MONEY AFFAIRS
Volume XXIII, Number 2
July-December 2010

CEMLA

MONEY AFFAIRS

Esteban Colla De Robertis

Monetary policy committees and the decision to publish voting records

1. INTRODUCTION

A modern trend in central banking is that more and more central banks are making monetary policy by committees. This fact suggests that committee decisions are perceived to be superior; also, there is an increasing literature highlighting several benefits of committee decision making in monetary policy: it allows the pooling of information and forecasts; it allows for diversity in methods for processing information; it reduces volatility since extreme positions are not adopted, which is presumably beneficial if agents are risk averse. Moreover, in the case of a monetary union, a committee is the natural way to reach a consensus on the best policy for the

different regions which may prefer different courses of action.

It is also a well documented fact (Fry et al., 2000; Lybek and Morris, 2004; Maier, 2007) that there are differences in the organization among central banks, and indeed, optimal organization is subject to debate (Gerlach-Kristen, 2003, 2007; Blinder and Morgan, 2005, 2007; Fujiki, 2005). Also, authors argue that a central bank's internal organization influences the way the members of an MPC decide (Besley et al., 2008; Meade and Sheets, 2005; Gerlach-Kristen, 2007; Romer and Romer, 2008). One of the main issues in this discussion is the disclosure of information. The present paper contributes to this literature by introducing information disclosure in the context of committee decision making in a framework of time inconsistency in monetary policy à la Barro and Gordon (1983). In particular, we focus on the decision of an hypothetical central bank's constitution designer, who has to determine which is the optimal disclosure rule regarding voting records and individual proposals of the members of the MPC, and ask under which circumstances she will choose to mandate the committee to disclose individual votes or opinions (for example through the publication of minutes of the MPC meetings), or mandate the central bank not to disclose that information. As we will show below, decision to disclose such information is important when monetary policy is discretionary and signaling motives are present.

In order to explain why some countries choose to appoint transparent monetary committees while others appoint opaque committees, we consider a stylized model of discretionary monetary policy with asymmetric information. Each committee member has private information about her relative preferences concerning inflation cost and output expansion, which can be signaled to private agents through monetary policy decisions in order to reduce the inflation bias that appears when policymaking is discretionary. We examine social welfare under two alternative institutions: transparent monetary policy, in which individual proposals and MPC's choice are made public, and opaque monetary policy, in which only MPC's choice is published.

Usually, a plethora of equilibria exist in signaling games. To address this problem, we focus the analysis on separating

equilibria, in which each MPC member reveals her type with her inflation proposal for the first period, and we refine the equilibrium concept assuming that MPC members do not play dominated strategies. We give sufficient conditions for the existence of a unique separating equilibrium in undominated strategies. In this equilibrium, the most inflation averse policymaker proposes the least costly inflation rate that allows her to separate from the least inflation averse policymaker, who proposes her preferred inflation rate in the absence of signaling motives.

Using this refinement, we evaluate society's expected welfare under both institutional frameworks. With costly signaling, we show that a strong policymaker proposes a lower inflation rate under transparency than under opacity, and in both cases, inflation proposals are lower than the strong policymaker's myopic inflation rate. We also show that under transparency, the inflation rate chosen by the strong policymaker is lower the higher the preference heterogeneity and patience of the MPC. For each discount factor, there is a threshold value for our measure of preference heterogeneity such that for higher values, the country will be better of with an opaque regime, in order to avoid extremely low and below the target inflation rates, which are welfare reducing. This is argued for example by Blanchard et al. (2010), who suggest that low inflation rates limit monetary policy effects during deflationary and recessionary episodes. Although they propose a higher inflation target as a solution to this problem, there are many banks that have no explicit or legal inflation targets –the European Central Bank and the Federal Reserve being leading examples– so the choice of opacity may be an alternative to a raise of the target in order to prevent the policy limitations due to extremely low inflation rates.

To see why under a transparent regime, average inflation rate may be too low, note that under such regime, preferences of every committee member are revealed in a separating equilibrium. This implies that the difference between the inflation rate that the public will rationally expect for the second period after observing a signal of weakness, and the inflation rate that the public will expect after observing a signal of strength, is larger under transparency than under opacity. For example, consider the case of a monetary policy committee

where both policymakers are strong. If under transparency, they play separating strategies, the public will know that both policymakers are strong after observing first period's inflation proposals, so they will accordingly learn that the inflation rate for the second period will surely be low.

