Cooperation between the International Monetary Fund and the World Bank. The role of competition and domain dissent in communication and decision making.

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Abstract

This paper focuses on the problem of information transmission between the World Bank and the International Monetary Fund, with communication modeled as cheap talk. I posit that the Fund and the Bank have strategically relevant and diverse expertise whose proper combination might provide a richer consideration and resolution of strategic issues. Although transparent sharing of all available information is in the best interest of Fund's and Bank's shareholders, competitive pressures might hinder such process, introducing biases in the two institutions' preferences. However, concerns for conformity, due to external political pressures, might mitigate such effect. By comparing model's results to the first best outcome I show that the expected loss is made up of two components: a "own preference confirmation" loss, and a "strategic communication" loss. When concerns for conformity are very relevant, strategic communication becomes the primary source of loss. Keywords: IMF and WB, cooperation, communication , decision making

JEL Classiffication: D83, F33, N2, O1

1 Introduction

The International Monetary Fund (IMF/Fund) and the World Bank (WB/Bank) were originally set up as two distinct and independent institutions with complementary tasks and different methods of intervention, within the framework of the Bretton Woods agreement (1944). Over the years, however, their mandates have expanded in response to the changing

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realities of the global economy and the degree of overlap between the two has increased, leading to more room for both conflict and cooperation.

The importance of close collaboration between the Bank and the Fund is a well recognized fact, which has also been periodically emphasized in a number of official documents. Krueger (1997) for example stresses that the functions of lending policy, advice, training, research and provision of information of both the Bank and the Fund are mutually complementary and that the spillover from each of the functions to the others are large. Indeed, macroeconomic and monetary stability (a major Fund concern) have a direct bearing on supply side measures and development prospects (a Bank responsibility). This implies, as the Malan Report (2007,p.18) argues, that "..for each institutions to effectively fulfill all its responsibilities, it must depend on the other, ...it means there must be trust that the other its doing its job because they have to rely on each other.".[1] In other words, the Fund and the Bank should not consider themselves as independent players, since in many situations the actions of one player do affect the outcome of the other player's actions.

However, despite a series of declarations and agreements aimed at strengthening Bank-Fund collaboration, it is widely believed that coordination still falls short of what could be rationally expected (Truman, 2006). The costs to recipient countries of insufficient cooperation between the Fund and the Bank are significant: studies have shown that uncoordinated activities can lead to conflicting advice and/or to place unnecessary demands on country's officials, and sometimes to duplication of conditionality (Lombardi and Momani, 2010). Having two self-interested staff, each giving conflicting advices, puts a strain on borrower countries and ultimately affects policy and program outcomes (Feinberg, 1988; Easterly, 2002; Dreher, 2009).

The official reports, that have tried to identify guidelines aimed at enhancing cooperation between the Bank and the Fund, have almost unanimously agreed that "information sharing" is the area which needs to be greatly improved. This comes as no surprise since successful cooperation does require effective transmission of information whenever informational asymmetries exist.[2] In this regard Levin, Cross, and Abrams (2004), for example, affirm that one way to measure inter-organizational trust or cooperation is to determine whether

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[1] The Malan Report is a report prepared by an independent high-level committee chaired by Pedro Malan, Chairman of the Board of Unibanco and a former Minister of Finance of Brazil, to examine cooperation between the IMF and the World Bank.

[2] Although the extent of overlap between the operations of the two organizations have increased over time, they still maintain a strongly specialized expertise in their core areas of intervention: monetary, fiscal, and exchange rate policies for the Fund and policy areas related to development for the Bank. Therefore, each institution collects specialized information that is only partially overlapping with what collected by the other.

knowledge is shared. More precisely, if two organizations share competence based trust, i.e. each believes that the counterpart is sufficiently knowledgeable of the topics, particularly when they are complex, knowledge sharing is expected to exist. Thus, investigating what factors influence the quality and the extent of communication between the Bank and the Fund is particularly relevant. Little theoretical and empirical analyses, however, exist about what circumstances may inhibit or encourage Bank-Fund communication.

This paper contributes to fill this gap. I focus on the problem of information transmission between these two institutions, with communication modeled as cheap talk.[3] This choice is justified by the fact that, as the reform agenda has deepened to include institutional and social reforms, the collection of specialized information by the Fund and the Bank has increasingly consisted in acquiring country-specific inputs (or local knowledge), which are mainly made up of unverifiable information (soft information).[4] In this context, the existence of incentives conflicts between the Bank and the Fund might hinder credible information transmission, as shown in the Crawford and Sobel (1982) seminal paper on strategic information transmission.

In this paper I posit that the Fund and the Bank have strategically relevant and diverse expertise whose proper combination might provide to both institutions a richer consideration and resolution of strategic issues. Although confrontation and transparent sharing of all available information is in the best interest of Fund's and Bank's shareholders (i.e. global taxpayers), competitive pressures might hinder such process, introducing biases in the two institutions' preferences. Indeed, anecdotal evidence suggests that "turf wars", due to "domain dissent", are frequent between the Fund and the Bank.[5] The existence of competitive goals due to the desire to take the lead on some political issue and/or the desire to differentiate and prove competence, might thus distort decision-making (relative to the first best). Specifically, competitive pressure might skew Fund and Bank decisions in the direction of their initial preferred alternative, exclusively based on their own private information, although such decisions might not be optimal from their shareholders' perspective. Competitive pressures might thus introduce a "own preference confirmation" bias in the Fund and the Bank preferences.[6] However, pressures for coordination, coming from large creditors and/or financial sector or from powerful borrower governments, might introduce concerns for conformity in each institution's objective function, which mitigate the negative effects of competition.

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[3] Cheap talk consists of costless, non binding, non verifiable messages that can affect receivers' beliefs.

[4] For more details on the importance of context-specific knowledge for reforms design see, among others, Dixit (2009), Easterly (2006, 2008), Rajan (2008) and Marchesi *et al.* (2011).

[5] See Woods (2006) and Fabricious (2007) on this point.

[6] See on this point Toma et al (2011).

This paper develops a model that incorporates in a stylized way the key features described above. Namely, each institution's decision process takes place in two stages: cheap talk communication and decision-making. In the communication stage the two institutions transmit their private information strategically to influence decision making to their advantage; in the decision making stage each institution tries to balance the benefit of setting its policy decision close to its preferred (biased) alternative, with the benefit of setting its decision close to the other institution's expected decision.

