Collective Memory, Social Capital and Integration*

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Abstract

I study the intergenerational transmission of knowledge in the presence of social externalities associated with individual investment decisions (human capital, learning and respecting social norms, cooperation with others). The younger generation's decisions are based on beliefs about the quality of existing institutions, social norms and values; these beliefs are influenced by the information received from the older generation. I examine whether and when the state can engage in welfare-enhancing manipulation of the information transmitted to the younger generation. I then investigate the costs and benefits of having multiple principals involved in the intergenerational transmission of knowledge, and in particular the role of close family ties. Finally, the paper studies the implications of heterogeneous cultural identities for the optimal transmission of knowledge.

Keywords: memory, knowledge, history, human capital, identity, integration, multi-cultural, social capital.

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1. Introduction

How should each generation communicate its knowledge to the following one? Should it aim to be as truthful and comprehensive as possible? Is there any scope for welfare-enhancing manipulation of the information transmitted to the younger generation? What are the implications for the role of the state, parents and communities? These questions are at the heart of many current debates, including those over education policy (e.g. how should history be taught? how much weight should be given to arts and science subjects in schools?), over social policy (e.g. should the state support or discourage close links between parents and children?), and over policies on cultural integration, both within countries (e.g. "assimilation" versus "multi-culturalism") and between countries (e.g. centralised versus decentralised institutions in the European Union). While the debates are of very general interest, economists are well-placed to help shed light on at least some of the key issues: this paper takes a small step in that direction.

The main idea I want to explore is very simple. The prosperity and well-being of any society depend to a large extent on the willingness of its members to make significant investments (time, effort, resources) which can benefit them individually but also generate substantial positive externalities: for example, investments in human capital, in learning and respecting certain social norms, in cooperating with others. The willingness of the young to invest in this way depends on how confident they are that the future returns will justify incurring current costs; their confidence in turn depends on their beliefs about the key determinants of those returns, including the quality of existing institutions, social norms and shared values, which may be thought of as the current stock of "social capital"[1]. At the time when their main investment decisions have to be taken, the young's beliefs are largely influenced by the information they receive from the older generation, which has a vested interest in these investment decisions and their outcome (partly because of their direct impact on the older generation, and partly because the older generation cares at least to some degree about the younger generation's well-being). Intuitively, therefore, the older generation may have an incentive to manipulate the information it transmits to the young, in order to "internalise" the externalities associated with individual investment decisions. However, such

[1] The concept of "social capital" has been widely used with a variety of rather different interpretations (on this, see Bourdieu (1986); Coleman (1988, 1990); Dasgupta and Serageldin (2000); Glaeser, Laibson and Sacerdote (2002); Lin (2001); Putnam (2000); Sobel (2002)). In the present paper I shall use the term to refer to all those social assets transmitted from one generation to the next which affect the younger generation's returns from learning and investing in human capital in the broadest sense. Thus in my definition social capital includes institutions, culture, history, language, values, norms, the notion of a shared identity, and so on (see section 3 below).

a strategy may be costly, to the extent that the young, aware of the likelihood of manipulation, may distrust the older generation and the information that it transmits to them.

The paper explores and develops this basic intuition in several ways. I begin by looking at the benchmark case of a "mono-cultural" society. The older generation is represented by a principal who chooses the information to be transmitted to the young so as to maximise their welfare. A natural interpretation for this principal is the state. In the presence of sufficiently important social externalities, I find that it can indeed be optimal for the state to manipulate the information it transmits to the young, in order to foster optimism about the value of the existing social capital and thereby induce greater investments by the young. This will be the case when the information available to the state includes an element of "bad news"; that is, something that can be interpreted as a "bad" signal about the true value of social capital, such as evidence casting doubt on the value of existing norms and institutions. "Telling the whole truth" is not an optimal strategy in this case[2]. If on the other hand the information available to the state includes only "good news", there is no gain from manipulation; on the contrary, doubt as to whether the information transmitted is accurate or not undermines incentives to invest, to the detriment of social welfare. This confirms the intuition mentioned above.

The state's ability to manipulate the information that is transmitted to the young may be restricted by the presence of alternative (credible) sources of information. I examine the informational role of parents from this perspective. The presence of close links between parents and children (high-trust family relationships) can have two types of informational effect: a welfare-reducing effect, since they represent a constraint on the state's ability to suppress "negative" information which discourages investment, and a welfare-enhancing effect, since they increase the credibility of "good news" and reduce the potential losses due to distrust of the information transmitted by the state. An intriguing implication is that governments faced with "negative" information may have an incentive to undermine close links between parents and children, provided they are able to do so in a way that cannot be accurately observed and correctly interpreted by the young; conversely, governments faced with "good news" have an incentive to encourage and support high-trust family relationships.

Many of the current debates over the way knowledge is transmitted from one generation to the next are explicitly concerned with the implications of cultural

[2] Of course, this does not imply that "negative" information should be suppressed more generally - for example, by modifying historical records. The manipulation of information considered here concerns the information transmitted to the young which directly impacts on their initial investment decisions: for instance, what they are taught at school, rather than what they can learn individually through experience and search later in life.

heterogeneity. I therefore extend and modify the analysis to study a society with two distinct communities ("cultural groups"), each endowed with its own cultural identity and related social capital (language, history, values, norms). In this case each individual has to make two investment decisions: the first concerns "own-cultural" investment (learning about and participating in the culture of his own cultural group), while the second concerns "cross-cultural" investment (learning about and participating in the culture of the other group). Corresponding to these two types of investment are two types of externality: the first is the externality exerted by each individual on other members of his own cultural group, and the second is the externality exerted by the individual on members of the other cultural group. I consider the natural benchmark case of two symmetric communities, which differ only in terms of their social capital. Moreover, I assume that the state maximises the sum of individuals' expected utilities, and that individuals are identical except for their cultural identity.

The key new issue that arises in the presence of cultural heterogeneity concerns the transmission of "mixed news" signals; that is, signals that are good news about the value of one culture's social capital and at the same time bad news about the value of the other culture's social capital. For example, evidence of the achievements and successes of one community can often draw attention, explicitly or implicitly, to the failures, or simply to the relative lack of achievements, of another community. It is sometimes suggested that this kind of signal should be suppressed in order for multi-cultural societies to function well. I find the reverse: with two symmetric communities, it is always optimal for the state to communicate truthfully "mixed news" signals. The reason is that the welfare loss from reducing confidence in the culture with the higher value of social capital (leading to under-investment in that culture by members of both cultural groups) would be greater than the welfare gain from increasing confidence in the culture with the lower value of social capital (which tends to correct for the under-investment due to the presence of externalities).

This means that the only potential for welfare-enhancing manipulation of information comes from the possibility of suppressing signals that are "bad news" for both cultures. In this sense, the presence of cultural heterogeneity reduces the scope for welfare-enhancing manipulation of information by the state. In equilibrium, this increases the credibility of "good news", which can benefit equally both communities. Disclosure of "mixed news", on the other hand, has an asymmetric impact on the two communities. The final section of the paper therefore discusses the role of policies aimed at encouraging cross-cultural investments in this case, taking into account the possible strategic responses by each cultural group, and their welfare consequences.

The intergenerational transmission and manipulation of information is obviously of great interest not only to economists, but also to sociologists, psychologists and historians: in section 2 below I briefly review the existing literature on collective memory and discuss its relationship with my work. The present paper is also related to several papers in the existing economics literature. Bisin and Verdier (2000, 2001) study the transmission of cultural traits which results from the interaction of two key influences on the preferences of the young: first, the direct socialization effort of their parents, who wish to transmit their own cultural traits; second, the effect of the broader social and cultural environment, including friends, peers, teachers and others who may act as role models. These influences are not modelled explicitly, however: parents can, at a cost, affect the probability that their children will inherit their cultural traits; if this parental socialization effort fails, children acquire the cultural traits of some role model chosen randomly from the population at large. I view my work as essentially complementary to that of Bisin and Verdier, since it explores one important way in which parents and society at large influence the acquisition of cultural traits by the young. Specifically, I analyse the transmission and manipulation of memory (information) by the state, communities (cultural groups) and parents. This in turn influences the cultural investment decisions made by the young: it is through this channel that it will ultimately affect their preferences, including their acquisition of cultural traits. While complementary to that of Bisin and Verdier, this approach allows me to identify a different set of important externalities and corresponding distinct roles for the state, communities and parents, with quite different welfare implications.

Collective memory is an important determinant of identity: in this sense, the present paper can also be viewed as complementary to Akerlof and Kranton (2000), which studies the implications of identity for individual behaviour. Moreover, Akerlof and Kranton examine individual decisions to adopt a particular identity. This paper also views identity as (partly) endogenous. In the model of section 6 below, individuals are endowed with an initial "cultural identity" through membership of a "cultural group", but they then choose how much to invest in their own culture, and in the other culture (bi-cultural society)[3]. These investments clearly shape their identity.

Finally, Bénabou and Tirole (2002) study the incentives that an individual may have to manage (manipulate) his own memory, when his preferences exhibit time inconsistency. There is an interesting analogy between this manipulation of individual memory and the manipulation of collective memory examined in the present paper. A key difference is that the gains from manipulation in Bénabou and Tirole stem from a feature of individual preferences (time inconsistency),

[3]For another related paper which explores the choice between bi-culturalism and monoculturalism, see Lazear (1999).

while here they are due to the presence of social externalities. In this respect my paper is also related to Bénabou and Tirole (2003), which studies an informed principal's incentives to manipulate an agent's self-confidence. The common link is that both papers analyse the transmission of information in the presence of externalities, although the nature of the game, the ways in which information may be manipulated, and the externalities involved, all differ considerably.