Instead, under opacity, only the final decision is published, and it will signal that at least one policymaker is strong; however public will not rationally rule out the possibility that one of the policymakers is weak, so they will expect a higher inflation rate than under transparency. Consider now the opposite case, that is, a committee integrated by weak policymakers. Under transparency and in a separating equilibrium, public will know that both policymakers are weak after observing inflation proposals for the first period, so they will be sure that the inflation rate for the second period will be high, while with opacity they will assign a positive probability that one of the policymakers is strong, so they will expect a lower inflation rate than under transparency.

In other words, under opacity the public is never sure that the committee is conformed only by doves or only by hawks. This means that interim expected inflation rates for the second period are more extreme under transparency. Thus, for each policymaker the effect of signaling weakness instead of strength on public's inflation expectations, is larger under transparency. To avoid this (larger) increase on inflation expectations, which is costly, a strong policymaker under transparency has to choose a lower inflation rate than under opacity. The differential effect of signaling weakness instead of strength is larger, the larger the difference in the preferences of a strong and a weak policymaker, that is, the greater preference heterogeneity of the committee. Thus, to avoid such a low (and below the target) inflation rate, the constituents of the country or monetary union may prefer to appoint an opaque committee.

Frequently, appointment of MPC members needs approval of the legislature. In other cases, such as the European Central Bank, the organic chart explicitly states that regions within the monetary union have to be represented in the MPC. This also applies to the Federal Open Market Committee, which is partially constituted by representatives of the regional federal reserves. Thus, an assumption made in this

paper is that through diverse political mechanisms, a greater preference heterogeneity and a greater patience in the country will be reflected in a greater preference heterogeneity and greater patience of the MPC –we believe that there is no reason to assume that in the long run, MPC's characteristics will persistently differ from those of the country. Thus, a prediction of the theoretical results introduced above is that we will observe opaque committees in heterogeneous and patient countries, and transparent committees in homogeneous and more impatient countries. We test this using a sample of 36 central banks. In particular, we test the significance of patience and heterogeneity as covariates of the probability that an MPC publishes its voting records or individual proposals. A Probit estimation allows us to confirm that higher heterogeneity is associated with a lower probability of publishing voting records. The sign of the proxy for patience is also the expected one in all of the specifications. However, it is not significant, so we cannot confirm that more patience is associated with more opacity.

The rest of the paper is organized as follows: we review the relevant literature in section two; the model is presented in section three; in section four we characterize separating equilibria in both frameworks, and we also characterize the least costly separating equilibrium (LCSE); in section five we characterize ex ante welfare under both disclosure rules and give conditions under which a country would choose opacity or transparency. In section six we present empirical support to the results of section five. We conclude in section seven. All proofs are provided in the appendix.

2. LITERATURE REVIEW

The argument that some kind of opacity on behalf of the policymaker may be welfare enhancing is not new. Cukierman and Meltzer (1986) show that under imperfect control of the policy instruments, the link between current inflation and future expected inflation is looser, because wage setters assign a lower informational content to the observed inflation rate in their inference process. As a consequence, the policymaker benefits from his private information. Also, Sibert

(2009) demonstrates that in a non-transparent regime, increased transparency need not improve the public's ability to infer a central bank's private information, but numerical results suggest that society and central banks prefer the transparent to the non-transparent regimes.

Another strand of literature incorporates monetary policymaking by committees to address informational issues. Sibert (2003) uses a model of overlapping generations and two types of policymakers (hawks and doves) to show that it may be profitable for doves to vote for a lower inflation rate, in order to appear as hawks. Under opacity, these incentives are lower. Hence, transparency increases incentives for doves to vote for low inflation in their first period, yielding a lower inflation bias. Sibert assumes that the average of the two proposals is adopted. Hahn (2002), commenting on a previous version of Sibert's paper, argues that given the average voting procedure and that there are dissenting interests in the MPC, it is not optimal for both central bankers to make the proposal that they individually estimate to be optimal. In the present paper we do not consider overlapping terms, and we assume a different voting procedure, which leads to the choice of the median proposal (instead of the average). In equilibrium, hawks, rather than doves, vote for a lower inflation rate than their preferred one. Thus, average inflation rate may be too low (deflation, or inflation below the target). Under these circumstances, opacity may be preferred.

