaker wants his group of population to perform relatively well. However social welfare is free from any strategic complementarity effect. Average private losses all over economy are defined only by the difference between private actions and corresponding economic fundamentals:

$$L_W \equiv \int_0^1 l_i(a,\theta)di = (1-r)\int_0^n (a_i-\theta_1)^2 di + (1-r)\int_n^1 (a_i-\theta_2)^2 di \tag{5}$$

As social losses (5) differ from policymakers objective functions (3) and (4) we expect that equilibrium may be ineffective in comparison to the social optimum. First of all every policymaker cares about how well the actions of his region mimic the relevant economic shock and does not take into account how his policy affects another region. Moreover, actions of policymakers are affected by strategic complementarity, which is totally excluded from the social loss function. We check this hypothesis in Section 5, after computing equilibrium strategies and social optimum.

3 Equilibrium

Morris and Shin (2002) showed that an equilibrium strategy of private agents is linear over all received signals. In our model, however, private actions are also defined by prior beliefs about economic variables. The reason is the finite variance of economic shocks ($\varphi_j > 0$). In this case prior belief about the shock is itself useful for prediction of future economic situation. So, the strategies are represented by (6):

$$\begin{array}{l} a_i(I_i) = \kappa_1 s_1 + \kappa_{1,\pi}\pi_1 + \kappa_2 s_2 + \kappa_{2,\pi}\pi_2 + \kappa_3 x_i \;\forall i \in [0,n] \\ a_i(I_i) = \lambda_1 s_1 + \lambda_{1,\pi}\pi_1 + \lambda_2 s_2 + \lambda_{2,\pi}\pi_2 + \lambda_3 x_i \;\forall i \in (n,1] \end{array}, \tag{6}$$

where π_j[1] stands for the prior of shock θ_j and κ_k and λ_k are weights attached by private agents to corresponding variables. Weighting both lines of (6) by the sizes of corresponding regions, we can derive an average private action in the economy:

[1]In our model $\pi_1 = \pi_2 = 0$

$$\overline{a} = (n\kappa_1 + (1-n)\lambda_1)s_1 + (n\kappa_2 + (1-n)\lambda_2)s_2 + (n\kappa_{1,\pi} + (1-n)\lambda_{1,\pi})\pi_1 + \\ + (n\kappa_{2,\pi} + (1-n)\lambda_{2,\pi})\pi_2 + \kappa_3 \int_0^n x_i di + \lambda_3 \int_n^1 x_i di \quad (7)$$

An expected by an agent i value of (7) depends on received public signals, on prior values of economic fundamentals and also on their conditional expectations:

$$E_i\overline{a} = (n\kappa_1 + (1-n)\lambda_1)s_1 + (n\kappa_2 + (1-n)\lambda_2)s_2 + (n\kappa_{1,\pi} + (1-n)\lambda_{1,\pi})\pi_1 + \\ + (n\kappa_{2,\pi} + (1-n)\lambda_{2,\pi})\pi_2 + \kappa_3 n E_i\theta_1 + \lambda_3(1-n)E_i\theta_2 \quad (8)$$

Expected values of both shocks are computed using Bayes rule. An agent from the first region uses two signals (one private and one public) to update his prior belief about home economic fundamental variable, and only one public signal to update his belief about foreign shock. The weights are as follows[2]:

$$E_i \begin{bmatrix} \theta_1 \\ \theta_2 \end{bmatrix} = \begin{pmatrix} \frac{\mu_1}{\mu_1+\varphi_1+\beta} & 0 & \frac{\beta}{\mu_1+\varphi_1+\beta} & \frac{\varphi_1}{\mu_1+\varphi_1+\beta} & 0 \\ 0 & \frac{\mu_2}{\mu_2+\varphi_2} & 0 & 0 & \frac{\varphi_2}{\mu_2+\varphi_2} \end{pmatrix} \begin{pmatrix} s_1 \\ s_2 \\ x_i \\ \pi_1 \\ \pi_2 \end{pmatrix} \quad (9)$$

As we can see from (9), the weights depend on precisions of public and private signals and on economic volatility. When volatility is high and precision φ_j goes to zero, the prior π_j is uninformative and is not used for computation of expected values. On the contrary, when there is no uncertainty and φ_j is infinite, agents do not need any signal to forecast the value of economic fundamental. The weight of prior value equals to 1. For all positive but finite values of φ_j the weights of signals are proportional to their precisions.

Substituting (8) and (9) into first-order condition (2) and solving for coefficients in (6) we compute equilibrium weights[3]:

$$\kappa_1 = \frac{\mu_1(1-r(1-n))}{\varphi_1+\mu_1+\beta(1-nr)} + \frac{\mu_1\beta r^2 n(1-n)}{(\varphi_1+\mu_1)(\varphi_1+\mu_1+\beta(1-nr))} \quad (10)$$

[2]Expectations on agents from the second region are formed analogically: $E_i \begin{bmatrix} \theta_1 \\ \theta_2 \end{bmatrix} = \begin{pmatrix} \frac{\mu_1}{\mu_1+\varphi_1} & 0 & 0 & \frac{\varphi_1}{\mu_1+\varphi_1} & 0 \\ 0 & \frac{\mu_2}{\mu_2+\varphi_2+\beta} & \frac{\beta}{\mu_2+\varphi_2+\beta} & 0 & \frac{\varphi_2}{\mu_2+\varphi_{2+\beta}} \end{pmatrix} \begin{pmatrix} s_1 \\ s_2 \\ x_i \\ \pi_1 \\ \pi_2 \end{pmatrix}$