By comparing results to the first best outcome, which is characterized by the Fund and the Bank sharing the same preferences (absence of conflict), we show that the expected loss is made up of two components: a "own preference confirmation" loss, and a "strategic communication" loss. The first component gives the expected loss under perfect information. It only depends on the preferences' bias, which impairs the ability of each organization to take decisions fully adapted to the "true" state of the world. This inefficiency cancels out as the need to coordinate actions becomes the main concern of the two institutions. The second component is due to the cost of strategic uncertainty that each institution faces over each other's decision after communication. Strategic uncertainty leads to coordination failures over and above any inherent biases in the equilibrium decisions. When concerns for conformity are very relevant, strategic communication becomes the primary source of loss relative to the *first best* outcome. Indeed, although the two institutions agree on the need to coordinate their actions, in an imperfect information context (with misaligned interests), communication is always distorted, since both actors will try, by manipulating information, to induce the counterpart to make an adjustment closer to their own (suboptimal) preferences. Two factors determine the relevance of such loss: the level of competition between the two institutions, which in turn determines the size of the preferences' bias, and the relevance of their specialized local information (unshared information) relative to shared information.

The paper is organized as follows. Section 2 briefly presents the related literature. Section 3 offers some institutional information and stylized facts regarding the "conflicting" relationship between the Fund and the Bank. Section 4 describes the model set up. Section 5 characterizes decision making. Section 6 discusses the main features of strategic communication. Section 7 analyses the performance of the two institutions relative to the first best. Section 8 discusses the normative implications of the model, and finally Section 9 concludes.

2   Related literature

This paper contributes to the theoretical literature on the role of international financial organizations (IFOs), in promoting financial stability and development. To a significant

extent this literature aims at explaining the failure of some devoloping countries to solve long-standing economic problems, despite extensive financial involvement by IFOs. Many papers in this literature use the Principal-Agent theory to model the interaction between the Fund and/or the Bank and the recipient governments. In this context, conditionality is viewed as an attempt of international financial institutions to use financing to 'buy' policy reforms, in a setting in which the objectives of the financial assistance providers and the authorities of the recipient governments do not fully coincide and there are informational asymmetries.[7] In this framework, Marchesi, Sabani and Dreher (2011), investigate how failures in information transmission between the IFO and the borrowing government affect conditionality intrusiveness. In doing this, they refer to the literature which examines cheap talk communication between private informed but biased agents.

All these contributions focus on the relationship between the IFOs (or aid donors) and the recipient country. In contrast the current paper analyses the relationship between the Fund and the Bank in countries where they both work with different but overlapping mandates. This paper aims at addressing the policy relevant problem of the cost to recipient countries, and in general to global taxpayers, of the lack of cooperation between the two institutions. Aid fragmentation and the lack of donor coordination have been widely recognized as principal problems impairing the effectiveness of official aid (Easterly,2007 and Knack and Rahman, 2007), but, while there are many official reports and contributions from political scientists dealing with the specific problem of the lack of coordination between the Fund and the Bank, to the best of my knowledge to date no theoretical study of IMF and World Bank collaboration is found in the academic literature.[8]

My contribution concentrates on the problem of information transmission between the two institutions. As such it reconnects with the arguments developed in Marchesi, Sabani and Dreher (2011) and at the same time relates to different strands of the economic literature which focus on communication and decision making in organizations. Specifically, a similar model set-up is used by Malenko (2014) to analyze communication and decision-making in corporate boards, where each board member has private information relevant to the board's collective decision, and she studies how diversity in member's preferences and concerns for conformity affect communication.

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[7]See for example Khan and Sharma (2001), Drazen (2001), Ivanova (2006), Marchesi and Sabani (2007). Differently Mayer and Mormouras (2005) examine the impact of IMF-supported reform programs on domestic politics using the theory of special interest politics.

[8]Some political scientists have focussed on the efficiency of the separation between the Fund and the Bank,(e.g., Clark 1990; Crook 1991; Shultz 1998; Burnham 1999 and Fischer 2004). On the empirical side, Fabricius (2007), drawing on field research conducted in Ghana, Pakistan, Peru, and Vietnam, over the 1980-96 period, has tried to identify empirically the conditions which inhibit or encourage Bank-Fund collaboration.

My model differs from Malenko, firstly because decisions are not collectively taken, but the Fund and the Bank decide their actions in complete autonomy. Also, in Malenko's model diversity in board memeber's preferences arise due to private benefits, while in my contribution the Fund and the Bank misalignment of interests depends on competitive pressures and /or domain dissent leading to the "own preference confirmation" bias as described in the experimental literature on group decision-making with "hidden profile" (Stasser and Titus, 2003, Toma et al 2011, 2013). In this literature it is argued that in a competitive context information pooling between group members is hindered by the fact that individuals exhibit a preference bias towards their initial preferred alternative, derived from their initial unshared information. Finally, differently from Malenko,where communication is costly and verifiable, I model communication between the Fund an the Bank as cheap talk. In doing this, I refer to the literature which examines cheap talk communication between private informed but biased agents (Harris and Raviv, 2008) and to the literature on coordination in organizations with multiple divisions and distributed information (Alonso, Dessein and Matouschek 2008, hereafter ADM; Rantakari, 2008). Precisely, my analysis of the communication and decision making stages, in case of domain dissent between the Fund and the Bank, builds on ADM. I do not address however the problem of the allocation of decision rights, since I take the current IMF and WB governance as given. In addition, the aggregate expected loss analysis differs from ADM since in my contribution the Fund and the Bank misalignment of interests is due to distorsions brought about by competitive pressures, while in ADM the agents'preferences are conflicting but not distorted

3   The IMF and the World Bank: cooperative vs competitive interactions

The World Bank and the IMF were set up as two distinct and independent institutions with different tasks and methods of intervention as part of the Bretton Woods agreement (1944). While the Fund was responsible for establishing short-run macroeconomic stability, the Bank was supposed to develop long-run development programs. Despite being separate institutions, it was immediately recognized that there were broad areas of common interest, that required close cooperation. However, relations between the two institutions have not always been "close", and they have frequently seemed to operate independently rather than in a cooperative manner (Gold, 1982). The difficulty of coordinating actions is also reflected in the large number of memoranda, statements, guidelines and reviews regarding the issue of "cooperation" which have been issued over the 61 years of existence of the two organizations

The first step towards formal recognition of the importance of cooperation between the

IMF and the World Bank had already been taken in 1966 with an agreement which explicitly laid out the chief responsibilities of each organization and the procedures required for the two to work together (Boughton 2001). The agreement actually arose from a conflict between the two institutions: the Bank was accused, most notably in India in 1965-66, of "mission creep" in providing support to a country's balance of payment crisis (one of the Fund's main responsibilities) through program loans. The 1966 memoranda made it clear that there were situations in which Bank and Fund functions overlapped and a clear-cut division of competence was not possible. Given the overlapping interests, collaboration was essential and the 1966 statement was followed in 1970 by a document that sought to outline formal procedures for regulating collaboration.[9]