The paper proceeds as follows. After reviewing the existing literature on collective memory in section 2, I present the basic version of the model in section 3. This is used in section 4 to analyse the informational role of the state in the benchmark case of a mono-cultural society. Section 5 extends the analysis to study the implications of close family ties. The case of a multi-cultural society is examined in section 6. Section 7 concludes.

2. Collective memory: an interdisciplinary research agenda

The transmission of knowledge, information and culture across generations, which is the main focus of the present paper, is obviously of crucial interest to sociologists, psychologists and historians, notably those engaged in the study of collective (social) memory[4]. Central to this study is the recognition that the process whereby information about the past is communicated to future generations is subject to various forms of bias and manipulation. As McBride (2001) remarks in a recent survey,

"there is a basic consensus running through the sociological literature that the recollection of the past is not simply a matter of filing away and retrieving information, but an active, continuing process...remembering and forgetting are social activities, and our images of the past are therefore reliant upon particular vocabularies, values, ideas and representations shared with other members of the present group".

The view that collective memory is to a large extent shaped by, and suited to, current needs and interests[5], can be traced back to the sociologist Maurice Halbwachs[6], and underlies the more recent work on social memory by sociologists[7], psychologists[8], and historians[9]. Some historians have emphasized the role of ruling élites in the manipulation of collective memory, notably through the "invention"

[4] See Olick and Robbins (1998) for a survey of the literature.

[5] This is not to say that there is only a one-way relationship between the present and the past: obviously current perceptions of needs and interests are themselves influenced by past experience and collective memory. On this see Hilton and Liu (2003).

[6] See Maurice Halbwachs (1925).

[7] See, for example, Schwartz (1990); Zerubavel (1995).

[8] See Edwards and Middleton (1990); Fentress and Wickham (1992).

[9] See Nora (1992); Samuel (1994).

of traditions[10]; others have drawn attention to the "unconscious methods which social groups use to reproduce themselves"[11] - suggesting that manipulation of information may occur both as a deliberate, conscious act, and as a result of those social practices that enable social (group) identities to be formed and maintained. The principal-agent framework applied in the present paper, whereby the older generation chooses the information that is transmitted to the younger generation, can obviously capture the first form of manipulation (conscious, deliberate), but may also capture the second, to the extent that the relevant social practices evolve "as if" optimally chosen by the groups concerned, given their objectives.

The particular form of manipulation of information examined in this paper concerns the suppression of "bad signals". Interestingly, one of the early works most often cited by historians of collective memory is concerned precisely with this issue: in his essay, "What is a nation?" (1882), Ernest Renan argued that forgetfulness and even historical error are indispensable for the achievement of national unity[12]. However, the suppression of bad signals examined in this paper can be interpreted much more widely: forgetting is only one way of achieving this. Bad signals can also be effectively suppressed from social memory by offering different interpretations, casting doubt on the accuracy of some, focusing attention on others, proposing favourable comparisons and avoiding potentially unfavourable ones, and so on: the manipulation of collective memory often entails what McBride refers to as "the imaginative reworking of pre-existing materials". Moreover, the rehearsal of good signals can be an equally effective strategy, since it directs attention away from bad signals.

As an illustration, consider the following two examples provided by Gersovits and Reich (1997):

(i) "U.S. collective memory sees Americans as victims of the Vietnam War even though the argument can certainly be made that it was the United States which destroyed Vietnam. But on all counts - the POWs/MIAs, the 58,000 dead and many more wounded, the absence of final victory - the power of the "Vietnam experience" lies precisely in the fact that we Americans regard ourselves as (at least partial) victims of this awful war"

(ii) "[the] notion of having been victimized by the Germans became an indispensable staple of the collective memories of most post-war European peo-

[10]Hobsbawm and Ranger (1983). Their work focuses particularly on the emergence of the western nation-states in the period 1870-1914, during which a variety of "traditions" (national festivals, symbols and rituals) were established, they argue, to provide a sense of continuity with the past and hence legitimacy for the ruling élites. For example, the institution of Bastille Day dates from this period (1880).

[11]See McBride (2001).

[12]Thus, for Renan, French national unity required forgetting the price that was paid in terms of violence and massacres, notably in the Vendée and the Midi.

ples...Thus arose the collective myth of resistance against the Nazis, which Judt[13] believes was essential in legitimating a "feel-good" Europe in which victimization by the Germans became a part of the "foundation myth"...Austrians managed to be declared Nazi Germany's first victims...and the French maintained a fifty-year myth of having been a nation of resistance fighters...the Germans...too defined themselves as victims of the Nazis".

One last example will help to make clear that the importance of the issues discussed in this section is not limited to collective memories of wars and conflicts. Thus Welch (1997), writing about the Renaissance, refers to the work of highly influential nineteenth-century historians Jules Michelet and Jacob Burckhardt as follows: "To these northern European writers, the Italian Renaissance was a fifteenth- and sixteenth-century episode which formed the crucial moment when ideals such as individualism, nationalism, secularism, and capitalist entrepreneurialism were born and then transmitted to the rest of the Western world...Today, however, we must ask whether this vision of a proto-modern Renaissance was...a construction".

In summary, this section's brief review of the related literature outside economics leads to the following conclusions:

(a) the collective memories of each adult generation, which are passed on to its children, are the result of an ongoing process of selection and interpretation of information which reflects that generation's values and aspirations;

(b) this process often entails the suppression of "bad signals", not only through selective "social amnesia", but also through a variety of more creative (manipulative) strategies of information transmission.

These observations are of obvious interest to economists, as they raise important normative as well as positive questions concerning the transmission of knowledge. These questions are at the heart of the analysis developed in the following sections.

3. The model

This section introduces the simplest version of the model, which will be used to study the benchmark case in section 4. Extensions and other cases will be examined in sections 5 and 6.

The model has three dates, $t = 0, 1, 2$, and three players, a "principal" P and two identical "agents", A_i and A_j.The principal represents the first generation ("old"), while the agents represent the second generation ("young"): for simplicity, all players are assumed to be risk-neutral. Information is transmitted by the

[13] See Judt (1992).

principal to the agents at date 0; given this information, the agents at date 1 have to make their investment ("effort") decisions, which may be thought of as investments in human capital in a broad sense, including the learning of social norms and values, as well as language, communication skills, social interaction skills, culture, scientific and technical knowledge, and so on. The returns from these investments are realised at date 2. The structure with one principal representing the first generation and two identical agents representing the second can be given various interpretations: in what follows I shall focus primarily on the interpretation of the principal as "the state", and the agents as two "representative" individuals belonging to the younger generation. This basic version of the model will be extended in later sections to allow for multiple principals, and for heterogeneous agents.

The agents' preferences are described by the following utility function:

$$U_i = mx_i + gmx_j - cx_i \tag{3.1}$$

where $x_i \in [0, 1]$ denotes agent A_i's investment (effort) decision: if the agent invests in the cooperative project (exerts effort), $x_i = 1$; if the agent does not invest (exerts no effort), $x_i = 0$. The variable m represents the value of the "social capital" passed on from the "old" to the "young" generation, which in my definition includes institutions, culture, history, language, values, norms, the notion of a shared identity, and other such social assets which affect the young generation's ability to succeed in the cooperative project. A higher value of m (richer stock of social capital) increases the returns from both agents' investments. Moreover, the constant g is assumed to be strictly positive, so that each agent benefits to some degree from the cooperative investment (effort) of the other agent: it is this externality which will create the potential for some welfare-enhancing manipulation of information transmission, as will become clear below. Each agent incurs an effort cost c if he invests in the cooperative project. This may be interpreted literally as an effort cost (e.g. the effort of learning, of respecting social norms), but also as an opportunity cost (reflecting the attractiveness of other options, e.g. leisure, crime).

I shall assume that the principal fully internalises the agents' welfare. Thus his utility is simply equal to the sum of the agents' individual utilities:

$$U_p = U_i + U_j = (m + gm - c)(x_i + x_j) \tag{3.2}$$

This specification provides an interesting benchmark because it represents perfect altruism on the part of the older generation, or equivalently a benevolent social planner (benevolent towards the young); other possibilities will be considered below.

The model's information structure is as follows. At date 0, the principal receives a signal s which is informative about m; this signal will be assumed to be "hard" information (e.g. historical evidence informative about how good those institutions and norms really are). I will assume that the principal cannot simply manufacture a good signal (e.g. invent history), but he can suppress a bad signal, as discussed in section 2: for example, by casting doubt on the reliability of historical records or, more subtly, by providing alternative interpretations, and by advertising and emphasizing good signals while failing to do the same for bad signals (think of the choice of schools' curriculum, but also potentially the role of the media, the arts, etc.). A bad signal may correspond to a change for the worst, relative to the past: in this case, if the current situation is publicly observable, the bad signal can nevertheless be suppressed by suppressing accurate records (memories) of the previous (better) situation, thereby eliminating the possibility of unfavourable comparisons.

For simplicity, I shall focus on the case where s can take just two values: $s = B$ ("bad" signal) and $s = \emptyset$ (no signal). The expected value of m conditional on each possible realisation of the true signal s is given by:

$$m_L = E[m|s = B] < m_H = E[m|s = \emptyset] \tag{3.3}$$

The problem for the young is that they do not observe the signal s before they have to make their effort (investment) decisions: they therefore rely on the information transmitted by the older generation. At the same time, they do not rely on such information blindly (naively), and they are aware of the possibility that the older generation may manipulate the information it transmits to them in order to manipulate their beliefs and thereby affect their investment decisions (see below).