[3]Note that $\sum \kappa_j = \sum \lambda_j = 1$

$$\kappa_2 = \frac{\mu_2 r(1-n)}{\varphi_2 + \mu_2} \tag{11}$$

$$\kappa_3 = \frac{(1-r)\beta}{\varphi_1 + \mu_1 + \beta(1-nr)} \tag{12}$$

$$\lambda_1 = \frac{\mu_1 rn}{\varphi_1 + \mu_1} \tag{13}$$

$$\lambda_2 = \frac{\mu_2(1-rn)}{\varphi_2 + \mu_2 + \beta(1-(1-n)r)} + \frac{\mu_2 \beta r^2 n(1-n)}{(\varphi_2 + \mu_2)(\varphi_2 + \mu_2 + \beta(1-(1-n)r))} \tag{14}$$

$$\lambda_3 = \frac{(1-r)\beta}{\varphi_2 + \mu_2 + \beta(1-(1-n)r)} \tag{15}$$

$$\kappa_{j,\pi} = \kappa_j \frac{\varphi_j}{\mu_j} \text{ and } \lambda_{j,\pi} = \lambda_j \frac{\varphi_j}{\mu_j} \; j \in \{1,2\} \tag{16}$$

From (10 - 16) it can be easily seen that strategic complementarity creates three different distortions in the use of information. First of all agents put too much weight to public signal in comparison to their private signals. When the extent of strategic complementarity goes up, weights of public signals increases, as an incentive “do as others do” becomes stronger. For the same reason the weight of private information decreases, as the goal to catch an economic shock becomes less important. This means that $\frac{\partial(\frac{\kappa_1}{\kappa_3})}{\partial r} > 0$ and $\frac{\partial(\frac{\lambda_2}{\lambda_3})}{\partial r} > 0$, so we can conclude that strategic complementarity distorts the relative importance of public and private signal for decision-making. This effect corresponds to the standard model of Morris and Shin (2002), but the presence of informative priors and idiosyncratic shocks allow us to capture two additional effects of strategic complementarity to private actions.

The second effect of strategic complementarity concerns the distortion of the use of priors. In our model priors π_j play the role, similar to the role of public signals. On the one hand, they can be used for prediction of future economic shocks, on the other hand they are commonly known and that's why can be successfully used to predict behavior of other agents. So, when strategic complementarity increases, not only weights of public signals but also weights attached to priors go up. As at the same time agents become more reactant to use private information, the ratios $\frac{\kappa_{1\pi}}{\kappa_3}$ and $\frac{\lambda_{2\pi}}{\lambda_3}$ goes up.

The third effect arises from the presence of the second region. Strategic complementarity forces agents to put positive weight to “irrelevant” economic variables. Let us assume for the moment that there is no complementarity at all and $r = 0$. In this case agents do not use information about foreign shocks and $\kappa_{2,\pi} = \kappa_2 = \lambda_1 = \lambda_{1,\pi} = 0$. When r is positive, all these weights becomes positive, as agents use information about “irrelevant” shocks in order to predict how other agents are going to act.

These two effects (the use of foreign information and ineffectively high weight of priors) along with the standard effect of strategic complementarity define the role and the limits for information policy. A change in the precision of public signals influences not only the possibility of agents to predict economic shocks. Distortions that have been described earlier are also affected.

Positive effects of less transparent policy comes from discouraging private agents from the use of public signals. It can be easily shown that $\frac{\partial\lambda_1}{\partial\mu_1} > 0$, $\frac{\partial\kappa_1}{\partial\mu_1} > 0$, $\frac{\partial\lambda_2}{\partial\mu_2} > 0$, $\frac{\partial\kappa_2}{\partial\mu_2} > 0$, so when μ_j decreases, all agents start to put less weight to corresponding public signal. This has two positive effects. First of all agents becomes less sensitive to foreign information. As a result they incorporate less of foreign signal noise. Secondly, a decrease in public signal precision cures the distortion between private and public signals inside the home region. We can show that $\frac{\partial(\frac{\kappa_1}{\kappa_3})}{\partial\mu_1} > 0$ and $\frac{\partial(\frac{\lambda_2}{\lambda_3})}{\partial\mu_2} > 0$, so with the use of information policy we can, at least partially, keep the relative weights $\frac{\kappa_1}{\kappa_3}$ and $\frac{\lambda_2}{\lambda_3}$ closer to their optimal values. This effect corresponds to the standard model of Morris and Shin (2002) and represents an argument con transparency. Nevertheless, opacity has several negative consequences.