The acknowledgement of the existence of structural links between the Fund and the Bank became increasingly important during the 1970s and the 1980s, when the IMF decided that demand management policies needed to be supplemented by supply side policies. Simultaneously, the Bank altered its stance and gave more explicit recognition of the importance of macropolicies besides its traditional role and sector lending. Moreover, during the 1980s, the Fund's lending became more concessional and related to structural matters, and increasingly focused on lower income countries which became the main recipients of the Bank's "services". Besides, the 1980s debt crisis called for more closely coordinated efforts to assist indebted countries.[10]

It became clearer that the structural links between the two institutions' operations made it impossible for them to act as independent players. For example, the public expenditure policy proposed by the Bank would not have been consistent with the Fund's targets in terms of macroeconomic stability; credit restraints to restore financial stability, required by the Fund, would have clashed with the need to finance supply side measures promoted by the Bank; the exchange rate regime proposed by the Fund would have not been consistent with the export support measures proposed by the Bank. As well as these direct links, indirect financial links also needed to be considered. In particular, the withholding of credit by either of the two institutions might have had a negative effect on the other's program, through third-party financial links (Feinberg, 1988).[11]

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[9]It is important to underline that *de facto* both institutions provide budget and balance of payment support. Indeed, fiscal and external financing needs are often closely intertwined and financial support from each institution provides foreign exchange and helps to loosen fiscal constraints. (IMF, 2010).

[10]Between 1980 and 1984 energy prices were addressed in 46% of Fund supported programs, the mobilization of domestic savings in 54% investment planning and execution in 37%. These were areas of primary responsibility of the Bank. Similarly the Bank was increasingly concerned with many variables central to Fund stabilization program (Feinberg, 1988).

[11]If the Fund had judged the borrower to be in non compliance, the commercial banks involved in the country may have halted disbursments as well. The loss of commercial bankscredits could thus have undermined the borrower's creditworthiness, destroying the ability to proceed with Bank - supported structural

Coordination was therefore crucial, but as Boughton (2001) observes, this awareness did not lead the two institutions to work together on commonly agreed strategies. Indeed, the response of the IMF and the World Bank staff was aimed at protecting their institution's respective area of competence from possible mission creep by the other institution (turf war). The lack of a cooperative culture thus led to defensive behaviour which culminated in a breakdown in coordination. This became evident in 1988 when the Bank provided additional finance to Argentina while the Fund was still negotiating. In this case, Bank staff blamed IMF counterparts for requiring unnecessary financial austerity in loan negotiations that would jeopardize the Bank's ability to implement a series of structural reforms This spectacular failure brought about the codification of Bank-Fund collaboration in the 1989 Concordat in which a vast area of overlapping responsibilities was explicitly identified. Cooperation should have been pursued and strengthened within this common area. To this end, the Concordat did define the guidelines and terms of the Bank-Fund interaction, and the mechanisms for resolving potential conflicts between the sister organizations. Both institutions undertook to exchange information systematically concerning low and middle-income countries. Moreover, the Concordat encouraged them to exchange this information not only within their decision-making bodies, but also among operative staff.

However, later on, in 1998, during the Asian crisis, a further disagreement led to a joint statement issued by the Bank president and the Fund managing director on Bank-Fund collaboration (e.g., see Mallaby, 2004) in which the leaders of the two organizations restated the need for improved collaboration. As stressed by the Malan Report (2007), the lack of a cooperative culture has caused the two institutions to operate as if they had competitive rather than cooperative goals The debate over "fiscal space" highlights this problem. The Bank staff who were interviewed by the Malan commission accused the Fund of focusing exclusively on short-term macroeconomic stability, jeopardizing both growth-enhancing investment and poverty reduction spending (a Bank responsibility). On the other hand, Fund staff accused the Bank of "mission creep", given its excessive involvement in fiscal space estimates, often leading to the conclusion that there was much more room for public spending than had been indicated by the Fund. According to the Malan Report, the tensions between the two institutions over the issue of "fiscal space" depended on the fact that macroeconomic stability and longer term growth were erroneously viewed by the two institutions as competitive goals rather than complementary goals. On the contrary, a properly designed fiscal policy should combine the Bank's and Fund's different expertise since".. macroeconomic stability will not

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reforms or investment projects.Similarly, a negative Bank finding could have disrupted commercial bank credit and adversely affected the borrower's budgetary revenues, credit policies, exchange reserves, causing it to fail to meet Fund program targets. (Feinberg, 1988)

be sustained unless it is linked and accompanied by supply side measures that enhance long term growth and development" (Malan Report, 2007 p. 32). The Fund work on aggregates should therefore rely on the Bank's analysis of the effectiveness of public spending programs and public spending priorities needed to achieve growth. This also implies that the exchange of country-specific information becomes of crucial importance, and it is hardly surprising that both the Bank staff and the Fund staff expressed concerns precisely over this point.

Cooperation between the Fund and the Bank seems to work better when it is mandatory. Following the creation of the Structural Adjustment Facility (SAF) and the Enhanced Structural Adjustment Facility (ESAF), later renamed the Poverty Reduction and Growth Facility (PRGF), an important area of mandatory joint work between the Bank and the Fund was created. To access this program the country has to prepare a policy framework paper, i.e. the Poverty Reduction Strategy Paper (PRSPs), jointly with the staff of the Fund and the Bank. The process of drafting the PRSPs was designed to ensure the consistency of the Bank's and the Fund's stances, by encouraging them to develop a common view of the appropriate policy advice for a country.

According to the Malan Report, cooperation between the two institutions seemed to have worked fairly well in PRGF programs, and the same can be said about another important area of mandatory joint work, the IMF-World Bank Financial Sector Assessment Program (FSAP), set up in 1999 to enhance practical collaborative initiatives between the Fund and the Bank in the financial sector. The rationale for the IMF/WB overlap in the FSAPs was that combining the two institutions respective expertise would produce a set of recommendations that would better address issues of stability and development (IMF-IEO, 2006).

Increased collaboration seen in the PRSP and FSAP programs has also been reinforced by the creation in 2007 of the Joint Management Action Plan (JMAP). The JMAP developed a series of specific procedural reforms to further tighten inter-institutional coordination. The 2010 assessment of the JMAP highlighted several key areas that still require greater attention. Not surprisingly, these include information sharing and trust building, confirming that the quality and the extent of communication between the Bank and the Fund is still a particular relevant problem..

4   Model set up

4.1   Information structure

The Fund and the Bank have different areas of expertise and thus have information that is relevant to different aspects of their own decisions. In general, official documents have often

emphasized the need to anchor the Fund and the Bank conditionalities in a coherent and satisfactory country-owned program, whose correct design clearly requires an agreement on the recipient country's "fundamentals". In this context, formulating mutually supportive conditionality requires a joint analysis of the recipient country with both organizations' specific expertise entering the final evaluation of "fundamentals".