Mihov and Sibert (2006) also consider a model with overlapping generations of policymakers. There are two possible types of policymakers: hawks, who mechanically vote for zero inflation, and doves, who are opportunistic and benevolent, wanting to maximize a social welfare function. They show that a transparent committee can deliver lower inflation rates (reducing the inflation bias due to dynamic inconsistency) without hindering its ability to react to stochastic shocks (that is, the committee keeps an activist role –flexible inflation targeting). The reason is that committee members are likely to opt for low inflation and building reputation when shocks are small, while if shocks are large, the incentive to react outweighs the reputation motive. For a wide range of parameters, this institution dominates discretionary monetary policy conducted by a single opportunistic policymaker, and also

dominates a zero-inflation rule (strict inflation targeting). As in Sibert (2003), a weighting rule is adopted in case of dissent, so the argument of Hahn (2002), also applies to this setting. A key parameter driving their results is the prior p that a policymaker is hawk. By increasing the ratio of hawks, society can attain lower inflation at the cost of less activism, which is in spirit of Rogoff's (1985) influential insight. This observation raises the normative issue of how to control the proportion of hawks. An alternative (positive) interpretation is that p is related to the probability that a policymaker is going to be captured by the financial sector (a highly inflation averse interest group). In societies with powerful financial sectors, a committee is a natural way to implement a flexible inflation targeting scheme, which dominates strict inflation targeting.

Other authors have stressed the importance of predictability on the effectiveness of monetary policy. (Blinder, 1999; Eggertsson and Woodford, 2003.) Furthermore, Gerlach-Kristen (2004) shows that publication of voting records enhances predictability, making it socially desirable. However, if there is a high degree of communication dispersion among committee members (high heterogeneity), ability of financial markets to anticipate future monetary policy decisions may suffer (Ehrmann and Fratzscher, 2009). Also, with bounded rationality, central bank may need to be careful not to confuse the public with extra information. This is shown in Weber (2010) in a model with time varying preferences, bounded rationality and perpetual learning on behalf of the private sector, and different institutional arrangements; however, voting is not strategic. It is also shown that greater heterogeneity makes decision making by majority rule more desirable, and also makes more likely that the publication of votes will be welfare enhancing.

On the contrary, in the present paper we assume strategic behavior. Moreover, strategic considerations drive our result that not disclosing voting records or individuals may be welfare enhancing if heterogeneity is high enough. Needless to say, strategical issues have also been at the core of the influential literature addressing time inconsistency, pioneered by Kydland and Prescott (1977) and Barro and Gordon (1983). These models correctly predict the inflation bias episodes of the seventies (high inflation and low growth). In spite of this,

authors have recently challenged the strategic behavior as-
sumption, arguing that modern central banks "just want to do
the right thing" (Blinder, 1999; McCallum, 1995). However,
institutional changes should not be left aside when explain-
ing actual motivations of central bankers. In other words,
modern central bankers may do the right thing only under
institutional constraints such as mechanisms to grant more
independence to central bankers, implicit contracts, and
mechanisms leading to the appointment of more conserva-
tive central bankers. Because our paper is about optimal cen-
tral banking institutions, we allow for strategic behavior and
ask how is the time inconsistency problem solved when a
committee decides policy under different information disclo-
sure rules. For this, we use as benchmark a discretionary
monetary policy model grounded on Kydland and Prescott
(1977), Barro and Gordon (1983) and Vickers (1986).

Another important argument in favor of transparency is
that it makes policymakers accountable, *(REFERENCES)* in-
ducing them to be more competent. However, accountability
may be problematic if an external interest group attempts to
influence committee decisions (Felgenhauer and Grüner,
2008). A concern of Issing (1999), is that national authorities
will put more pressure on the members of the European Cen-
tral Bank governing council if voting records are published.
Buiter (1999) disagrees, arguing that due to information
leaks, authorities will know voting behavior even if votes are
not disclosed. Also, while an increase in transparency can
raise welfare by reducing the informational asymmetry, stra-
tegic behavior could potentially offset the welfare gain if poli-
cymakers withhold information during their deliberations in
order to enhance their reputations. For example, Gersbach
and Hahn (2009) show that the publication of voting records
lowers welfare if members care more about being reap-
pointed than about beneficial policy outcomes.