The first negative effect is rather trivial: low precision of public signal prevents private agents from improvement of their forecasts of economic shocks. Other negative effects arise because *policymakers have nothing to do with an incentive of private agents to rely on their prior beliefs*. Moreover, with a decrease in the precision of public signals, private agents loose some part of commonly known information. So, less precise foreign public information makes home private action less sensitive to foreign information noise. However strategic complementary incentive forces them to put more weight to another source of common knowledge - common priors. We can see that $\frac{\partial\kappa_{2,\pi}}{\partial\mu_2} < 0$ and $\frac{\partial\lambda_{1,\pi}}{\partial\mu_1} < 0$, so a decrease in the precision of foreign public signal leads to an increase in the weight attached to the corresponding prior. This means that private actions become more affected by foreign economic volatility itself. Moreover, less precise public information aggravates distortion between the use of private information and the use of home prior beliefs. We can see that $\frac{\partial\frac{\kappa_{1\pi}}{\kappa_3}}{\partial\mu_1} < 0$ and $\frac{\partial\frac{\lambda_{2\pi}}{\lambda_3}}{\partial\mu_2} < 0$, so less transparent policy makes ratios $\frac{\kappa_{1\pi}}{\kappa_3}$ and $\frac{\lambda_{2\pi}}{\lambda_3}$ even higher.

To sum up, similar to Morris and Shin (2002) in our model less transparent policy can repair the relative use of public and private information but at the same time it prevents agents from having an opportunity to improve their forecasts. Contrary to Morris and Shin (2002) we have several additional effects of opacity. First of all, less transparent policy lowers the weights attached to foreign public signals and keeps them closer to optimal values. Nevertheless, low precision of public information aggravates distortion in prior-private information use. All these effects influence socially optimal design of information policy that is discussed in the next section.

4 Social value of public information

From (5) we can see that social losses are defined by the distance between private actions and corresponding economic shocks. This distance depends on two terms: information noise and volatility of economic fundamentals. For example, for any agent from the first region this distance can be computed as follows:

$$\begin{aligned} a_i - \theta_1 &= \kappa_1(s_1 - \theta_1) + \kappa_3(x_i - \theta_1) - (1 - \kappa_1 - \kappa_3)\theta_1 + \kappa_2 s_2 = \\ &= [\kappa_1(\eta_1 + v_1) + \kappa_3(\varepsilon_i) + \kappa_2(\eta_2 + v_2)] + [\kappa_2\theta_2 - (\kappa_2 + \kappa_{1,\pi} + \kappa_{2,\pi})\theta_1] \end{aligned} \tag{17}$$

The first part of the second line in (17) reflects the information noise incorporated in private actions. Higher weight attached to the corresponding signal means that its possible mistakes have more impact on the private actions. The second part of (17) represents an influence of economic volatility on private agents. Private agents incorporate a part of foreign economic volatility, because they rely on the foreign signal (the term $\kappa_2\theta_2$). Moreover, as private agents put positive weights to variables that are not connected to the home shocks (that is foreign signal and priors), they also absorb a part of home volatility - the term $(\kappa_2 + \kappa_{1,\pi} + \kappa_{2,\pi})\theta_1$. The same is true for the second region. The overall losses of private agents are thus defined by the information design:

$$L_W = (1 - r)[L_1^W(\mu_1) + L_2^W(\mu_2)] \tag{18}$$

where

$$L_1^W = n(\frac{\kappa_1^2}{\mu_1} + \frac{\kappa_3^2}{\beta} + \frac{(1 - \kappa_1 - \kappa_3)^2}{\varphi_1}) + (1 - n)\lambda_1^2(\frac{1}{\mu_1} + \frac{1}{\varphi_1}) \tag{19}$$

$$L_2^W = (1 - n)(\frac{\lambda_2^2}{\mu_2} + \frac{\lambda_3^2}{\beta} + \frac{(1 - \lambda_2 - \lambda_3)^2}{\varphi_2}) + n\kappa_2^2(\frac{1}{\mu_2} + \frac{1}{\varphi_2}) \tag{20}$$

The first parts of (19) and (20) represent direct effect that each of public signals has on its home private sector. The second part represents a negative externality of public signals, that forces foreign agents to go away from their home economic fundamental. The relative weights of direct and external effects depend on the relative sizes of both regions. To analyze the whole impact of information policy on social welfare we substitute (10 - 15) into (19 - 20). Note that $\frac{\partial L^W}{\partial \mu_j} = \frac{\partial L^W}{\partial \tau_j}\frac{1}{\beta}$, where $\tau_j(\mu_j) = \frac{\mu_j + \varphi_j}{\beta} \in [\tau_{j,0}, \tau_{j,0} + \frac{\alpha_j}{\beta}]$ and $\tau_{j,0} = \frac{\varphi_j}{\beta}$. So to define an impact of μ_j on social losses it is enough to compute $\frac{\partial L^W}{\partial \tau_j}$:

$$\frac{\partial L^W}{\partial \tau_j} = \frac{(1 - r)n_j P_W(\tau_j, n_j, r)}{\beta\, \tau_j^2\, (\tau_j - n_j r + 1)^3}, \tag{21}$$

where $P_W(\tau_j, n_j, r) = -(1 - (1 - n_j)r^2)\tau_j^3 + (3n_j^2 r^3 - 3n_j r(r^2 + r - 1) + r^2 - 1)\tau_j^2 + 3n_j r^2(1 - n_j)(n_j r^2 - 2r + 1)\tau_j + n_j r^2(1 - n_j)(1 - n_j r)(n_j r^2 - 2r + 1)$. As $(1 - n_j r) > 0$, denominator of (21) is positive and the sign of $\frac{\partial L^W}{\partial \tau_j}$ coincides with the sign of polynomial $P_W(\tau_j, n_j, r)$.We can easily show that depending on the values of r and n_j one of three cases takes place:

a) either L_j^W is decreasing in τ_j for any positive value of τ_j (Figure 1a)

b) either there exist a unique value $\tau^* > 0$ such that for any $\tau_j \in (0, \tau^*)$ L_j^W is an increasing function of τ_j, and for any $\tau_j > \tau^*$ $L_j^W(\tau_j)$ is a decreasing function (Figure 1b)

c) or there are two values τ_1^* and τ_2^* such that $\tau_2^* > \tau_1^* > 0$ and $L_j^W(\tau_j)$ is increasing function for any $\tau \in [\tau_1^*, \tau_2^*]$ and decreasing otherwise (Figure 1c)

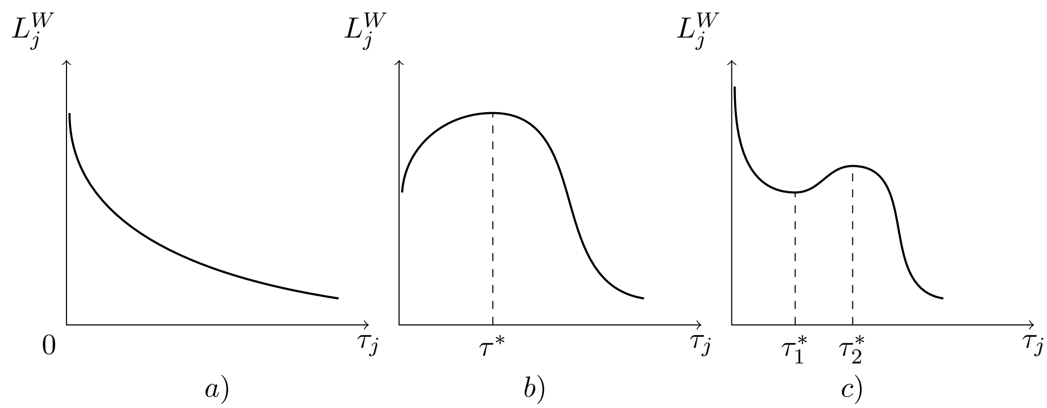

Figure 1: Social losses

In the first case a) losses decrease with a rise in τ_j. This means that losses are decreasing function of policy transparency μ_j for any φ_j and β. From here we can conclude that the maximum level of public precision $\mu_j^* = \alpha_j$ is socially optimal.

In the second case b) optimal level of transparency depends on the relative quality of private information and on the volatility of economic shock. Suppose for example that private agents have relatively bad information about economic fundamental: $\tau_{j,0} = \frac{\varphi_j}{\beta} > \tau^*$. The reason for this can be either low precision of private signal (low β) or low volatility of fundamental variable (high φ_j) (or both). In this situation private signal is relatively uninformative and agents put excessive weight to their prior belief of θ_j. So, to prevent agents from incorporating too much of economic volatility in their actions, social planner should provide population with the most precise information, $\mu_j^* = \alpha_j$.

By the way, if private information is rather good ($\frac{\varphi_j}{\beta} < \tau^*$), losses increase in the quality of public information for small values of μ_j. This happens due to standard effect described in Morris and Shin (2002): when precision of public information increases, private agents start to put too much weight to public signal even if its quality is poor. As a result for low values of μ_j this transfers possible errors of policymakers to the private sector. So in this case transparency may be detrimental. If the quality of public information is rather bad losses that arise when policymaker is totally transparent are higher than losses under full opacity. This requires that precision of policymaker's information is lower than $\overline{\alpha}$ such that $L_j^W(0) = L_j^W(\overline{\alpha})$. If the quality of public information is rather good ($\alpha_j > \overline{\alpha}$), transparency is optimal.

Similarly to the previous situation, in the third case c) transparency is socially beneficial if private information is relatively bad or when $\frac{\varphi_j}{\beta} > \tau_2^*$. For better private information quality, when $\tau_1^* < \frac{\varphi_j}{\beta} < \tau_2^*$, transparency is detrimental, if the quality of public information is poor ($\alpha_j < \overline{\alpha}$), and beneficial, if precision of signal received by policymaker is high ($\alpha_j > \overline{\alpha}$). The most interesting solution may arise if the quality of private information is very low, or $\frac{\varphi_j}{\beta} < \tau_1^*$. From c) it can be easily seen that in this situation full opacity is never optimal. Then, when the quality of public information is rather bad ($\frac{\alpha_j+\varphi_j}{\beta} < \tau_1^*$) or rather good ($\alpha_j > \tilde{\alpha}$ and $\tilde{\alpha}$ is the solution of the following equation: $L_j^W(\tau_1^*\beta - \varphi_j) = L_j^W(\tilde{\alpha})$), full transparency is optimal. For intermediate values of public signal precision ($\tau_1^*\beta - \varphi_j < \alpha_j < \tilde{\alpha}$) an intermediate transparency is optimal: $\mu_j^* = \tau_1^*\beta - \varphi_j$. As we can see here, an optimal degree of transparency positively depends on the quality of private signal and on volatility of economic shock. Which of these situations will be realized, depends on two parameters: extent of strategic complementarity r and group size n_j.