Let $\hat{s}$ be the signal transmitted by the principal to the agents (public communication, "hard" information). Given our assumptions, if the true signal is $s = \emptyset$, there is no opportunity for signal manipulation; thus $\hat{s} = \emptyset$. On the other hand, if the true signal is $s = B$, the principal may either communicate the signal truthfully to the agents ($\hat{s} = B$), or he may decide to suppress the bad signal ($\hat{s} = \emptyset$). Given the information transmitted by the principal at date 0, the agents at date 1 have to make their respective investment decisions. At this date, and before choosing his effort, each agent learns the cost of effort, c. I assume that this is not known at date 0: this is a convenient way of allowing for some uncertainty at date 0 which is resolved at date 1, so that when the principal decides which signal to transmit to the agents he cannot know with certainty the impact that his decision will have on the agents' effort choices, and its welfare implications. However, he knows that the effort cost c has a continuous distribution $F(c)$ over the interval $[c_L, c_H]$, with density $f(c) > 0$. To make the analysis interesting, I will make the following assumption:

$$c_L < m_L < m_H < c_H \tag{3.4}$$

implying that, regardless of the information transmitted by the principal, there is a strictly positive ex-ante probability that the agents will exert effort ex post, and a strictly positive ex-ante probability that they will not. Finally, I assume, for simplicity, that the value of g is public information: that is, the principal and the agents all know the magnitude of the externalities associated with each agent's investment decision.

4. The role of the state in a mono-cultural society

This section examines the implications of the benchmark case outlined in section 3, with a single principal and two identical agents. Consider to begin with the agents' decisions at date 1, in the light of the information then available to them. Each agent has to form expectations over the returns from exerting effort, hence over m. In doing so, the agents will take into account the possibility that the signal transmitted by the principal may be manipulated, relative to the true signal s. Let the agents' prior beliefs concerning the true signal be described by the probability q; that is, the agents believe that $s = \emptyset$ with probability q and $s = B$ with probability $1-q$ (these "uninformed" beliefs will be based on whatever information is readily apparent to everyone, including the young). When they receive the principal's signal, $\hat{s}$, the agents have to assess its reliability, based on their beliefs concerning the true signal and their beliefs concerning the communication strategy (truthful or otherwise) used by the principal. Given our assumptions, the principal's *communication strategy* can be described by the probability h that the principal will truthfully communicate the bad signal:

$$h = \Pr[\hat{s} = B | s = B] \tag{4.1}$$

The agents' beliefs concerning the principal's communication strategy will be denoted by h^*: thus a high value of h^* corresponds to a high level of "trust" between the older and the younger generation, and conversely a low value of h^* implies that the young give a relatively low weight to the information transmitted by the older generation in forming their beliefs. In the limit, when $h^* = 0$, the young regard the signal transmitted by the old as completely uninformative.

I will assume that the agents update their beliefs according to Bayes' rule, which captures the idea that the young cannot simply be fooled into believing anything the older generation wishes them to believe. Thus if the principal transmits the signal $\hat{s} = \emptyset$, the agents estimate the following probability that the signal is accurate (the signal's "*reliability*"):

$$r^* = \Pr[s = \emptyset | \hat{s} = \emptyset; h^*] = \frac{q}{q + (1-q)(1-h^*)} \tag{4.2}$$

implying that their expected value of m is given by:

$$m(r^*) = r^* m_H + (1 - r^*) m_L \tag{4.3}$$

When will the agents provide effort? Given the principal's signal $\hat{s}$, each agent will provide effort (invest in the cooperative project) if, and only if:

$$E[m|\hat{s}] \geqslant c \tag{4.4}$$

We can immediately see that the principal may have an incentive to manipulate the information he communicates to the agents by considering his expected utility when the true signal is s and he transmits the signal $\hat{s}$:

$$E(U_p|s, \hat{s}) = \int_{c_L}^{E[m|\hat{s}]} 2\{(1+g)E[m|s] - c\} dF(c) \tag{4.5}$$

If the principal could simply *choose* the agents' beliefs, he would clearly set them equal to:

$$E[m|\hat{s}] = (1+g)E[m|s] \tag{4.6}$$

Thus as long as $g > 0$, the *principal would like the agents to be optimistic* about the value of social capital; that is, to form higher expectations than they would if they could observe the true signal s. The reason is of course that when $g > 0$, each agent's decision to invest in the cooperative project exerts a positive externality on the other agent, but neither agent takes this into account when choosing his effort. If the agents are accurately informed about the true signal, the result is an under-provision of effort relative to the social optimum. By manipulating the agents' beliefs and increasing their confidence in the value of social capital, the principal could correct this under-provision of effort.

However, the principal cannot simply choose the agents' beliefs. We must therefore examine the relationship between the principal's communication strategy, h, and the agents' beliefs and investment decisions.

4.1. What to do with bad signals: tell the truth or cover up?

Suppose the principal observes the "bad" signal ($s = B$) at date 0. If he transmits the signal accurately to the agents ($\hat{s} = B$), his expected utility is given by:

$$SW_T(m_L) = \int_{c_L}^{m_L} 2\{(1+g)m_L - c\} dF(c) \tag{4.7}$$

where the subscript T stands for "telling the truth". If on the other hand the principal suppresses the bad signal ($\hat{s} = \emptyset$), his expected utility depends on the agents' beliefs about the reliability of the principal's signal, r^*,and is given by:

$$SW_C(m_L, r^*) = \int_{c_L}^{m(r^*)} 2\{(1+g)m_L - c\}dF(c) \tag{4.8}$$

where the subscript C stands for "cover up". The net gain from "covering up" the bad signal is therefore equal to:

$$SW_C(m_L, r^*) - SW_T(m_L) = \int_{m_L}^{m(r^*)} 2\{(1+g)m_L - c\}dF(c) \tag{4.9}$$

If $m(r^*) > (1+g)m_L$, the net gain can be written as follows:

$$\int_{m_L}^{(1+g)m_L} 2\{(1+g)m_L - c\}dF(c) - \int_{(1+g)m_L}^{m(r^*)} 2\{c - (1+g)m_L\}dF(c) \tag{4.10}$$

The first integral represents the gains from "covering up" the bad signal: by inducing greater optimism about the value of social capital and hence about the returns from investment, suppression of the bad signal elicits more effort and thereby corrects the under-provision of effort due to the presence of externalities between the agents. However, optimism can go too far: the second integral represents the loss from excessive optimism, which leads agents to provide too much effort (i.e. provide effort even in those states of nature - cost realisations - in which it would be socially optimal not to provide effort).

The net gain from suppressing the bad signal is clearly increasing in g, the magnitude of the externalities between the two agents, and decreasing in r^*, the agents' beliefs about the reliability of the principal's signal. Thus when the agents' "trust" is high (high value of r^*), the principal's net gain from manipulating information (suppressing the bad signal) tends to be lower, because there is a greater danger of excessive optimism: this suggests the possibility of multiple equilibria with different degrees of trust. On the other hand, for sufficiently large values of g (sufficiently important externalities), the net gain from manipulating information will always be strictly positive, irrespective of the agents' beliefs: in this case "high trust" equilibria cannot be sustained. The intuition just outlined is confirmed by Proposition 1 below, which characterises the set of Perfect Bayesian equilibria (PBEs)[14].

Proposition 1 *There exist g_H and g_L, with $g_H > g_L > 0$, such that:*

[14]Details of the principal's optimisation problem, as well as the definition of PBE, are relegated to Appendix 2 for ease of exposition.

(i) *For all* $g > g_H$*, there is a unique PBE with* $h^* = 0$;

(ii) *For all* $g < g_L$*, there is a unique PBE with* $h^* = 1$;

(iii) *For all* $g \in [g_L, g_H]$*, there are three PBEs: (a)* $h^* = 0$*, (b)* $h^* = 1$*, and (c)* $h^* = h(g)$*, where* $h(g)$ *increases from* 0 *to* 1 *as* g *increases from* g_L *to* g_H.

Proof: see Appendix 1.

Proposition 1 indeed confirms our intuition concerning the possibility of multiple equilibria: for intermediate values of g, both "high-trust" ($h^* = 1$) and "low-trust" ($h^* = 0$) equilibria are feasible, as well as equilibria with an intermediate degree of trust. For high values of g, on the other hand, only low-trust equilibria are feasible: when the externalities between the two agents are sufficiently important, the only credible strategy for the principal is to suppress the bad signal. For sufficiently low values of g, the opposite is true: the loss from over-investment would exceed any gain from the correction of under-investment; thus the principal's optimal strategy is always to tell the truth, and the only equilibria are high-trust equilibria.

Interpretation and discussion

We can now go back to our interpretation of the principal as "the state". The results so far have a number of interesting implications for its role in the intergenerational transmission of knowledge. We have shown that if the state's objective is to maximise the welfare of the younger generation, it will choose to cover up bad signals when the externalities generated by individual decisions to invest in the cooperative project are sufficiently important. Thus "telling the whole truth" is not always an optimal strategy: in some cases it is better to manipulate the information transmitted to the young in order to foster optimism about the value of social capital and hence about the returns from investment. This leads to a higher provision of effort than would be the case with truthful information transmission, thereby counteracting the tendency for individuals to under-provide effort because they do not take into account the positive externalities their effort exerts on others.

While the results have been obtained under the assumption that the state is only concerned with maximising the younger generation's welfare, it is straightforward to extend the analysis to allow for a direct impact on the older generation's welfare (as opposed to the indirect impact due to the fact that the older generation may, at least to some degree, care for the well-being of the younger generation). In practice, the younger generation's investment in the cooperative project will imply some costs (time, effort and resources) for the older generation; at the same time, the older generation will reap some benefits from these investments. The net direct benefits to the older generation therefore represent an important additional, intergenerational externality, with qualitatively similar implications to those associated with the intragenerational externalities examined earlier. Specifically, if the net direct benefits to the older generation are strictly positive (negative), the net gains from covering up bad signals will be correspondingly higher (lower). This extension of the model could also be used to analyse the effect of additional expenditures, incurred by the older generation, to encourage investment in the co-operative project by the young (e.g. expenditures on institutional improvements that increase the expected returns from investment, and/or reduce the effort cost).