The present paper makes the following contributions to
the literature reviewed above: even without accountability
mechanisms or political pressure, a central bank may prefer
opacity if public's preferences are very heterogeneous.
Transparency may be different from opacity in a discretionary
setting because signaling costs under each disclosure rule dif-
fer, leading to different average inflation rates for the first

period. Hawks (and not doves) vote for a lower inflation rate then their preferred one. Thus, average inflation rate may be too low (deflation, or inflation below the target). Under these circumstances, opacity may be preferred.

3. THE MODEL

The model considers an economy that lasts for two periods, indexed by $t = 1, 2$. There are two sets of agents: the public and the members of a monetarypolicy committee (MPC). We assume the simplest form of committee: one comprising two members, designed A and B, who are elected for two periods. There is no reelection and members have no reputational concerns after their mandate. For simplicity, we assume that inflation is controlled without errors or lags, so we consider committee members as directly choosing the inflation rate for the period. we use P to indicate the public and $i \in \{A, B\}$ to indicate any committee member. We also refer to a committee member as a *policymaker.*

The voting mechanism is as follows: in each period, both policymakers propose simultaneously an inflation rate for the period. If proposals coincide, the proposed inflation rate is implemented. If they do not coincide, one of them is chosen with probability $1/2$. Under this procedure, each policymaker is pivotal with equal probability. There is no commitment technology to a rule, so in each period, MPC chooses monetary policy in a discretional way. We consider two possible information disclosure rules: under transparency, proposals are disclosed to the public; under opacity, proposals are not disclosed to the public. MPC's final decision is always disclosed to the public.

Instantaneous payoff for policymaker $i \in \{A, B\}$ is:

$$(1) \qquad W_t^i = -\frac{1}{2}(\pi_t)^2 + \omega_i (\pi_t - \pi_t^e),$$

where π_t is the chosen inflation rate for the period, π_t^e is rationally expected inflation rate for the period and ω_i is a preference parameter for policymaker i. The policymaker desires to stabilize inflation rate but also wants to boost output (proxied by the term $\pi_t - \pi_t^e$). ω_i is also the proposal that

a policymaker would make absent signaling motives (i.e. in an economy lasting one period). The reason is that ω_i maximizes W_t^i given π_t^e. We henceforth refer to this proposal as policymaker's *myopic proposal*. In view of (1), committee members are better off if expectations are lower. Thus, both types have incentives to keep expectations low for the second period, in order to boost output.[1]

Intertemporal payoff is:

$$W_1^i + \beta W_2^i,$$

where β is a common discount factor. We assume that ω_i can take two values: $\omega_i \in \{\omega_S, \omega_W\}$ with $0 < \omega_S < \omega_W$. We refer to a policymaker with preference parameter ω_S as a strong policymaker (the most inflation averse) and to a policymaker with ω_W as a weak policymaker (the least inflation averse).

In each period, public chooses expected inflation rationally. That is, they use all available information to make a prediction of the inflation rate that will be chosen by the MPC.

Timing for period one is as follows: *i)* nature chooses each policymaker's type ω_i with prior $p \equiv \Pr(\omega_i = \omega_W)$, and each policymaker privately observes her type; *ii)* public chooses π_1^e and simultaneously each MPC member proposes an inflation rate for the period, π_1^i. One of the proposals is chosen by the procedure described above. Under transparency, public observes both proposals (π_1^A, π_1^B) and final decision π_1. Under opacity, public only observes final decision.

In period two, public form expectations π_2^e using available information (first period's proposals and policy decision under transparency or first period's policy decision under opacity), and simultaneously, each policymaker proposes an inflation rate for the period, π_2^i, $i = A, B$. One of the proposals is chosen by the procedure described above. First period's proposals and final decision (under transparency) or final decision (under opacity) are used for choosing expected inflation

---

[1] A more general specification would be:

$$W_t^i = -\frac{1}{2}(\pi_t - \pi_T)^2 + w_i(\pi_t - \pi_t^e),$$

where π_T is an exogenous inflation target. Without loss in generality we consider this target to be 0. Indeed, every inflation proposal described below can be interpreted as a deviation from some target π_T.

rate for the second period. We assume that in both institutions (transparency and opacity) votes are made public within the committee, so each MPC member at the beginning of period two knows first period's proposal of the other policymaker.