I model these arguments in a stylized way by assuming that the Fund and the Bank are contemplating decisions $d_F \in R$ and $d_B \in R$ respectively. Which decision is best depends on the unknown state of nature θ equal to a weighted sum of two signals x_F and x_B

$$\theta = \alpha x_F + (1 - \alpha)x_B \tag{1}$$

I assume that the Fund observes x_F without knowing the Bank's signal x_B and *vice-versa*. From (1) it is known that a precise evaluation of the state of nature θ requires the two complementary pieces of information x_F and x_B to be pooled together. For example, in providing financial support (d_F) the Fund hinges on its information about the recipient country's macro imbalances problems (x_F), but could also benefit from drawing on Bank expertise on the composition and efficiency of public spending, and the capacity of the country to effectively spend incremental resources (x_B). On the other hand, the impact of measures contained in the Bank structural adjustment programs (d_B) would be difficult to evaluate without a deep comprehension of the underlying, structural causes of recipient country's balance of payments problems (x_F).[12]

It is common knowledge that x_F and x_B are uniformly distributed on $\left[-\bar{x}_i, \bar{x}_i \right]$, with $i = F, B$, and the draws of x_F and x_B are independent.[13] Formally, the variance of x_F (i.e., σ_F^2), represents the degree of environmental volatility faced by the Fund while that faced by the Bank is given by the variance of x_B (i.e., σ_B^2).

4.2   Preferences

In theory the Fund and the Bank are responsible for different areas of conditionality but in practice, as we have seen in sect 2, their responsibilities have become more and more difficult to distinguish. In these situations the Fund and the Bank often engage in disputes which are mainly motivated by competition on the leading role. Woods (2006, p.6) calls this conflict "..a turf war that results when each institution vies for the lead role in promulgating a particular economic reform". In other words, the confrontation is often about which

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[12]The weight α cav vary according to the policy issue at hand.

[13]Mathematical analysis is simplified by this hypothesis. Qualitative results would continue to hold if signals were correlated .

institution should take the lead on which issue. In this regard, Fabricius (2007), referring to case studies, stresses that in each of the policy areas where domain dissent was actually observed, the Bank and the Fund carried out *de facto* independent assessments and came to independent conclusions about the stance to be taken vis-à-vis the borrowing government.[14] According to Fabricius, domain dissent appears to be concentrated in three policy areas, namely macroeconomic policy, fiscal policy and financial sector reform, which are areas where Bank and Fund mandates mostly overlap. For other policy areas (i.e., privatization, agricultural policy, trade policy, and aid coordination) domain consensus seems to prevail. In the following I posit that domain dissent alters the two institutions' preferences relatively to a situation in which domain consensus prevails. I first characterize preferences with domain consensus, then I analyze preferences in the competing case.

4.2.1 Preferences with domain consensus

For domain consensus I mean a situation in which the two organizations agree that a correct evaluation of country's "fundamentals" requires a joint analysis of the recipient country, with each institution guiding the other in its core areas of expertise. The joint analysis thus leads to a common evaluation of the state of the world given by (1).

In this scenario I assume that the Fund and the Bank have to minimize respectively the following quadratic loss functions

$$L^F = (d_F - \theta)^2 + \delta (d_F - d_B)^2 \tag{2}$$

$$L^B = (d_B - \theta)^2 + \delta (d_F - d_B)^2 \tag{3}$$

The first term of the loss functions represents the loss due to a not satisfactory adaptation to the state of the world θ given by (1). The second component reflects the Fund's or the Bank's concern for conformity: that is, I assume that each organization suffers a loss if its action deviates from the action of the other. Concerns for conformity might capture the reluctance to deviate from the other institution's decision due to strong pressures for coordination coming from large creditors and/or financial sector or from powerful borrower governments.[15] The parameter $\delta \in [0, \infty)$ measures the relative weight of coordination losses

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[14]Fabricious (2007) reports several episodes where strong turf sensitivity and resulting protectionist stance was found to lead to domain dissent. The author also stresses that this turf sensitivity occurred exclusively among individuals in the Fund and never on the part of the Bank . The IMF (1998) external evaluation report confirms that "Fund staff are often cast in an inflexible mold by their briefing papers and mandates, and are much to quick to plead jurisdiction and turf when differences arise" (IMF 1998, p. 58).

[15]Concerns for conformity might also capture the presence of strategic complementariness of the Fund and the Bank actions For example, Bank supported structural reforms or investment projects could not be feasible, if credit restraints decided by the Fund undermine borrower's credit worthiness; similarly, a negative Bank assessment of the country could disrupt commercial bank credit, and adversely affect the

relative to adaptation losses.

4.2.2 Preferences with domain dissent

Focusing on situations where domain dissent prevails, I assume that the presence of competitive pressures causes both organizations to have biased views of the state of the world. Namely, in evaluating fundamentals both institutions give more weight to their own private information (signal) relative to a situation characterized by the absence of competitive pressures. In turn, this implies that the Fund and the Bank would have different and suboptimal (biased) views of the state of the world, that is respectively

$$\theta_F = \alpha_F x_F + (1 - \alpha_F)x_B \tag{4}$$

for the Fund and

$$\theta_B = \alpha_B x_F + (1 - \alpha_B)x_B \tag{5}$$

for the Bank, where $\alpha_F > \alpha > \alpha_B$.

Loss functions can therefore be rewritten as:

$$L^F = (d_F - \theta_F)^2 + \delta (d_F - d_B)^2 \tag{6}$$

$$L^B = (d_B - \theta_B)^2 + \delta (d_F - d_B)^2 \tag{7}$$

This assumption on preferences is justified by results of a great deal of experimental literature on team groups. Such contributions have shown that competitive pressures cause people who work in teams to be reluctant to accept others' perspectives, leading to biased support of suboptimal preferences based on partial information (Toma et al., 2011). Conversely, in absence of competitive pressures individuals are encouraged to investigate alternative solutions and to assimilate divergent perspectives (Johnson and Johnson, 2005).

The negative effects of competitive pressures are partially amended by the second term of the loss functions (6) and (7), which represents concern for conformity. For high values of δ, "turf" sensitivity would matter less and staff of the two organizations would be forced to put aside their own preferences to achieve conformity of actions.

recipient country's ability to meet Fund financial assistance expected targets; the exchange rate regime proposed by the Fund could prevent export support measures proposed by the Bank from achieving their desired outcomes etc..

4.3 Time line

At t=0, the Fund and the Bank learn x_F and x_B respectively. At t=1, before taking actions, the Fund and the Bank communicate the realizations of their signals by sending messages m_F and m_B, respectively. Finally, at t=2 decisions d_F and d_B are made. Each institution chooses the decisions that minimize its expected loss function, given the information that has been communicated.

In the following section I characterize decision making under domain consensus and under domain dissent, taking as given the posterior beliefs of the Fund and the Bank over x_B and x_F, respectively. Then, I analyze the communication subgame where beliefs are endogenized.