A second implication of the results summarised in Proposition 1 is that low-trust equilibria may be better than high-trust equilibria in terms of welfare. For sufficiently high values of g (large externalities), low-trust equilibria are the only possible equilibria, and they imply a higher level of social welfare than the high-trust equilibria associated with lower values of g. Moreover, for intermediate values of g, there exist multiple equilibria, with low-trust equilibria which are strictly better in terms of social welfare than the corresponding high-trust equilibria (i.e. holding the value of g constant). Thus a high degree of scepticism on the part of the young concerning the reliability of the information transmitted by the state need not mean that the society is trapped in a "bad" (low social welfare) equilibrium. Moreover, if a society evolves in such a way that the externalities generated by individual agents' effort (investment) decisions become more important, one could observe a transition from a high-trust equilibrium, in which the young have a great deal of confidence in the reliability of the information provided by the state, to a low-trust equilibrium, in which the young are far more sceptical, and social welfare is nevertheless higher.

However, this can only be the case if the information available to the state represents a "bad" signal ($s = B$), as assumed in this section so far. The implications of a high or low level of trust are of course very different when the information available to the state represents a "good" signal ($s = \emptyset$). In this case, it is easy to verify that, for any given value of g, social welfare when trust is high ($h^* = 1$) is strictly higher than social welfare when trust is low ($h^* = 0$). Distrust of the state is costly in this case because it means that the young give no weight to the (truthful) good signal, and as a consequence invest too little. Clearly, therefore, if the state could credibly restrict its own ability to suppress "negative" information, it could have a beneficial effect on investment, by increasing the perceived reliability of the good signal. On the other hand, such a restriction would obviously reduce the possible gains from manipulating information when the signal is bad.

One possible source of effective constraints on the state's ability to manipulate information is the presence of alternative (credible) sources of information: the next section analyses the implications of close family ties from this perspective.

5. Multiple principals in a mono-cultural society: the different roles of parents and the state

The benchmark analysis developed in section 4 was based on the assumption that the older generation could be represented by a single principal: a natural interpretation for this principal was of course "the state", which may be thought of as embodying the "collective will" of the older generation. This section extends the analysis by allowing for greater heterogeneity within the older generation; specifically, I investigate the different roles of parents and the state.

5.1. The model: modifications

In terms of the model, the extension requires introducing multiple principals. I shall retain the original players of section 4, namely a principal P and two identical agents A_i and A_j, and add two additional players, principals P_i and P_j. Principal P represents the state, while P_i and P_j are the parents of A_i and A_j, respectively. To focus attention on the consequences of allowing for multiple principals, I continue to make the same assumptions as in section 4 concerning P, A_i and A_j: specifically, they have the same preferences (described by equations (3.1) and (3.2)), and possess the same information as in section 4.

The question is then what assumptions to make concerning the preferences and information set of P_i and P_j. For simplicity, I shall assume that each parent fully internalises the utility of her[15] child:

$$U_{P_i} = U_i = mx_i + gmx_j - cx_i \tag{5.1}$$

While this may be extreme, it captures the very plausible notion that each parent will give a higher weight to her own child's welfare, and correspondingly lower weight to other children's welfare, than the state. Other assumptions concerning the parents' utility functions will be discussed below.

As for the information set, the state can typically obtain more and better information than the average parent, who is much more constrained in terms of the time and resources she can devote to gathering and interpreting information (and in terms of the power to obtain access to certain types of information). I model the state's informational advantage relative to individual parents as follows. The state (P) receives the "true" signal, s; parents, however, only observe whether the true signal is bad with probability w $(1 > w > 0)$. Formally, each parent receives a a coarser signal, s_p, such that if $s = \emptyset$, $s_p = \emptyset$; if $s = B$, $s_p = B$ with probability w, and otherwise $s_p = \emptyset$. The signal s_p can be thought of as information that was

[15] For expositional convenience, I shall refer to each parent as "she" and each child as "he" from now on.

publicly available to the older generation. In this case, the state will be aware that the information was publicly available, and will be able to condition its own (public) communication strategy on the signal received by parents.

Given the parents' assumed preferences, each parent will communicate her signal truthfully to her child[16]. It is therefore pointless for the state to suppress the bad signal when it knows the signal has also been received by parents. The state's communication strategy is then given by the probability j that it will communicate truthfully the bad signal when the signal has not been received by parents:

$$j = \Pr[\hat{s} = B | s = B, s_p = \emptyset] \tag{5.2}$$

Letting "uninformed" beliefs be represented by the probability q as in section 4, the reliability of a "good" signal is now given by:

$$r_j^* = \Pr[s = \emptyset | \hat{s} = \hat{s}_p = \emptyset; j^*] = \frac{q}{q + (1-q)(1-w)(1-j^*)} \tag{5.3}$$

where j^* represents the agents' beliefs concerning P's communication strategy.

5.2. Parents and the state

We can now apply the same analysis[17] as in section 4, to obtain an analogous result:

Proposition 2 *There exist G_H and G_L, with $G_H = g_H$* and *$G_L > g_L$, such that:*

(i) *For all $g > G_H$, there is a unique PBE with $j^* = 0$;*

(ii) *For all $g < G_L$, there is a unique PBE with $j^* = 1$;*

(iii) *For all $g \in [G_L, G_H]$, there are three PBEs: (a) $j^* = 0$, (b) $j^* = 1$, and (c) $j^* = j(g)$, where $j(g)$ increases from 0 to 1 as g increases from G_L to G_H.*

Proof: as for Proposition 1. The only difference is that
$r_j \in [\frac{q}{q+(1-q)(1-w)}, 1]$, so that $G_H = G(1) = g_H$,
while $G_L = G(\frac{q}{q+(1-q)(1-w)}) > G(q) = g_L$.

Proposition 2 shows that the value of the externality g below which we have a unique PBE with truthful communication is higher in the multi-principals case examined here than in the single-principal case analysed in the previous section ($G_L > g_L$). The reason is that the reliability of the good signal (r_j^*) cannot

[16] Thus it does not matter whether we assume that the signal s_p is "soft" or "hard" information.

[17] Details are available in Appendix 2.

fall below a threshold level which is strictly higher than the corresponding level for the single-principal case. Thus for values of g in the range $g_L \leqslant g < G_L$, we have multiple equilibria in the single-principal case, including equilibria with partial or total suppression of the bad signal; in the multi-principals case, the unique equilibrium entails truthful communication. This is one sense in which the presence of principals P_i and P_j who communicate truthfully with agents A_i and A_j, respectively, restricts P's ability to manipulate information in equilibrium. The other restriction is the obvious one: in the presence of P_i and P_j, irrespective of P's communication strategy, the agents will always receive the (true) bad signal with strictly positive probability ($w > 0$).

This suggests that having a single principal, P, might be (weakly) preferred when the true signal is bad, while having multiple principals, P, P_i and P_j, might be (weakly) preferred when the true signal is good. The following Proposition investigates this intuition.

Proposition 3 *(a) Suppose $g > g_H$. Then: (i) if $s = \emptyset$, social welfare is strictly higher with multiple principals P, P_i and P_j than with a single principal P; (ii) if $s = B$, and the effort cost c is uniformly distributed, social welfare is strictly higher with a single principal than with multiple principals. But there exist distributions $F(c)$ for which social welfare is strictly higher with multiple principals.*

(b) Suppose $g_L \leqslant g < G_L$. Then: (i) if $s = \emptyset$, social welfare is (weakly) higher with multiple principals than with a single principal; (ii) if $s = B$, social welfare is (weakly) higher with a single principal.

(c) Suppose $g < g_L$. Then social welfare is the same irrespective of whether there is a single principal or multiple principals.

Proof: see Appendix 1.

Interpretation and discussion

This result confirms to some extent our original intuition, but also provides additional insights. When social externalities are sufficiently low ($g < g_L$), it clearly does not matter whether we have a single principal or multiple principals: truthful communication is the unique equilibrium strategy in both cases. For the intermediate range $g_L \leqslant g < G_L$, having multiple principals rules out the equilibria associated with partial or total suppression of the bad signal, which exist in the single-principal case. This may be beneficial when the true signal is good (the state can commit to truthful communication, thereby avoiding welfare losses due to distrust), and detrimental when the true signal is bad (social welfare is higher in the equilibria where the signal is suppressed). These results are in line with the intuition mentioned above.

When social externalities are sufficiently high ($g > g_H$), the intuition has to be developed a little further. The state's optimal strategy in this case is always to suppress the bad signal, if it can. Close links between parents and children restrict its ability to do so, which makes "good news" ($\hat{s} = \emptyset$) more credible. As we would expect, this is welfare-enhancing when the true signal is good. But it need not reduce welfare even when the true signal is bad. The reason is that there are two effects at work. First, with probability w, the bad signal is communicated truthfully to the agents: this reduces welfare because it discourages investment for cost realisations in the range $[m_L, m(q)]$. Second, with probability $1-w$, the bad signal is suppressed, and the enhanced credibility of "good news" encourages investment for cost realisations in the range $[m(q), m(\frac{q}{q+(1-q)(1-w)})]$: this increases welfare[18]. The net effect obviously depends on the distribution function, $F(c)$. If c is uniformly distributed, the first effect dominates, and social welfare is lower with multiple principals. On the other hand, if the distribution function has very little probability mass in the range $[m_L, m(q)]$, and a much greater probability mass concentrated in the range $[m(q), m(\frac{q}{q+(1-q)(1-w)})]$, the result can be reversed, yielding higher social welfare with multiple principals.