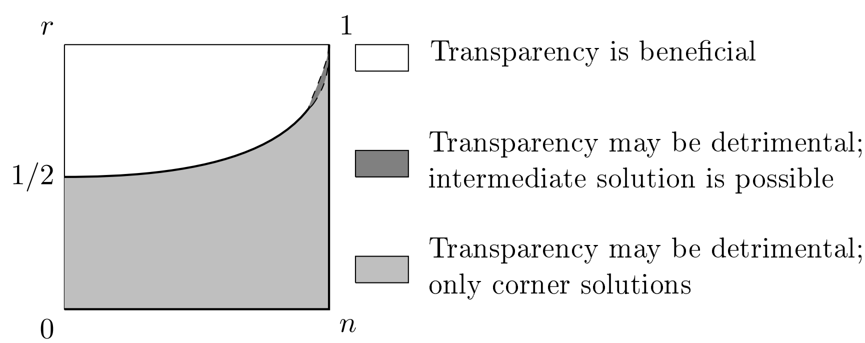

Figure 2: Social optimum

The second case b) takes place when region size is rather big $n_j \geq \overline{n} = \frac{2r-1}{r^2}$ (the lower part of Figure 2) or, to put it differently, when strategic complementarity is rather weak: $r \leq \overline{r} = \frac{1-\sqrt{1-n}}{n}$. The third case, when $L_j^W(\tau_j)$ has two extrema, may realize only if both n_j and r are high and $n_j \in (\hat{n}, \overline{n})$ (dark gray part of Figure 2), where $\hat{n}$ is the feasible solution for $\Delta_{PW} = 0$, different from $\overline{n}$ and Δ_{PW} stands for discriminant of cubic polynomial $P(\tau_j, n_j, r)$. It is obvious that this case is rather specific, so in what follows we do not put much attention to it and focus on more standard situations a) and b). All this gives us several interesting results, that are summarized below.

Proposition 1. *Transparency is always beneficial if economy is rather stable.*

It is obvious that irrespective of the form of $L_j^W(\tau_j)$ (see Figure 1) if $\tau_{j,0}$ is rather high, $\frac{\partial L^W}{\partial \tau_j}$ is negative and transparency is beneficial. Sufficient for this result condition is $\tau_{j,0} \geq \overline{\tau_j}$, where

$$\overline{\tau_j} = \begin{cases} 0 & \text{if (a)} \\ \tau^* & \text{if (b)} \\ \tau_2^* & \text{if (c)} \end{cases}.$$

High value of $\tau_{j,0}$ means that precision of economic shock is high in comparison to private information quality. In this case prior belief about economic shock becomes a good predictor of its real value. So incentives to use private signals are poor irrespective of information policy. Under such circumstances opacity of policymaker cannot provide much to re-balancing of public-private information use. Thus possible positive effects of opacity, discussed in the Section 3, cannot outweigh the negative effect of less accurate forecasts. Therefore, transparency is beneficial whatever precision of policymaker information, α_j, is .

We computed the maximum value of τ^* that allows transparency to be detrimental for different values of n_j. As we can see in the Picture 3, τ^* is a bell-shaped function of r. An influence of n_j has an ambiguous effect on the form of this function. To some extent an increase in region size increases τ^* for small extents of strategic complementarity. But when n_j reaches some significant level, its further increase lowers the value of τ^* for small r. Moreover, an increase in region size leads to a rise in the maximum value of r for which τ^* is still positive.

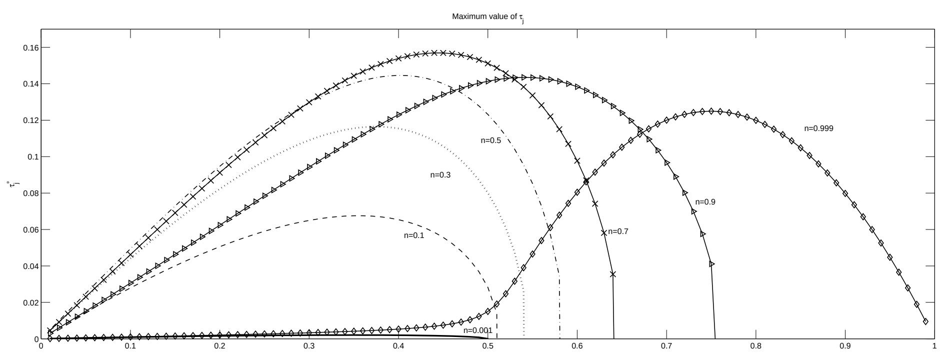

Figure 3: The highest relative stability τ^* that allows opacity to be socially optimal

Proposition 2. *Transparency may be detrimental only for relatively low extents of strategic complementarity.*

As we have shown[4], for any extent of strategic complementarity that is lower than $\overline{r}$, the function $L_j^W(\tau_j)$ is bell-shaped and situation b) takes place. In this case transparency is detrimental if economic volatility is high ($\tau_{j,0} < \tau^*$) and policymaker's information is poor ($\alpha_j < \overline{\alpha}$). The same is true if $r \in (\overline{r}, \hat{r})$, where $\hat{r} = (\hat{n}(r))^{-1}$, and the case c) realizes (see discussion above). By the way, if an extent of strategic complementarity is high ($r > r^* = max\{\overline{r}, \hat{r}\}$), $\frac{\partial L^W}{\partial \tau_j}$ is negative and transparency is beneficial for all possible values of $\tau_{j,0}$.