5   Decision making

5.1   Domain consensus

In case of domain consensus the Fund and the Bank take their decisions to minimize the expected value of (2) and (3) respectively, given the observed signals and the communicated information.

$$\min_{d_i} E((d_i - \theta)^2 + \delta (d_i - dj)^2 \mid x_i , m_j)$$

with $i = F, B$ and $j = F, B$

Taking the first order conditions and solving the reaction functions for the equilibrium actions, yields

$$d_F = E(\theta \mid x_F, m_B) = \alpha x_F + (1 - \alpha)E(x_B \mid m_B) \tag{8}$$

$$d_B = E(\theta \mid x_B, m_F) = \alpha E(x_F \mid m_F) + (1 - \alpha)x_B \tag{9}$$

5.2   Domain dissent

Now I focus on the case in which there is domain dissent. In this situation there is a conflict on the evaluation of the state of the world, with both organization giving more weight to their private information relatively to (1). I focus on the extreme scenario in which both organizations give zero weight to the other organization's information in evaluating the state of the world. This is consistent with what observed by Fabricious (2007) that, in case of domain dissent, the Fund and the Bank appeared to carry out independent evaluations of the state of the world. This means that (6) and (7) reduce to

$$L^F = (d_F - x_F)^2 + \delta (d_F - d_B)^2 \tag{10}$$

$$L^B = (d_B - x_B)^2 + \delta (d_F - d_B)^2 \tag{11}$$

These preferences' structure permits to refer to the theoretical framework developed by ADM to study coordination in organizations with multiple divisions and distributed information. At the decision-making stage, institution i with $i = F, B$ solves,

$$\min_{d_i} E((d_i - x_i)^2 + \delta (d_i - dj)^2 \mid x_i, m_j)$$

Taking the first order conditions, and solving the reaction functions for the equilibrium decisions yields

$$d_F = ax_F + (1 - a)(bE(x_F \mid x_B, m_F) + (1 - b)E(x_B \mid x_F, m_B)) \tag{12}$$

and

$$d_B = ax_B + (1 - a)(bE(x_B \mid x_F, m_B) + (1 - b)E(x_F \mid x_B, m_F)) \tag{13}$$

where

$$a = \frac{1}{1 + \delta} \quad b = \frac{\delta}{1 + 2\delta} \tag{14}$$

The Fund decision is a convex combination of its signal x_F, its posterior beliefs about x_B (i.e., $E(x_B \mid x_F, m_B)$), and the Bank posterior belief about x_F (i.e., $E(x_F \mid x_B, m_F)$). Similarly, the Bank decision is a convex combination of its signal x_B, its posterior beliefs about x_F, (i.e., $E(x_F \mid x_B, m_F)$), and the Fund posterior belief about x_B, (i.e., $E(x_B \mid x_F, m_B)$).[16]

6 Communication

Before starting the analysis of the incentives to mirepresent information (strategic communication), it is important to underline that in case of domain consensus, i.e. in absence of conflicting goals, it is rational to communicate truthfully private information, that is $m_F = x_F$ and $m_B = x_B$. This result can be easily derived from (8) and (9) Thus, equilibrium actions would reduce to $d_F = d_B = \theta$ and each institution's expected loss would be equal to zero. In this section I therefore analyze incentives to misrepresent information under domain dissent, and derive endogenously the quality of communication in equilibrium. The analysis follows ADM, so I refer to their contribution for technical details.

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[16] As $\delta \to \infty$, for given posterior beliefs, both decisions converge to the same value, that is $d_F = d_B = \frac{1}{2}(E(x_B \mid x_F, m_B) + E(x_F \mid x_B, m_F))$ When $\delta = 0$, the need to balance conflicting preferences and coordination disappears and both institutions only put weight on the adaptation to their respective signal draw. This implies that $d_F = x_F$ and $d_B = x_B$.

6.1 Incentives to misrepresent information

The Malan Report (2007) stresses that major coordination problems between the Fund and the Bank have occurred in presence of poor or inadequate communication [17] Indeed, misalignement of incentives and non-verifiability of information (i.e., soft information) creates communication problems. Namely, there will always be incentive for either the Fund or the Bank to exaggerate the realization of their signal, with a positive bias if $x_i > 0$ and with a negative bias if $x_i < 0$, with $i = F, B$. To give the intuition of the incentive to distort the transmitted information, let suppose that the Fund sends message m_F to the Bank. From (13) it is easy to check that the Bank's expected response to message m_F will be $(1-a)(1-b)E(x_F \mid x_B, m_F)$, with $(1-a)(1-b) < 1$. Then, the Fund, anticipating the Bank's response, will try to induce a higher reaction by the Bank, by exaggerating the value of its report about the realized x_F.[18] Since rationality would lead the Bank to "discount" the Fund's message, the IMF will be induced to exaggerate even further its reported value. Nonetheless, in equilibrium, communication does not become meaningless as we might expect. Indeed, the incentive to lie is somewhat limited by the fact that the Fund not only wants the Bank to set an action close to its own, but also close to its observed signal. In other words, imprecise cheap talk can indeed convey information (Crawford and Sobel ,1982).

6.2 Communication equilibria.

In the context of this communication game, ADM show that all communication equilibria are interval equilibria in which the state space, $[-\overline{x}_i, \overline{x}_i]$, $i = F, B$, is partitioned into intervals, and agent i chooses a random message from the subinterval to which the true value x_i belongs.[19] The message, therefore, reveals to the other agent only the range in which the true observation lies and the quality of communication is indeed represented by the interval length: the coarser the partition, the nosier communication. It follows that the receiver's posterior on x_i, given the message m_i, is uniform on the interval that contains m_i (i.e., $E(x_i \mid x_j, m_i)$ is the midpoint of the interval that contains m_i).

---

[17]On this point see the Malan Report (2007) and the Joint Management Action Plan on Bank-Fund Collaboration (JMAP) Report (2010). The Malan Report indicates a number of specific issues where collaboration needs to be strenghtened. Among them it is stressed for example that the Fund is not readily sharing financial programming data with the Bank; Bank works on public expenditure without informing Fund programs and surveillance in a systematic way; the Fund's Government Finance Statistics does not provide adequate breakdown of expenditure to be used by the Bank.

[18]It is straightforward to show that only when $x_F = 0$ communication will be truthful.

[19]The solution concept employed is Perfect Bayesian Nash equilibrium,which is simply a Nash equilibrium in which each agent responds optimally to his opponent's strategy choice, taking into account his probabilistic beliefs, and minimizing expected loss over his possible strategy choices.