What implications does Proposition 3 have for the informational role of parents and the state? We have seen that the presence of close links and high-trust relationships between parents and children acts as a constraint on the state's ability to manipulate information. The constraint does not matter if social externalities are sufficiently low, since there is nothing to be gained by manipulating information. This is no longer the case in the presence of important social externalities. The constraint can then be *detrimental* to social welfare when the true expected value of social capital is *low* (based on all the information available to the state, i.e. $s = B$), because in this case it would be socially desirable to manipulate the information transmitted to the young so as to foster optimism and elicit greater effort[19]. On the other hand, high-trust relationships between parents and children have a *beneficial* impact on social welfare when the true expected value of social capital is *high* (based on the information available to the state, i.e. $s = \emptyset$). In this case, the presence of close links between parents and children enables the state to commit to a lower degree of manipulation of the information transmitted to the

[18] More precisely, it increases welfare whenever $m(\frac{q}{q+(1-q)(1-w)}) < (1+g)m_L$. Otherwise the net effect on welfare is unambiguously negative; see Appendix 1.

[19] As we saw in Proposition 3, the presence of multiple principals may increase welfare even when the true signal is bad, if the distribution function $F(c)$ is highly skewed; however, while worthy of comment in the theoretical discussion, this possibility seems unlikely in practice. The distribution $F(c)$ captures the uncertainty over the effort (opportunity) cost of investing in the cooperative project for the "representative" member of the younger generation. This cost will be affected, for example, by technological factors, but there is no reason to believe, a priori, that relatively high cost realisations are much more likely than relatively low cost realisations.

young, which makes "good news" more credible and alleviates the under-provision of effort due to distrust of the state.

Obviously the state cannot determine the nature of family relationships and the degree of closeness and trust that exist between parents and children. Nevertheless, the state can and does adopt a variety of policies that affect families, supporting or undermining close family ties (think of taxes and benefits, childcare, parental leave...): the informational implications of these policies have received relatively little attention. At the same time, the state may also be able to influence w, by making it easier or harder for parents to obtain relevant information (e.g. disclosure policies). Proposition 3 suggests that the state may have an incentive to support (undermine) close links between parents and children, and facilitate (hinder) parental access to information, when the signal s is good (bad) - to the extent that the younger generation cannot observe and correctly interpret the state's actions.

What if parents are biased? For example, they may be biased in favour of investment in the cooperative project by their children, for ideological reasons, or reasons of social esteem. Conversely, they may be biased against, because they perceive the net direct benefits to themselves as negative, and they are not (very) altruistic. The model can easily be modified to allow for these possibilities. If parents are sufficiently biased in favour of investment, they will never disclose the bad signal; the possible equilibria in this case are described by Proposition 1 (assuming that the children, as well as the state, are aware of the bias). If parents are biased against investment, the most they can do is to transmit the bad signal to their children when they receive it, yielding the equilibrium outcomes described in Proposition 2.

What if the state is biased instead? For example, it may be that the true signal s is informative about the state's past performance, so that the state has a vested interest in suppressing a bad signal even when social externalities are small, which leads to over-investment. Clearly in this case there will be further gains from close family ties, to the extent that they limit the scope for manipulation of information.

Finally, although I have focused on the informational role of parents, the same approach could be applied to study the role of other "principals" as possible sources of information (e.g. the media; teachers; opposition political parties - particularly in an adversarial political system), identifying their preferences and the information available to them, and hence deriving their implications for equilibrium outcomes and social welfare.

6. Collective memory and cultural heterogeneity

What is the role of the state in the intergenerational transmission of knowledge when different members of society have different cultural identities? What is the role of communities? I now modify the model to investigate these issues.

6.1. The model: modifications

I retain the basic structure of the model of section 3, that is, two agents, A_i and A_j, and one principal, P, who represents the state. However, the two agents are no longer assumed to be identical: each agent belongs to a different "cultural group" (has a different "cultural identity"). The agents' preferences are described by the following utility function:

$$U_i = m_i x_{ii} + b m_j x_{ij} + g m_i x_{ji} - c(x_{ii} + x_{ij}) \tag{6.1}$$

where m_i and m_j represent the social capital of the two cultural groups (language, history, norms and so on). Each agent now has to take two decisions: whether to invest in his own culture (that of his cultural group), and whether to invest in the other culture. For agent A_i (agent A_j), denote by x_{ii} (x_{jj}) the effort he devotes to learning about his own culture, and by x_{ij} (x_{ji}) the effort he devotes to learning about the other culture. The net benefits from investing in a given culture will depend partly on that culture's social capital (as in sections 4 and 5), and partly on the cultural identity of the agent who invests. Thus if agent A_i invests in learning about culture j, he may face higher costs and/or reap lower benefits than if agent A_j makes an equivalent investment: for example, because agent A_j's parents belong to cultural group j, and can more easily communicate knowledge of their own culture to their child (thereby reducing the agent's learning costs), and because agent A_j has greater opportunities to interact with members of cultural group j (which reduces his costs and increases his benefits from learning about culture j). This possible difference is captured by the parameter b: if $b < 1$, there is a comparative disadvantage in learning a culture other than one's own; the disadvantage disappears for $b = 1$. Clearly the value of b can be affected by a variety of policies; I shall return to this point below. However, for now I shall assume that b is given exogenously, in order to focus on the state's role in the transmission of knowledge. Similarly the effort (opportunity) cost c is assumed to be given exogenously. Moreover, I assume that ex ante the cost is uniformly distributed over the interval $[0, 1]$ for both agents (i.e. both cultural groups), in order to have as much symmetry as possible between the two agents (groups). This will provide a clear benchmark analysis, and allow me to focus on the implications of asymmetric signals in an otherwise symmetric setting, as discussed below. Finally, the parameter $g > 0$ now captures the externality exerted by each agent on the other when it invests in the other's culture.

I shall assume that the state gives equal weight to each cultural group; this represents a natural benchmark case. The state's utility will be given by:

$$U_p = U_i + U_j + Vm_i x_{ii} + Vm_j x_{jj} \tag{6.2}$$

The state therefore maximises the sum of the two agents' utilities, plus two terms reflecting the fact that each agent's decision to invest in his own culture exerts a positive externality, represented by $V > 0$, on other members of his cultural group. This is a convenient way of allowing for the intra-group positive externalities that were studied in section 4 without explicitly modelling the interaction of agents within the same cultural group as well as across cultural groups.

The information structure of the model is modified as follows. P (the state) now receives a two-dimensional signal, $s = [s_i, s_j]$, where s_i is informative about the value of m_i and s_j is informative about the value of m_j. I allow for the possibility of "bad news", "no news" and "good news"; thus $s_k \in [\emptyset, B, G]$ ($k = i, j$). The expected value of m_k ($k = i, j$), conditional on each possible realisation of s_k, is given by:

$$m_L = E[m_k|s_k = B] < m_M = E[m_k|s_k = \emptyset] < m_H = E[m_k|s_k = G] \tag{6.3}$$

where $0 < m_L < m_H < 1$. I assume that "good news" and "bad news" are symmetric relative to "no news", in the sense that m_L and m_H are equidistant from m_M:

$$m_L + z = m_M = m_H - z \tag{6.4}$$

for some $z > 0$.

As noted in the introduction, I am particularly interested in studying the state's optimal communication strategy in the presence of "mixed news": that is, a signal which is good news about the social capital of one group but simultaneously bad news about the other group's social capital. Disclosure of such signals clearly has an asymmetric impact on the two cultural groups, and is therefore an important issue to study in the context of multi-cultural societies. Moreover, signals can easily represent "mixed news" in the sense of this paper: recollections of the achievements and successes of one group often draw attention, implicitly or explicitly, to the failures, or more simply the lack of achievements, of another group. This potential problem manifests itself in a particularly severe and striking form in situations of conflict between groups; see, for example, McBride (2001) for a very interesting account of the (very different) collective memories of Catholics and Protestants in Northern Ireland.

To investigate the issue of mixed news, I shall focus on the case where s can take just four possible values: $s \in \{[\emptyset, \emptyset], [B, B], [B, G], [G, B]\}$. Thus the principal may receive no signal about either m_i or m_j; he may receive a bad signal about both, or he may receive a signal which is bad for one and good for the other. This is the simplest framework I can use to study the issues of interest. I continue to assume that the principal cannot simply manufacture a signal; on the other hand he can suppress a signal. Thus if the true value of s is $[\emptyset, \emptyset]$, the principal has no scope for manipulating the information he transmits to the agents: $\hat{s} = [\emptyset, \emptyset]$. However, if the principal receives a signal $s \in \{[B, B], [B, G], [G, B]\}$, he can either communicate the signal truthfully to the agents, or suppress it (in the latter case, $\hat{s} = [\emptyset, \emptyset]$).

The principal's communication strategy therefore consists of three probabilities, h_{BB}, h_{GB} and h_{BG}, defined by:

$$h_{BB} = \Pr\{\hat{s} = [B, B] \,|s = [B, B]\} \tag{6.5}$$

$$h_{BG} = \Pr\{\hat{s} = [B, G] \,|s = [B, G]\} \tag{6.6}$$

$$h_{GB} = \Pr\{\hat{s} = [G, B] \,|s = [G, B]\} \tag{6.7}$$

As for beliefs, I assume full symmetry between the agents (again, as a benchmark); that is, they share the same "uninformed" beliefs before they receive the principal's signal[20].

6.2. Multi-cultural societies: mixed-news signals

This section investigates the issue of mixed-news signals discussed above. Suppose the principal receives such a signal; for example, $s = [G, B]$. If he communicates the signal truthfully to the agents, his expected utility is equal to:

$$\begin{aligned} & SW_T(m_H, m_L) && (6.8)\\ = & \int_0^{m_H} [m_H(1+V) - c]\, dc + \int_0^{m_L} [m_L(1+V) - c]\, dc && (6.9)\\ & + \int_0^{bm_L} [(b+g)m_L - c]\, dc + \int_0^{bm_H} [(b+g)m_H - c]\, dc && (6.10) \end{aligned}$$

[20]Further details about this version of the model can be found in Appendix 2.