[4] See Appendix for formal proof

This result is totally different from the main conclusion of Morris and Shin (2002) who showed that transparency may be detrimental only if strategic complementarity is high (namely $r > 1/2$). This distinction arises due to the fact that in our model an impact of public signal is different for home and foreign agents. In Morris and Shin (2002) model (that can be obtained from ours by assuming that $n \to 1$ and $\tau \to 0$) the only positive effect of opacity is rebalancing the use of private and public signals. This effect is sufficiently large only if strategic complementarity is high and initial distortion between κ_1 and κ_3 is substantial. When r is small, the positive effect of opacity does not outweigh the negative effect of less accurate forecasts.

On the contrary, in our model when r is rather high, policymaker cannot do much. For sure, opacity helps to improve distortion between κ_1 and κ_3, but it also aggravates another distortion between κ_1 and $\kappa_{1,\pi}$. Opacity forces agents not to use public signal, but their incentive to coordinate leads to even higher weight of prior belief about economic shock. As a result, home agents incorporate too much volatility to their actions: the term $\frac{(1-\kappa_1-\kappa_3)^2}{\varphi_1} = \frac{(\kappa_2+\kappa_{1,\pi}+\kappa_{2,\pi})^2}{\varphi_1}$ in loss function (19) increases and welfare of home agents goes down. Moreover, a decrease in accuracy of forecasts that home agents make about their home shock also raises their losses. Honestly, there is some positive effect on foreign agents: as they incorporate less noise from public signal, their losses decrease (the last term in (19)). But this effect is rather limited: public signal influence foreigners only through their strategic complementarity incentive. Effect on the home agents is always higher as they use home public information not only to predict actions of others but also to forecast their home economic conditions. So a negative effect caused by opacity on home agents is much larger then positive effects on foreigners and on the use of private information. However if the extent of strategic complementarity is low, opacity does not create substantial distortion between κ_1 and $\kappa_{1,\pi}$ and that's why it can be beneficial.

As we can clearly see on the Figure 2, the maximum value of strategic complementarity that insures that transparency may be detrimental (r^*) increases with rise in the size of region. The main reason for this effect is that when n_j becomes higher, inefficient use of private information inside the home region becomes more important. Thus a positive effect of opacity on welfare of home agents becomes more substantial and a range of values of r that assure that opacity is detrimental, shrinks.

5 Information policy

From 3 and 4 we can see that overall losses of both regions are defined by two terms. First of all policymakers should assure that actions of their voters fit relevant economic conditions. In this aspect interests of policymakers coincide with objective function of social planner. Besides of this direct goal, policymakers also care about an average performance of their regions relatively to the whole economy. This incentive represents a strategic effect at the level of policymakers and is denoted by $\Delta_j = \overline{L}_j - n_j\overline{L}$ in 3 and 4. The difference with similar effect at the level of private agents is that private agents cannot influence an average losses of others, while policymakers can. To show this we rewrite the strategic effect by using the definition of $\overline{L}$:

$$\Delta_j = \overline{L}_j - n_j\overline{L} = \overline{L}_j - n_j(\overline{L}_j + \overline{L}_{-j}) = (1-n_j)\overline{L}_j - n_j\overline{L}_{-j} \tag{22}$$

(22) shows that strategic aspect consists of two parts. Each policymaker is interested in decreasing relative complementary losses of agents from his own regions, $\overline{L}_j$, and in increasing relative losses of foreigners $\overline{L}_{-j}$. Moreover, the weights attached to both of the incentives are defined by relative sizes of regions. If the ratio of population who lives in the region j, goes up, the policymaker associated with this region becomes more conscious about increasing losses of foreigners than about lowering relative losses of his own inhabitants.

We can further rewrite the strategic affect if we remember that an average complementarity $\overline{L}_j$ can be represented by the sum of two terms: $\overline{L}_j^{in}$ and $\overline{L}^{between}$, where the first stands for quadratic difference between private actions inside the region j and the second represents an average quadratic difference between two groups of population:

$$\Delta_j = (1-n_j)(\overline{L}_j^{in} + \overline{L}^{between}) - n_j(\overline{L}_{-j}^{in} + \overline{L}^{between}) = [(1-n_j)\overline{L}_j^{in} - n_j\overline{L}_{-j}^{in}] + (1-2n_j)\overline{L}^{between} \tag{23}$$