Let denote by $t_i^{2N_i} = (t_{i,-N_i}, .t_{i,-j}..t_{i,-1}, t_{i,0}, t_{i,1}, .t_{i,j}..t_{i,N_i})$ the partitioning of $[-\bar{x}_i, \bar{x}_i]$, into $2N_i$ intervals, for $i = F, B$ and $j = (-N_i....0, 1...N_i)$. ADM show that in equilibrium the size of the generic interval $(t_{i,j+1} - t_{i,j})$ is equal to the size of the preceding interval $(t_{i,j} - t_{i,j-1})$ plus $4\frac{1+\delta}{\delta}t_{i,j}$; symmetrically, the size of the interval $(t_{i,-(j+1)} - t_{i,-j})$ is equal to that of the preceding interval plus $4\frac{1+\delta}{\delta}t_{i,-j}$. This implies that the quality of communication deteriorates as x_i moves further away from its mean value, that is $x_i = 0$. Therefore, the less information is communicated by each institution to the other, the larger the observed value of the signal is. This result is intuitive since the incentives to misrepresent information increase with the module of x_i. Furthermore, we can see that the length of the intervals decreases with δ. Consistently with intuition, this means that communication becomes more precise as the need for coordination increases. ADM demonstrate that as the number of partitions $2N_i$ goes to infinity, the most efficient Perfect Bayesian Equilibrium is achieved. In such an equilibrium the size of the intervals is infinitesimally small for x_i close to 0 and increases at a growing rate as the module of the observed x_i increases. In what follows, I refer to this equilibrium, which represents the focal point of the communication game.

6.3 Information loss due to strategic communication.

Let $\bar{m}_i = E(x_i \mid x_j, m_i)$ denote the posterior expectation of the signal x_i by the receiver of message m_i. Since $E_{x_i}(\bar{m}_i) = 0$, the variance of the posteriors is defined as $E_{x_i}(\bar{m}_i^2)$. In the case of truthful communication, $E_{x_i}(\bar{m}_i^2)$ is equal to σ_i^2, while with meaningless communication (bubbling equilibrium), $E_{x_i}(\bar{m}_i^2)$ is equal to zero (no information is transmitted). Therefore, I define as residual variance (or RV), the variance that institution i ex ante expects to face after receiving the message by the other institution. Formally

$$RV = \sigma_i^2 - E_{x_i}(\bar{m}_i^2) \text{ for } i = F, B. \tag{15}$$

The residual variance gives a measure of the information loss due to strategic communication. The coarser the space partition, the lower the value of $E_{x_i}(\bar{m}_i^2)$, and in turn the greater the information loss. In the focal equilibrium, ADM show that

$$RV = S\sigma_i^2 \tag{16}$$

where

$$S = \frac{\delta + 1}{7\delta + 4}. \tag{17}$$

16

It is straightforward to verify that S tends to $\frac{1}{4}$ (upper bound) as δ goes to 0. This means that as concern for conformity tends to zero, agents reveal each other only the sign of the observed signal (that is the partition contains just two intervals). Conversely, the quality of communication improves as δ increases, although it always remains bounded away from perfect information. Indeed, it can be shown that S tends to $\frac{1}{7}$ (lower bound) as δ goes to infinity. Intuitively, although the two institutions agree on the need to better coordinate their actions, in a imperfect information context with misaligned interests, each of them will distort the transmitted information in order to convince the other to make an adjustment that suits better its own preferences. In this way much valuable information is lost.

7   Social expected loss

Having derived the decisions and the quality of communication in equilibrium, I can solve for the social expected loss.

If the state of the world is θ given by (1), Fund and Bank shareholders' loss would depend on the distance of the Fund and the Bank actions d_F and d_B from θ. Thus, I define the social expected loss as

$$EL^{Social} = E\left[(d_F - \theta)^2\right] + E\left[(d_B - \theta)^2\right] \tag{18}$$

In case of *domain consensus (*no conflicting preferences*)* the social expected loss is equal to zero since $d_F = d_B = \theta$. In other words full alignment of interests and truthful communication allow the pooling of the two complementary pieces of unshared information, leading to actions fully adapted to the state of the world. I refer to this case as the *First Best.* In case of *domain dissent* (conflicting preferences), by substituting (12) and (13) in (18) and by taking the expected value, yields [20]

$$
\begin{aligned}
EL^{Social} =\ & \left[(a - \alpha)^2 + \alpha^2\right]\sigma_F^2 + \left[(a - (1-\alpha))^2 + (1-\alpha)^2\right]\sigma_B^2 + \\
& + C(E_{x_F}(\bar{m_F}^2) + E_{x_B}(\bar{m_B}^2)) + D(\alpha E_{x_F}(\bar{m_F}^2) + (1-\alpha)E_{x_B}(\bar{m_B}^2)) \quad (19)
\end{aligned}
$$

---

[20] In taking the expected value I make use of the following equalities

$E_{x_i}(\bar{m_F}\bar{m_B}) = E_{x_i}(x_j\bar{m_i}) = E_{x_j}(x_j\bar{m_i}) = 0$

$E_{x_i}(x_i\bar{m_i}) = E_{x_i}((\bar{m_i})^2)$

All equalities follow from independence of x_F and x_B and from the fact that in equilibrium

$E(\bar{m_i}) = E(x_i) = 0$

where

$$C = (1 - a)((1 - a) + 2b(b - 2ab + 2a - 1))$$

$$D = -2(1 - a)$$

and where a and b are given by (14). .

From (15), $E_{x_i}(\overline{m_i}^2) = (1 - S)\sigma_i^2$, with $i = F, B$. Substituting in (19), yields

$$
\begin{aligned}
EL^{Social} &= \left[(a - \alpha)^2 + \alpha^2\right]\sigma_F^2 + \left[(a - (1 - \alpha))^2 + (1 - \alpha)^2\right]\sigma_B^2 + C(\sigma_F^2 + \sigma_B^2) \\
&\quad + D(\alpha\sigma_F^2 + (1 - \alpha)\sigma_B^2) - CS(\sigma_F^2 + \sigma_B^2) - DS(\alpha\sigma_F^2 + (1 - \alpha)\sigma_B^2) \quad (20)
\end{aligned}
$$

Remembering that S measures the information loss due to strategic communication, I can rewrite the social expected loss as being made by two components: EL^{PI} and EL^C. The first component is obtained by putting $S = 0$ in (20) and shows the social expected loss under perfect information, that is

$$
\begin{aligned}
EL^{PI} &= \left[(a - \alpha)^2 + \alpha^2\right]\sigma_F^2 + \left[(a - (1 - \alpha))^2 + (1 - \alpha)^2\right]\sigma_B^2 + \\
&\quad + C(\sigma_F^2 + \sigma_B^2) + D(\alpha\sigma_F^2 + (1 - \alpha)\sigma_B^2) \quad (21)
\end{aligned}
$$

EL^{PI} captures the loss solely due to the "turf battle", which leads the two organizations to choose actions "too distant" from the "true" state of the world, since too much biased towards their own initial preference (i.e. their observed signal x_i , $i = F, B$), even in a context of perfect symmetric information.