If the principal suppresses the true signal, his expected utility is given instead by the following expression:

$$SW_C(m_H, m_L) \tag{6.11}$$
$$= \int_0^{m_i(r^*)} [m_H(1+V) - c]\, dc + \int_0^{m_j(r^*)} [m_L(1+V) - c]\, dc \tag{6.12}$$
$$+ \int_0^{bm_j(r^*)} [(b+g)m_L - c]\, dc + \int_0^{bm_i(r^*)} [(b+g)m_H - c]\, dc \tag{6.13}$$

Thus the net gain from suppressing the mixed-news signal is equal to:

$$SW_C(m_H, m_L) - SW_T(m_H, m_L) \tag{6.14}$$
$$= -\int_{m_i(r^*)}^{m_H} [m_H(1+V) - c]\, dc + \int_{m_L}^{m_j(r^*)} [m_L(1+V) - c]\, dc \tag{6.15}$$
$$+ \int_{bm_L}^{bm_j(r^*)} [(b+g)m_L - c]\, dc - \int_{bm_i(r^*)}^{bm_H} [(b+g)m_H - c]\, dc \tag{6.16}$$

The first term in expression (6.15) represents the effect on agent A_i's decision to invest in his own culture: suppressing the true signal, which was "good news" about the value of m_i, reduces A_i's incentives to invest, leading to an under-provision of effort. This term therefore represents a net loss from the suppression of the true signal. The second term shows the effect on agent A_j's decision to invest in his own culture: suppressing the true signal, which was "bad news" about m_j, increases his incentives to invest, which mitigates the under-provision of effort due to the presence of positive externalities ($V > 0$) among members of A_j's cultural group. However, if $m_j(r^*) > (1+V)m_L$, there will be an over-provision of effort. The net gain from this second effect is therefore analogous to the one examined earlier, in section 4, and is increasing in V, the magnitude of the intra-group externalities.

There are two additional "cross-cultural" effects. Expression (6.16) shows the effect on each agent's decision to invest in the other agent's culture. Suppressing the true signal increases A_i's cross-cultural investment and reduces A_j's cross-cultural investment. If we assume that $bm_j(r^*) > (b+g)m_L$, we can write expression (6.16) as follows:

$$\int_{bm_L}^{(b+g)m_L} [(b+g)m_L - c]\, dc - \int_{(b+g)m_L}^{bm_j(r^*)} [c - (b+g)m_L]\, dc \tag{6.17}$$

$$-\int_{bm_i(r^*)}^{bm_H} [(b+g)m_H - c]\, dc \tag{6.18}$$

This makes clear the different effects at work. The first term represents the gain from agent A_i's greater optimism about the other culture, which corrects the tendency to under-invest due to the presence of positive cross-cultural externalities. The second term represents the loss from A_i's excessive optimism about the other culture, which leads him to over-invest. Finally, the last term represents the loss from agent A_j's under-investment in the other culture.

The following result characterises the state's optimal communication strategy:

Proposition 4 *Suppose the principal receives the signal $s = [G, B]$. Then he will always communicate the signal truthfully to the agents : $\hat{s} = [G, B]$* (i.e. $h_{GB} = 1$).

Proof: see Appendix 1.

Given the symmetry of the problem, the same obviously applies when the principal receives the signal $s = [B, G]$: in this case, $\hat{s} = [B, G]$. Thus the principal's optimal communication strategy when he receives a "mixed news" signal is to transmit the signal truthfully to the agents. It follows that the only circumstances in which there is a potential for beneficial manipulation of the information transmitted to the agents are those corresponding to receipt of a signal which is "bad news" for both cultures, i.e. $s = [B, B]$. In this case, as in the mono-cultural case analysed in section 4, suppression of the true signal can be welfare-enhancing, provided social externalities (within each cultural group and between cultural groups) are sufficiently important.

Interpretation and discussion

The intuition for the result summarised in Proposition 4 is that the marginal productivity of investment is higher for the culture with the richer social capital (higher value of m); thus under-investment in that culture is more costly in terms of social welfare than under-investment in the culture with the poorer social capital. Accurate public transmission of the true signal s is therefore needed to provide efficient investment incentives to both agents.

What are the welfare implications for each cultural group? These can easily be seen by comparing the expected utility of each agent when the signal is $s = [G, B]$. Agent A_i's expected utility in this case is given by:

$$E[U_i] = \int_0^{m_H} [m_H - c]\, dc + \int_0^{bm_L} [bm_L - c]\, dc \tag{6.19}$$

$$+ \int_0^{bm_H} [gm_H] dc \tag{6.20}$$

while agent A_j's expected utility is equal to:

$$E[U_j] = \int_0^{m_L} [m_L - c]\, dc + \int_0^{bm_H} [bm_H - c]\, dc \qquad (6.21)$$

$$+ \int_0^{bm_L} [gm_L] dc \qquad (6.22)$$

If $b = 1$, the sum of the first two terms in each of the above expressions has the same value, but agent A_i is strictly better off because he obtains a higher benefit from the presence of positive cross-cultural externalities. If $b < 1$, there is an additional effect which further reduces A_j's expected utility relative to A_i's, due to the fact that A_i has a comparative advantage in investing in the culture with the higher value of social capital (hence higher marginal productivity of investment). It is easy to verify that the value of intra-group externalities will also be higher for cultural group i than for group j.

Thus the group whose social capital is poorer will be worse off than the group whose social capital is richer. The state may therefore want to implement, for example, policies designed to increase the value of b (hence the returns from cross-cultural investments), together with various forms of transfers to help the disadvantaged group. However, attempts by the state to encourage cross-cultural investments may encounter considerable opposition at the level of the cultural groups, concerned that cross-cultural investments will undermine group identity and cohesion. The groups may therefore adopt information strategies which have the opposite effect, encouraging own-cultural and discouraging cross-cultural investment. The welfare implications of such strategies are themselves of considerable interest. The model can shed some light on these. Consider the example studied above. Assume that agent A_j's cultural group is well-organised and concerned to maximise the welfare of its members, $W_j = U_j + Vm_j x_{jj}$. Moreover, suppose that the group can influence the signal received by A_j: in particular, it can "filter" the signal transmitted by the state so as to suppress any bad signal about m_j. Thus if the state transmits the signal $\hat{s} = [G, B]$, group j can ensure that agent A_j receives a "filtered" signal, $\hat{s}^F = [\emptyset, \emptyset]$. This might be achieved by casting doubt on the reliability of the state as a source of information, by offering a different interpretation of the evidence, and so on (as discussed in section 2). Denote by m_k^l ($k = i, j$; $l = i, j$) agent A_l's expectation of the value of group k's social capital, conditional on receiving a "no news" signal ($[\emptyset, \emptyset]$): this will obviously depend on the agent's beliefs not only about the state's communication strategy, as before, but also about his group's "filtering" strategy. Notice that $m_H > m_k^l > m_L$.

It can be easily verified that if group j "filters" the state's signal $\hat{s} = [G, B]$, the resulting change in group j welfare is equal to:

$$\Delta W_j = \int_{m_L}^{m_j^j} [m_L - c]\, dc - \int_{bm_i^j}^{bm_H} [bm_H - c]\, dc \tag{6.23}$$

$$+ \int_{m_L}^{m_j^j} [V m_L] dc \tag{6.24}$$

The first two terms in this expression represent the negative effect on agent A_j, who has been induced to increase his own-cultural investment (first integral) and reduce his cross-cultural investment (second integral). The third term represents the positive effect on other members of group j, who benefit from the additional intra-group externalities. The net effect may be positive or negative: it is more likely to be positive if b is small (low returns to cross-cultural investments) and V is large (high intra-group externalities). The corresponding change in social welfare is equal to

$$\Delta SW = \int_{m_L}^{m_j^j} [m_L - c]\, dc - \int_{bm_i^j}^{bm_H} [bm_H - c]\, dc \tag{6.25}$$

$$+ \int_{m_L}^{m_j^j} [V m_L] dc - \int_{bm_i^j}^{bm_H} [g m_H]\, dc \tag{6.26}$$

reflecting the additional negative effect on the welfare of group i, which now benefits less from cross-cultural externalities.

Thus a manipulative information strategy by the disadvantaged group j, which succeeds in suppressing the bad signal about the group's social capital (only) for members of the group, may have a positive effect on group welfare and even on social welfare, provided V is sufficiently large and b and g sufficiently small. The possibility of increasing social welfare arises because this type of information strategy essentially allows society to "unbundle" the signal s, preserving the good own signal for group i while suppressing the bad own signal for group j, which may be desirable in some circumstances. However, if V is small and b is large, such a manipulative strategy can only be costly, both for the group and for society at large. Thus policies that aim to encourage cross-cultural investments by increasing b, if they succeed, may well become self-reinforcing[21].

[21] For expositional simplicity I have ignored the potential for positive intra-group externalities associated with cross-cultural investments by group members: allowing for these would not affect the result described by Proposition 4, but would reduce the possible benefits from a manipulative information strategy by group j of the kind described above, and clearly strengthen the case for policies designed to increase b.

7. Conclusions

This paper studies the transmission of knowledge across generations. It investigates the role of the state in this process, and explains why some manipulation of the information transmitted to the young (the suppression of bad signals) may at times be beneficial, by fostering optimism about the value of social capital and thereby encouraging investments which generate substantial positive social externalities. This may be seen as providing a rationale for certain biases documented by sociologists, psychologists and historians working on collective memory. However, manipulative strategies can also be very costly, by generating distrust of the state in equilibrium, which undermines the credibility of good signals and hence reduces socially beneficial investment and social welfare. Thus the presence of trustworthy sources of information, such as parents, can have both positive and negative effects on social welfare, depending on whether the underlying signal is good or bad.