Because inhabitants inside any region put equal weights to all the signals, the only difference in actions inside a region comes from the heterogeneity of private signals. So a policymaker cannot do anything with an average complementary losses inside the foreign region ($\overline{L}_{-j}^{in}$). Nevertheless, he can influence average losses inside his own region by changing precision of his public signal. When a policymaker becomes more transparent, private agents put less weight to their private signals and thus the variance of their actions goes down. Moreover, policymakers can influence an average difference between two regions. When precision of public signal increases, agents across the whole economy have more possibilities to coordinate and the difference between their actions decreases. The overall effect of this change on the policymaker losses depends on the size of the region. If the region is small ($n_j < 1/2$) a policymaker is more interested in decreasing the complementary losses of his voters, than in increasing the losses of foreigners. Thus, his goal is to keep $\overline{L}^{between}$ at a low level and therefore he has more incentives to be transparent. On the contrary, when the region is large ($n_j > 1/2$), a policymaker can decrease his relative losses by increasing a difference between regions, so he is less disposed to be transparent. Using the fact that $\Delta_1 = -\Delta_2 = \Delta$ and equilibrium private strategies from Section 3, we can rewrite loss functions of policymakers:

$$LP_1 = (1-r)n(\frac{\kappa_1^2}{\mu_1} + \frac{\kappa_3^2}{\beta} + \frac{(1-\kappa_1-\kappa_3)^2}{\varphi_1}) + r\Delta \tag{24}$$

$$LP_2 = (1-r)(1-n)(\frac{\lambda_2^2}{\mu_2} + \frac{\lambda_3^2}{\beta} + \frac{(1-\lambda_2-\lambda_3)^2}{\varphi_2}) - r\Delta \tag{25}$$

$$\Delta = n(1-n)[2\frac{n\kappa_3^2-(1-n)\lambda_3^2}{\beta}+(1-2n)(\frac{(\kappa_1-\lambda_1)^2}{\mu_1}+\frac{(\kappa_2-\lambda_2)^2}{\mu_2}+\frac{(\kappa_1-\lambda_1+\kappa_3)^2}{\varphi_1}+\frac{(\kappa_2-\lambda_2-\lambda_3)^2}{\varphi_2})] \quad (26)$$

Similar to the previous section we compute $\frac{\partial LP_j}{\partial \tau_j}$:

$$\frac{\partial LP_i}{\partial \tau_j} = \frac{(1-r)P_L(\tau_j,n_j,r)}{\beta\,\tau_j^2\,(\tau_j-n_jr+1)^3}, \quad (27)$$

where $P_L(\tau_j,n_j,r) = -(n_j^2r^2-2n_j^2r-nr_j^2+3n_jr-r+1)\tau_j^3+(3n_j^3r^3-6n_j^3r^2-3n_j^2r^3+6n_j^2r^2+6n_j^2r-2n_jr^2-4n_jr+r-1)\tau_j^2-3n_jr^2(1-n_j)(2-n_jr)(n_jr-2n_j+1)\tau_j-n_jr^2(1-n_j)(1-n_jr)(2-n_jr)(n_jr-2n_j+1)$

So, the overall effect of signal precision on the policymaker losses is defined by the sign of polynomial P_L. We found out that only two cases are possible: either LP_j is a decreasing function of τ_j (case a)), or $LP_j(\tau_j)$ has one extremum (case b)). Therefore, policymakers never choose an intermediate value of signal precision in equilibrium. Situation with one extremum (case b)) takes place if $n_j \geq \widetilde{n} = \frac{1}{2-r}$ or $r < \widetilde{r} = \frac{2n-1}{n}$ (lower part of figure 4). If region is rather small ($n_j \leq \widetilde{n}$), transparency decreases losses for all values of values of τ_j. This conclusion corresponds to the discussion of loss functions (24 - 25) above: small regions have more incentives to be transparent.

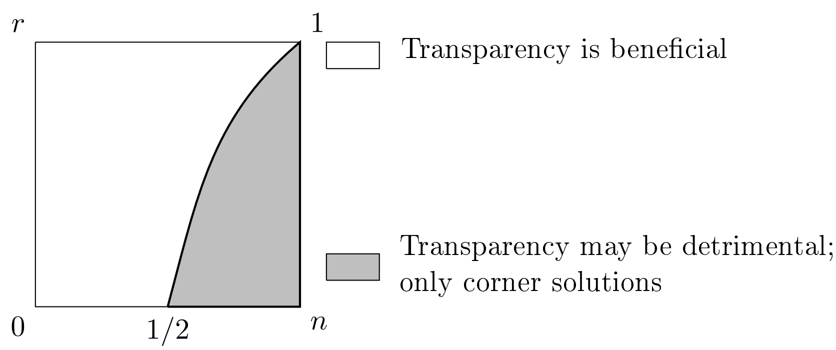

Figure 4: Information policy

Proposition 3. *Policymakers from small regions tend to be too transparent.*

We can see on figure 4 that if the size of region is less than 1/2, policymaker will be transparent whatever strategic complementarity, quality of private information and volatility of economic shocks are. Moreover, it can be easily seen that for any $r \leq 2/3$ $\widetilde{n} \geq \overline{n}$. Thus we can conclude that for rather small strategic complementarity policymaker from sufficiently small region ($\overline{n} \leq n_j \leq \widetilde{n}$) will be ineffectively transparent if τ_j is small. Such policymaker will choose the maximum value of his signal precision even if opacity is a better outcome for all the society.

Proposition 4. *Policymakers from large regions may be too opaque if strategic complementarity is high.*

As we have already stated, for high values of r $\widetilde{n} \leq \overline{n}$. This means that for all $\widetilde{n} \leq n_j \leq \overline{n}$ there exist τ_j such that policymaker will choose to be opaque. But as we saw in the previous section, in this case transparency is socially optimal.