The second component is the loss resulting from strategic uncertainty, that is

$$EL^C = \sigma_F^2(-CS - \alpha DS) + \sigma_B^2(-CS - (1 - \alpha)DS) \quad (22)$$

EL^C captures the fact that domain dissent causes communication to be distorted. Indeed, both organizations try, by manipulating information, to induce the counterpart to make an adjustment closer to their own signal. In this attempt much socially valuable information is lost.

In the following, I investigate how concerns for conformity affect the two components of the social expected loss. For analytical tractability, I assume $\sigma_F^2 = \sigma_B^2 = \sigma^2$

As for the first component of the social expected loss, I prove the following proposition.

Proposition 1 *In case of perfect information, as concerns for conformity increase, the quality of decisions gradually improves. Nonetheless, as δ goes to infinity, decisions will never converge to the first best, unless $\alpha = \frac{1}{2}$. Conversely, the expected loss is at its maximum when $\delta = 0$.*

    Proof. *See Appendix* ∎

Consistently with intuition, in a perfect information context, the inefficiency, which is due to each organization "own preference confirmation" bias, decreases as pressures for coordination increase (i.e. δ increases) .Namely, as $\delta \to \infty$ decisions converge to $d_F = d_B = \frac{1}{2}(x_F + x_B)$.-Therefore, external pressures for coordination lead to consistency, although decisions will never converge to the *first best*, (i.e $d_F = d_B = \alpha x_F + (1 - \alpha)x_B$.), unless $\alpha = \frac{1}{2}$. Put another way, concerns for conformity may force the two organizations to speak with one voice, but they do not fully substitute for the cooperative behaviour observable in case of domain consensus. Nonetheless, current forms of collaboration, that strive for consistency, may actually improve the Bank's and the Fund's performance.[21]

As for the strategic communication component, I prove the following proposition.

Proposition 2 *The expected loss due to strategic communication is zero for $\delta = 0$. As δ increases the quality of information increases as well as the value agents give to information. Overall the expected loss rises and as $\delta \to \infty$ converging to $.\frac{1}{7}\sigma^2$ (communication will never be perfect).*

    Proof. See Appendix ∎

When the two organizations do not give importance to coordinate actions (($\delta = 0$), counterpart's information and therefore communication has not value. In other words, decisions do not depend from transmitted information. This implies that the strategic communication loss is equal to zero (while EL^{PI} is at its maximum). As concerns for conformity increase, communication becomes more valuable and the expected loss due to strategic uncertainty starts rising. However, as the need of coordination keeps on rising, both the Fund and the Bank improve communication quality although truthful communication will never be achieved: namely, EL^C remains bounded away from zero as δ tends to infinity. Finally, from the above propositions the following Lemma can be proved.

Lemma 1 *Given α,the expected social loss is a decreasing function of δ.*

    Proof. See Appendix ∎

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[21]For a different view see Fabricius (2007) and Hagen (2013)

To sum up, if the two institutions perceive (or they are forced to perceive) a great mutual dependency, they try to coordinate their actions in order to minimize expected losses. This amends the misalignments of interests due to the "turf battle", and, as δ goes to infinity, brings to *first best* decisions in case of perfect information and $\alpha = \frac{1}{2}$. Conversely, in case of imperfect information, the expected social loss always remains bounded away from zero, because of the loss due to strategic uncertainty. Indeed, although the two institutions agree on the need of better coordinating their actions, in an imperfect information context, communication is always distorted, since both actors will try, by manipulating information, to induce the counterpart to make an adjustment closer to their own preferences. Nonethlessl, pressures for coordination always improve the two organizations' expected performance.

8   Normative and testable implications

The model does provide some normative implications on how to ameliorate cooperation between IMF and WB.

Fabricius (2007) and the Malan report (2007) stress that to remove "turf war" conflicts that jeopardize collaboration, the two organizations should move towards a stronger division of labor. Although this is not an easy task, attempts should certainly be made to more clearly focus the activities and the responsibilities of each institution. To this end, each organization's comparative advantage should be without equivocation restated in each specific conditional lending context. Indeed, the explicit introduction of the "lead agency" concept for dealing with specific policy issues could help to ensure clarity of roles, improve accountability, and increase transparency. However, since the Bank and the Fund activities are often inherently linked, it should be stressed that in many cases it would not be possible to cordon off areas of exclusive responsibilities and in this context "assigning experts" might not bring about the desired positive effects, unless the two institutions ultimate goals were explicitly motivated by cooperation.[22] Indeed, experimental research on hidden profiles has revealed that when group members are motivated by self-interest, the positive effects of identifying clear comparative advantages (i.e. "assigning experts") may be questioned or even reversed (Toma et al 2013). Thus, it is not surprising that the various arrangements to promote a division of labor between the Bank and the Fund have fallen short of ensuring consistency. A stronger division of labor should come along with the introduction of contract provisions directed to ameliorate incentive alignments between the two organiza-

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[22] "Relying on formal divisions of labor..is .. problematic because of the interdependence between different policy variables. Generally, such a division makes the Fund responsible for the aggregate management of the economy and the Bank responsible for individual sectors. Such a distinction is highly artificial calling into question the viability of any division of labor." Fabricius (2007) p. 41.

tions. Specifically, in order to decrease the self-interest, it is essential that staff incentives be appropriately aligned with institutional commitments to improve Bank-Fund collaboration. [23]Requirements to hold compulsory regular joint consultations for country teams go in this direction, since they could help building trust relationships, which are fundamental to overcome competitive pressures.[24] Introducing new programs were collaboration is mandatory, like PRGF and FSAP, would also works in the right direction, since this would be equivalent to increasing the value of the parameter δ in the loss function of each institution.

Overall, current forms of collaboration, that strive for consistency, may actually improve the Bank's and the Fund's performance, but they do not fully substitute for the cooperative behaviour observable in case of domain consensus. Specifically, external pressure for more collaboration do not eliminate the problem of strategic uncertainty; it is therefore also fundamental the introduction of clear guidelines on information sharing between Bank and Fund. Lack of clarity on what documents could be shared, obviously increases the strategic communication loss.

The theoretical analysis gives also some hints for testable implications. According to the model the overall performance of the two institutions is mainly jeopardised by competition, which is responsible for preferences' bias and ultimately for strategic communication. I expect therefore to find a relationship between variables used as proxies for the degree of asymmetric information and/or the degree of competition between the two institutions, and an opportunely chosen measure of their performance. [25].