The scope for beneficial manipulation of information by the state is reduced in multi-cultural societies, where the truthful disclosure of "mixed-news" signals is needed to provide efficient own-cultural and cross-cultural investment incentives. The state may nevertheless be able to implement policies that increase social welfare and reduce cross-cultural inequality by encouraging cross-cultural investments. The paper suggests a number of promising areas for future research. One would involve studying the state's role in the presence of asymmetric cultural groups. This would be interesting from both a normative and a positive point of view. It would also be interesting in future work to relax the simplifying assumption of homogeneity within each cultural group, allowing for the diverse interests of, among others, consumers, workers, employers and political representatives.

8. References

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9. Appendix 1

Proof of Proposition 1

For all $r \in [q,1]$ and $g \geqslant 0$, define:

$$B(r,g) = \frac{1}{2}[SW_C(m_L, r) - SW_T(m_L)] = \int_{m_L}^{m(r)} \{(1+g)m_L - c\} dF(c) \qquad (9.1)$$

Lemma 1. For all $r \in [q,1]$, there exists a unique $G(r) > 0$ such that $B(r, G(r)) = 0$ and:

(i) $B(r,g) > 0$ for all $g > G(r)$, while $B(r,g) < 0$ for all $g < G(r)$;

(ii) $G(r) < \dfrac{r(m_H - m_L)}{m_L}$ and $G(r)$ is strictly increasing in r.

Proof of Lemma 1. For any given r, it is clear from (8.1) that $B(r,g) > 0$ for $g \geqslant \dfrac{r(m_H - m_L)}{m_L}$, while $B(r,0) < 0$. Moreover, for all $g \geqslant 0$, we have

$$\frac{\partial B(r,g)}{\partial g} = \int_{m_L}^{m(r)} m_L dF(c) > 0 \qquad (9.2)$$

This establishes that there is a unique value $G(r)$ such that $B(r, G(r)) = 0$, and that $0 < G(r) < \dfrac{r(m_H - m_L)}{m_L}$. Moreover, it establishes part (i) of Lemma 1. It remains to establish that $G'(r) > 0$. We have:

$$\frac{\partial B(r,g)}{\partial r} = (m_H - m_L)[(1+g)m_L - m(r)]f(m(r)) \qquad (9.3)$$

Moreover, for all $G(r)$ such that $0 < G(r) < \dfrac{r(m_H - m_L)}{m_L}$, we have:

$$m(r) > m_L(1 + G(r)) \qquad (9.4)$$

implying that $\dfrac{\partial B(r,g)}{\partial r} < 0$. Therefore, by the implicit function theorem, $G'(r) > 0$. $\square$

To prove Proposition 1 using Lemma 1, note that:

(i) for all $g > G(1)$ we have, for all $r \in [q,1]$, $G(r) < g$, and therefore $B(r,g) > 0$. Thus the principal's optimal strategy is $h = 0$;

(ii) for all $g < G(q)$ we have, for all $r \in [q,1]$, $G(r) > g$, and therefore $B(r,g) < 0$. Thus the principal's optimal strategy is $h = 1$;

(iii) for $G(q) \leqslant g \leqslant G(1)$, there exists by the lemma a unique inverse function $R(g) \equiv G^{-1}(g)$, such that $B(R(g), g) = 0$. Moreover, the function R is increasing, and for any $r \in [q,1]$, $B(r,g)$ has the sign of $R(g) - r$. This implies that the only equilibrium with $r > R(g)$ is $r = 1$ ($h = 1$), with $B(1, g) < 0$; the only equilibrium with $r < R(g)$ is $r = q$ ($h = 0$), with $B(q, g) > 0$; and finally $r = R(g)$ is an equilibrium, with $h = h(g) \equiv \dfrac{1 - \dfrac{q}{R(g)}}{1 - q}$, and $B(R(g), g) = 0$.

To complete the proof, define $g_H \equiv G(1)$ and $g_L \equiv G(q)$. $\square$

Proof of Proposition 3

(a) Suppose $g > g_H$. Then for each value of g, the unique equilibrium in the single-principal case has $h^* = 0$, and the unique equilibrium in the multi-principals case has $j^* = 0$.

(i) If $s = \emptyset$, social welfare is given by:

$$SW_C(m_H, r^*) = \int_{c_L}^{m(r^*)} 2\{(1 + g)m_H - c\}dF(c) \tag{9.5}$$

in the single-principal case, and by:

$$SW_C(m_H, r_j^*) = \int_{c_L}^{m(r_j^*)} 2\{(1 + g)m_H - c\}dF(c) \tag{9.6}$$

in the multi-principals case, where $r^* = q$ and $r_j^* = \dfrac{q}{q + (1 - q)(1 - w)}$. Thus social welfare is strictly higher with multiple principals.

(ii) If $s = B$, social welfare is given by

$$U^S = SW_C(m_L, r^*) = \int_{c_L}^{m(r^*)} 2\{(1 + g)m_L - c\}dF(c) \tag{9.7}$$

in the single-principal case, and by

$$U^M = wSW_T(m_L) + (1 - w)SW_C(m_L, r_j^*) \tag{9.8}$$

which is equal to

$$w \int_{c_L}^{m_L} 2\{(1 + g)m_L - c\}dF(c) + (1 - w) \int_{c_L}^{m(r_j^*)} 2\{(1 + g)m_L - c\}dF(c) \tag{9.9}$$

in the multi-principals case, where again $r^* = q$ and $r_j^* = \dfrac{q}{q + (1 - q)(1 - w)}$.

We can define $Z(w) \equiv (U^S - U^M)/2$; i.e.

$$Z(w) = w \int_{m_L}^{m(r^*)} \{(1 + g)m_L - c\}dF(c) - (1 - w) \int_{m(r^*)}^{m(r_j^*)} \{(1 + g)m_L - c\}dF(c) \tag{9.10}$$

Clearly $Z(0) = 0$, while $Z(1) = \int_{m_L}^{m(r^*)} \{(1+g)m_L - c\} dF(c) > 0$. Moreover,

$$Z'(w) = \int_{m_L}^{m(r_j^*)} \{(1+g)m_L - c\} dF(c) - (1-w)[(1+g)m_L - m(r_j^*)] dF(m(r_j^*)) \frac{\partial m(r_j^*)}{\partial r_j^*} \frac{\partial r_j^*}{\partial w} \tag{9.11}$$

which can be written as follows:

$$\int_{m_L}^{m(r_j^*)} \{(1+g)m_L - c\} dF(c) - a[(1+g)m_L - m(r_j^*)] dF(m(r_j^*))[m(r_j^*) - m_L] \tag{9.12}$$

where the constant a is defined by $0 < a \equiv \dfrac{(1-w)(1-q)}{q + (1-q)(1-w)} < 1$.

There are two cases to consider.

Case 1. Suppose $m(r_j^*) \geqslant (1+g)m_L$. Then clearly $Z'(w) > 0$ for $0 < w < 1$. Hence $U^S > U^M$.

Case 2. Suppose $m(r_j^*) < (1+g)m_L$. I first show that if c is uniformly distributed over the interval $[c_L, c_H]$, $Z'(w) > 0$. We have:

$$Z'(w) = (\frac{1}{c_H - c_L})\{\int_{m_L}^{m(r_j^*)} [(1+g)m_L - c]dc - a[(1+g)m_L - m(r_j^*)][m(r_j^*) - m_L]\} \tag{9.13}$$

But we know that:

$$\int_{m_L}^{m(r_j^*)} \{(1+g)m_L - c\} dc > \int_{m_L}^{m(r_j^*)} \{(1+g)m_L - m(r_j^*)\} dc \tag{9.14}$$

and

$$\int_{m_L}^{m(r_j^*)} \{(1+g)m_L - m(r_j^*)\} dc = [(1+g)m_L - m(r_j^*)][m(r_j^*) - m_L] \tag{9.15}$$

Hence $Z'(w) > 0$ for $0 < w < 1$, and $U^S > U^M$.

To show that there exist distributions $F(c)$ such that $U^M > U^S$, consider expression (9.10). Clearly the value of the first integral can be made very small by having very little probability mass in the range $[m_L, m(r^*)]$, while the value of the second integral can be made large by having sufficient probability mass in the range $[m(r^*), m(r_j^*)]$.

(b) Suppose $g_L \leqslant g < G_L$. Then there is a unique equilibrium in the multi-principals case, with $j^* = 1$. In the single-principal case, there are three equilibria:

(a) $h^* = 0$, (b) $h^* = 1$, and (c) $h^* = h(g)$. The equilibrium with $h^* = 1$ is equivalent, in terms of social welfare, to the equilibrium with $j^* = 1$ in the multi-principals case: in both cases the bad signal is always communicated truthfully to the agents.