Similar to the previous section we computed the value of τ_P^* such that for all $\tau_{j,0} < \tau_P^*$ a policymaker may choose opacity if the quality of his information is bad. On figure 5 we see that τ_P^* is a bell-shaped function of r. To a certain level an increase in the region size causes a rise of τ_P^* for small extents of strategic complementarity. This means that incentives to be opaque strengthen. Starting from some point a further increase in n_j leads to a decrease in τ_P^* for low r. When a region is sufficiently large, possible benefits from opacity are low if strategic complementarity incentive is not very strong. However, an increase in region size raises $\widetilde{r}$, the maximum value of r for which transparency may be detrimental.

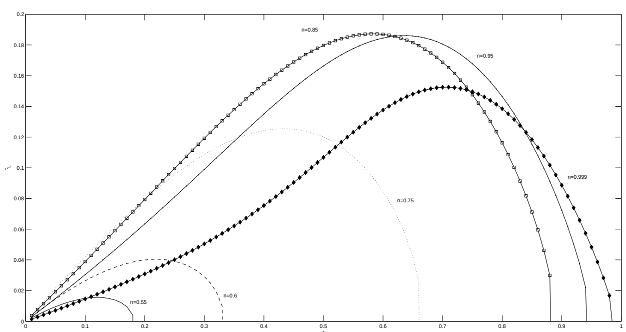

Figure 5: The highest relative stability τ_P^* that allows policymaker to choose opacity

Comparison of τ_P^* to τ^* gives ambiguous results. If n_j is small, τ^* is higher than τ_P^* for all possible values of r. This means that policymaker may be too transparent if economy is rather stable or if the quality of private information is bad. On the contrary, when the region is large, τ_P^* is higher than τ^* and policymaker tends to be too opaque. For intermediate values of n_j relationship between τ_P^* and τ^* depends on the extent of strategic complementarity.

6 Conclusion

The paper of Morris and Shin (2002) has provoked extensive debates about the role of public signals. The literature shows that an optimal transparency of policymakers depends on a number of factors such as an extent of strategic complementarity, the quality of private and public information, nature of economic shocks and so on. Nevertheless, almost all these studies ignore the real design of information structure.

Therefore, we proposed a new direction of research. Our goal was not a usual investigation of properties of optimal information policy. Instead of this we tried to create a framework for analysis of information interaction between public signal senders with different objectives. For this purpose we built a two-region model with policymakers who maximize welfare of distinct groups of population. Using this framework we came to a numbers of results. First of all we showed that policymakers from small regions tend to be too transparent, while policymakers who maximize welfare of larger regions may be too opaque. Then we found out that heterogeneous structure of public information along with finite economic volatility make transparency optimal for high extents of strategic complementarity. In our model opacity may be beneficial only if strategic complementarity is strong. This result is contrary to the standard ideology of Morris and Shin (2002) who argue that transparency may be detrimental for high extents of complementarity and is undoubtedly beneficial if strategic complementarity is weak.

For sure our model is too simplified. A number of modifications can make it more realistic. First of all we assumed that changes in economic fundamentals are uncorrelated and shocks in one region influence another only due to strategic complementarity effect. Nevertheless an assumption of correlated shocks would probably be more appropriate. Secondly, we can hardly imagine that inhabitants of different regions have identical access to both public signals. More likely the noise that distort the value of signal on its way from sender to receiver differs according to the distance between them. All these modifications represent important but nevertheless, minor transformation of basic framework. What would be really crucial for future research is adding standard policy instruments to our model. This can create a serious foundation for analysis of policy interaction in reality.

References

Angeletos, G.-M. and Pavan, A. (2004). Transparency of information and coordination in economies with investment complementarities. *The American Economic Review*, 94(1):91–98.

Angeletos, G.-M. and Pavan, A. (2009). Policy with dispersed information. *Journal of the European Economic Association*, 7(1):11–60.

Cornand, C. and Heinemann, F. (2008). Optimal degree of public information dissemination*. *The Economic Journal*, 118(528):718–742.

Hahn, V. (2014). Transparency in monetary policy, signaling, and heterogeneous information. *Macroeconomic Dynamics*, 18(02):369–394.

Hellwig, C. (2005). Heterogeneous information and the welfare effects of public information disclosures. *unpublished, UCLA*.

James, J. G. and Lawler, P. (2011). Optimal policy intervention and the social value of public information. *The American Economic Review*, 101(4):1561–1574.

Morris, S. and Shin, H. S. (2002). Social value of public information. *The American Economic Review*, 92(5):1521–1534.

Morris, S. and Shin, H. S. (2007). Optimal communication. *Journal of the European Economic Association*, 5(2-3):594–602.

Myatt, D. P. and Wallace, C. (2008). On the sources and value of information: Public announcements and macroeconomic performance.

Svensson, L. E. (2006). Social value of public information: Morris and shin (2002) is actually pro-transparency, not con: Reply. *The American Economic Review*, pages 453–455.

Walsh, C. E. (2013). Announcements and the role of policy guidance. *Federal Reserve Bank of St. Louis Review*, 95(November/December 2013).