9 Conclusions

Despite a series of official agreements aimed at strengthening Bank-Fund cooperation, it is widely believed that coordination between the two organizations often falls short of what should be rationally expected. In this paper I present a theoretical model which, focusing on the quality of information transmission between the IMF and the WB, analyses the sources of the expected loss in the overall performance of the two institutions relative to the *first best* outcome. The latter is defined as a situation where each institution recognizes the other institution's information and competence as complementary to its own, and they

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[23]For example, the ability to work in team with the other organization's staff members could become a criterion to employ new people for both institutions. In this direction goes also the proposal to introduce a recognition award for staff that demonstrate a particularly strong commitment to working constructively with their Bretton Woods counterparts.

[24]It is important to note that the requirement of holding regular joint consultation between country teams was a key component of the Joint Management Action Plan (JMAP) and was introduced in 2008. However, results have not been fully satisfactory. By december 2009 only 44% of country teams had met the requirement. (IMF, 2010).

[25]For a first attempt is this direction see Marchesi and Sabani (2013)

both agree that a correct evaluation of country's "fundamentals" requires a joint analysis of the recipient country, with each institution guiding the other in its core areas of expertise (domain consensus). On the contrary we have domain dissent when the Fund and the Bank engage in disputes motivated by competition on the leading role, with the two institutions carrying out *de facto* independent assessments of country's fundamentals, not recognizing the relevance of the other institution's information and competence.

In this paper each institution's decision process takes place in two stages: cheap talk communication and decision-making In case of domain dissent, each institution tries to balance the benefit of setting its policy decision close to its preferred (biased) alternative, with the benefit of setting its decision close to the other institution's expected decision. As a consequence, in the communication stage the two institutions transmit their private information strategically in order to induce the counterpart to make an adjustment closer to their own (suboptimal) preferences.

By comparing our results to the *first best* outcome, we show that the expected loss is made up of two components: a "own preference confirmation" loss, and a "strategic communication" loss. The first component gives the expected loss under perfect information. It only depends on the fact that in case of domain dissent each institution overlooks the counterpart information in evaluating the state of the world. The "own preference confirmation" bias impairs the ability of each organization to take decisions fully adapted to the "true" state of the world. This inefficiency cancels out as the need to coordinate actions becomes the main concern of the two institutions. The second component is due to the cost of strategic uncertainty that each institution faces over each other's decision after communication, leading to coordination failures over and above any inherent biases in the equilibrium decisions. When concerns for conformity are very relevant, strategic communication becomes the primary source of loss relative to the *first best* outcome. Two factors play an important role in determining the relevance of such loss: the level of competition between the two institutions, which determines the size of the preference's bias, and the relevance of their specialized local information (unshared information) relative to shared information.

This paper contains a number of policy implications. Firstly, identifying in strategic uncertainty an important source of loss relative to the *first best*, it provides a rational foundation to a large number of official reports calling for more information sharing between the two institutions. The introduction of clear guidelines on information sharing between Bank and Fund staff would ameliorate (although not eliminate) the existing distortions in communication. Secondly, paper's results suggest that a stronger division of labor could help to mitigate "turf war" problems, but the clear identification of each institution's comparative advantage, for each specific policy issue, should come along the introduction of contract

provisions directed to ameliorate incentive alignments between the two organizations. Indeed, experimental literature on hidden profiles has shown that "assigning experts" produces the desired positive effects, in terms of enhancing unshared information pooling, only when experts are motivated by cooperation and not by self-interest.

The paper could be extended in at least a couple of directions. First of all, the model could analyze what happens when the assumption of costless acquisition and transmission of information is relaxed. In this case concerns for conformity could probably lead to inefficiently low investment in information acquisition. Finally, this framework might prove useful in approaching the problems related to aid fragmentation (OECD, 2005). I leave these questions for future research.

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APPENDIX

Proposition 1.
Proof.

$$EL^{PI} = \left[(a-\alpha)^2 + \alpha^2\right]\sigma_F^2 + \left[(a-(1-\alpha))^2 + (1-\alpha)^2\right]\sigma_B^2 + C(\sigma_F^2 + \sigma_B^2) + D(\alpha\sigma_F^2 + (1-\alpha)\sigma_B^2)$$

Substituting $\sigma_B^2 = \sigma_F^2 = \sigma^2$ yields

$$EL^{PI} = \sigma^2 \left[(a - \alpha)^2 + \alpha^2 \right] + \left[(a - (1 - \alpha))^2 + (1 - \alpha)^2 \right] + \sigma^2 (2C + D)$$

where

$$C = (1 - a)((1 - a) + 2b(b - 2ab + 2a - 1))$$

$$D = -2(1 - a)$$

and where a and b are given by (14). Substituting in C and D , it is possible to verify that

$$2C + D = 2 \left(\frac{2\delta^4 + 4\delta^3 + 3\delta^2}{\left(2\delta^2 + 3\delta + 1\right)^2} - \frac{\delta}{1 + \delta} \right) < 0$$

For $\delta = 0$, $2C + D = 0$ therefore

$$EL_{\delta=0}^{PI} = 2\sigma^2 \left[1 + 2\alpha(\alpha - 1) \right]$$

that is greater than zero for any α, and reach its minimum for $\alpha = \frac{1}{2}$, and reaches its maximum for $\alpha = 0$ and $\alpha = 1$; while for $\delta \to \infty$,

$$EL_{\delta \to \infty}^{PI} = \sigma^2 (2\alpha - 1)^2$$

that would be zero only when $\alpha = \frac{1}{2}$ and reaches its maximum for $\alpha = 0$ and $\alpha = 1$.
Finally it is possible to show that $\frac{\partial EL^{PI}}{\partial \delta} < 0$. ■

Proposition 2

Proof.

$$EL^C = -CS(\sigma_F^2 + \sigma_B^2) - DS(\alpha \sigma_F^2 + (1 - \alpha)\sigma_B^2)$$

Substituting $\sigma_B^2 = \sigma_F^2 = \sigma^2$ yields

$$EL^C = -\sigma^2 S(2C + D) = \sigma^2 \delta \frac{\delta + 1}{(7\delta + 4)\left(2\delta^2 + 3\delta + 1\right)^2} \left(2\delta^3 + 4\delta^2 + 2\delta + 1\right) > 0$$

For $\delta = 0$, $EL^C = 0$; for $\delta \to \infty$ $EL^C \to \frac{1}{7}\sigma^2$.
Furthermore it is possible to verify that $\frac{\partial EL^C}{\partial \delta} > 0$ ■

Lemma

Proof. To prove the Lemma it is sufficient to show that

$$\frac{\partial(EL^C + EL^{PI})}{\partial \delta} < 0$$

where

$$EL^{PI} + EL^{C} = \sigma^2 \left[(a - \alpha)^2 + \alpha^2 \right] + \left[(a - (1 - \alpha))^2 + (1 - \alpha)^2 \right] + \sigma^2 (1 - S)(2C + D)$$

The first term in square brackets on the right hand side is clearly decreasing with δ, since a is decreasing with δ. As for the second term , that is negative, it is increasing in absolute value with δ. ∎