(i) To show that social welfare is weakly higher with multiple principals when $s = \emptyset$, we just need to show that in the single-principal case, social welfare is (weakly) higher in the equilibrium with $h^* = 1$ than in the other two equilibria. Social welfare is given by

$$SW_T(m_H) = \int_{c_L}^{m_H} 2\{(1+g)m_H - c\}dF(c) \tag{9.16}$$

in the $h^* = 1$ equilibrium; it is equal to

$$SW_C(m_H, q) = \int_{c_L}^{qm_H+(1-q)m_L} 2\{(1+g)m_H - c\}dF(c) \tag{9.17}$$

in the $h^* = 0$ equilibrium. Clearly $SW_T(m_H) > SW_C(m_H, q)$. Moreover, social welfare in the third equilibrium is given by

$$SW_C(m_H, r^*(h(g))) < SW_T(m_H) \tag{9.18}$$

(ii) To see that social welfare is weakly higher with the single principal P when $s = B$, note that social welfare is given by

$$SW_C(m_L, q) = \int_{c_L}^{m(q)} 2\{(1+g)m_L - c\}dF(c) \tag{9.19}$$

in the $h^* = 0$ equilibrium, and by

$$SW_T(m_L) = \int_{c_L}^{m_L} 2\{(1+g)m_L - c\}dF(c) \tag{9.20}$$

in the $h^* = 1$ equilibrium. Moreover, we know from the proof of Proposition 1 that $B(q, g) > 0$; i.e.

$$B(q, g) = \frac{1}{2}[SW_C(m_L, q) - SW_T(m_L)] > 0 \tag{9.21}$$

(c) Suppose $g < g_L$. Then the unique equilibrium in the single-principal case and the unique equilibrium in the multi-principals case both entail truthful communication, yielding the same social welfare. $\square$

Proof of Proposition 4

For all $r \in [q_N, 1]$, $r_{BB} \in [0, \dfrac{q_B}{q_N + q_B}]$, $r_{BG} \in [0, \dfrac{q_M}{q_N + q_M}]$, $r_{GB} \in [0, \dfrac{q_M}{q_N + q_M}]$, $V \geqslant 0$, $b \geqslant 0$ and $g \geqslant 0$, define the net gain from suppressing the signal $s = [G, B]$:

$$\Re = \Re(r, r_{BB}, r_{BG}, r_{GB}, V, b, g) = SW_C(m_H, m_L) - SW_T(m_H, m_L) \tag{9.22}$$

$$= -\int_{m_i}^{m_H} [m_H(1+V) - c]\, dc + \int_{m_L}^{m_j} [m_L(1+V) - c]\, dc \tag{9.23}$$

$$+\int_{bm_L}^{bm_j} [(b+g)m_L - c]\, dc - \int_{bm_i}^{bm_H} [(b+g)m_H - c]\, dc \tag{9.24}$$

where

$$m_i = \frac{q_N m_M + q_M(1-h^*_{BG})m_L + q_M(1-h^*_{GB})m_H + q_B(1-h^*_{BB})m_L}{q_N + q_M(1-h^*_{BG}) + q_M(1-h^*_{GB}) + q_B(1-h^*_{BB})} \tag{9.25}$$

and

$$m_j = \frac{q_N m_M + q_M(1-h^*_{BG})m_H + q_M(1-h^*_{GB})m_L + q_B(1-h^*_{BB})m_L}{q_N + q_M(1-h^*_{BG}) + q_M(1-h^*_{GB}) + q_B(1-h^*_{BB})} \tag{9.26}$$

Letting $x \equiv m_j - m_L$ and $y \equiv m_H - m_i$, some manipulation yields:

$$\Re = (V + bg)(m_L x - m_H y) - \frac{1}{2}(1+b^2)(y^2 + x^2) \tag{9.27}$$

It is straightforward to verify that $x \leqslant y$. Hence $\Re < 0$, and the principal never suppresses the signal. $\square$

10. Appendix 2

This appendix provides some of the details that were left out of the exposition in the main text, and referred to in footnotes (14), (17) and (20).

(i) Section 4.1: the benchmark model

The principal's optimal choice of communication strategy, h, given the agents' beliefs h^* (or equivalently r^*), is obtained by solving:

$$h \in \arg\max[hSW_T(m_L) + (1-h)SW_C(m_L, r^*)] \tag{10.1}$$

The first-order condition for this problem (which is necessary and sufficient for the solution) is given by:

$$SW_T(m_L) - SW_C(m_L, r^*) \geqslant 0; \qquad h = 1 \tag{10.2}$$

$$SW_T(m_L) - SW_C(m_L, r^*) \leqslant 0; \qquad h = 0 \tag{10.3}$$

$$SW_T(m_L) - SW_C(m_L, r^*) = 0; \qquad 0 < h < 1 \tag{10.4}$$

Thus, as might be expected, if the net gain from signal manipulation, equal to $SW_C(m_L, r^*) - SW_T(m_L)$, is strictly positive, the principal will always "cover up" the bad signal; if the net gain is strictly negative, he will always tell the truth; finally, if the net gain is equal to zero, the principal is indifferent, and h can take any value in the interval $[0, 1]$.

I focus on Perfect Bayesian equilibria, which satisfy the following conditions:

$$h^* \in \arg\max[hSW_T(m_L) + (1-h)SW_C(m_L, r^*)] \tag{10.5}$$

$$r^* = \frac{q}{q + (1-q)(1-h^*)} \tag{10.6}$$

(ii) Section 5: the model with multiple principals and identical agents

The analysis proceeds as in section 4. Each agent will provide effort if, and only if

$$E[m|\hat{s}, \hat{s}_p] \geqslant c \tag{10.7}$$

If P transmits the bad signal accurately ($\hat{s} = B$), his expected utility is equal to

$$SW_T(m_L) = \int_{c_L}^{m_L} 2\{(1+g)m_L - c\}dF(c) \tag{10.8}$$

If on the other hand P_i, P_j have not received the bad signal and P suppresses the bad signal ($\hat{s} = \emptyset$), his expected utility is given by:

$$SW_C(m_L, r_j^*) = \int_{c_L}^{m(r_j^*)} 2\{(1+g)m_L - c\}dF(c) \tag{10.9}$$

where $m(r_j^*) = r_j^* m_H + (1 - r_j^*)m_L$. The net gain from (successfully) suppressing the bad signal is therefore equal to:

$$SW_C(m_L, r_j^*) - SW_T(m_L) = \int_{m_L}^{m(r_j^*)} 2\{(1+g)m_L - c\}dF(c) \tag{10.10}$$

Given the agents' beliefs, P will choose its communication strategy j so that:

$$j \in \arg\max[(w+(1-w)j)SW_T(m_L)+(1-w)(1-j)SW_C(m_L,r_j^*)] \quad (10.11)$$

The first-order condition for this problem is analogous to the one for the single-principal problem:

$$SW_T(m_L) - SW_C(m_L, r_j^*) \geqslant 0; \qquad j=1 \quad (10.12)$$

$$SW_T(m_L) - SW_C(m_L, r_j^*) \leqslant 0; \qquad j=0 \quad (10.13)$$

$$SW_T(m_L) - SW_C(m_L, r_j^*) = 0; \qquad 0<j<1 \quad (10.14)$$

(iii) Section 6: the model with heterogeneous agents

I use the following notation for uninformed beliefs: each agent believes that $s=[\emptyset,\emptyset]$ with probability q_N, $s=[B,B]$ with probability q_B, $s=[B,G]$ with probability q_M, and $s=[G,B]$ with probability q_M, where the subscript N stands for "no news", the subscript B for "bad news", and the subscript M for "mixed news".Given our assumptions about preferences, agent A_i will invest in his own culture ($x_{ii}=1$) if, and only if,

$$E[m_i|\hat{s}] \geqslant c \quad (10.15)$$

Moreover, he will invest in the other agent's culture ($x_{ij}=1$) if, and only if,

$$bE[m_j|\hat{s}] \geqslant c \quad (10.16)$$

The same applies to agent A_j.

To compute the conditional expected values of m_i and m_j, it is again useful to define the "reliability" of a "no news" signal, which is given by:

$$\begin{aligned} r^* &= \Pr[s=[\emptyset,\emptyset]\,|\hat{s}=[\emptyset,\emptyset]\,; h_{BB}^*, h_{GB}^*, h_{BG}^*] && (10.17)\\ &= \frac{q_N}{q_N+q_M(1-h_{BG}^*)+q_M(1-h_{GB}^*)+q_B(1-h_{BB}^*)} && (10.18)\end{aligned}$$

We shall also need the following notation:

$$r_{BB}^* = \Pr[s=[B,B]\,|\hat{s}=[\emptyset,\emptyset]\,; h_{BB}^*, h_{GB}^*, h_{BG}^*] \quad (10.19)$$

$$r_{BG}^* = \Pr[s=[B,G]\,|\hat{s}=[\emptyset,\emptyset]\,; h_{BB}^*, h_{GB}^*, h_{BG}^*] \quad (10.20)$$

$$r^*_{GB} = \Pr[s = [G, B] \,|\hat{s} = [\emptyset, \emptyset]\,; h^*_{BB}, h^*_{GB}, h^*_{BG}] \tag{10.21}$$

where each probability is obtained applying Bayes' rule.

The agents' expected value of m_i conditional on each possible signal $\hat{s}$ transmitted by the principal is then given by:

$$E\{m_i|\hat{s} = [\emptyset, \emptyset]\} = r^* m_M + r^*_{BB} m_L + r^*_{BG} m_L + r^*_{GB} m_H \equiv m_i(r^*) \tag{10.22}$$

$$E\{m_i|\hat{s} = [B, B]\} = m_L \tag{10.23}$$

$$E\{m_i|\hat{s} = [B, G]\} = m_L \tag{10.24}$$

$$E\{m_i|\hat{s} = [G, B]\} = m_H \tag{10.25}$$

The expected value of m_j conditional on each possible signal $\hat{s}$ is similarly given by:

$$E\{m_j|\hat{s} = [\emptyset, \emptyset]\} = r^* m_M + r^*_{BB} m_L + r^*_{BG} m_H + r^*_{GB} m_L \equiv m_j(r^*) \tag{10.26}$$

$$E\{m_j|\hat{s} = [B, B]\} = m_L \tag{10.27}$$

$$E\{m_j|\hat{s} = [B, G]\} = m_H \tag{10.28}$$

$$E\{m_j|\hat{s} = [G, B]\} = m_L \tag{10.29}$$