FIGURE 1. TIMING UNDER OPACITY AND TRANSPARENCY. IN STAGE 4, UNDER TRANSPARENCY, MPC DISCLOSES PROPOSALS AND SELECTED INFLATION RATE, WHILE UNDER OPACITY, MPC DISCLOSES ONLY SELECTED INFLATION RATE

1	2	3	4	5
Nature chooses policymaker's types	Each policymaker observes her own type	Public chooses inflation expectations; MPC chooses 1st period's inflation rate	MPC discloses information	Public chooses inflation expectations; MPC chooses 2nd period's inflation rate
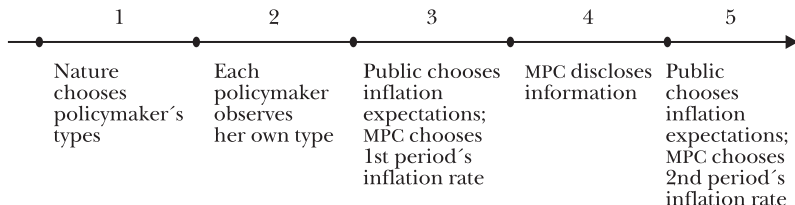
To compare social welfare under opacity and transparency, we use the following function:

$$W_1 + \beta W_2,$$

where:

$$W_t = -\frac{1}{2}(\pi_t)^2 + \chi(\pi_t - \pi_t^e)$$

and $\chi \geq 0$. The literature that proposes the appointment of a conservative central banker as a solution to the dynamic inconsistency problem in monetary policy assumes $\chi \geq \omega_W > 0$ (Rogoff, 1985).

3.1. Information structure

Let $I^{F,a}$ denote the information available for decision making at period two for agent a (public P or policymakers A or B) when institutional framework is $F \in \{T,O\}$ where T is an abbreviation for transparency and O is an abbreviation for opacity. Thus, $I^{T,P} = \{\pi_1^A, \pi_1^B, \pi_1\}$ and $I^{O,P} = \{\pi_1\}$. Note that (π_1^A, π_1^B) is a sufficient statistic for π_1 in $I^{T,P}$. (If (π_1^A, π_1^B) is known, π_1 does not add more information.) As in both institutions (transparency and opacity) votes are made public within the committee, the information available for each MPC member in period two is $I^{F,i} = \{w_1, \pi_1^{j\grave{}}\}$. The information available for each MPC member in period one is her own type:

w_i. In period one, public has no information. However, the prior p is common knowledge among all the agents in the economy.

4. EQUILIBRIUM

4.1. Equilibrium concept

The equilibrium concept used in this paper is that of perfect Bayesian equilibrium (PBE). This equilibrium entails strategies for the policymakers and for the public and beliefs for the policymakers and for the public such that each policymaker's strategy maximizes her welfare taking into account its effect on public's beliefs and on the other policymaker's beliefs, public and policymaker's beliefs are updated using Bayes rule whenever possible and use every information available and are formed using the correct conjecture about equilibrium strategies; this in turn implies that public's equilibrium expectations are rational. Formally:

Definition 1. A perfect Bayesian equilibrium (PBE) is given by:

i) strategies for committee members $\pi_1^i(\omega_i)$, $\pi_2^i(I_2^{F,i})$

ii) strategies for the public π_1^e, $\pi_2^e(I^{F,P})$

iii) beliefs for policymakers $i = A, B$

$$\mu_1^i \equiv \Pr(w_j = w_W)$$

$$\mu_2^i(I^{F,i}) \equiv \Pr(w_j = w_W \mid I^{F,i})$$

and

iv) beliefs for the public

$$\mu_1^P \equiv \Pr \textit{ (pivotal policymaker in period } 1 \textit{ is weak)}$$

$$\mu_2^P(I^{F,P}) \equiv \Pr \textit{ (pivotal policymaker in period } 2 \textit{ is weak} \mid I^{F,P})$$

such that

i) $\pi_2^i(I^{F,i})$ maximizes expected payoff in the second period, for each w_i, π_1^j, given beliefs of agents and of j,

ii) inflation expectations in the second period are rational *($I_2^{F,P}$ is used)* given the strategies $\pi_1^i(w_i)$, $\pi_2^i(I_2^{F,i})$, ,

iii) $\pi_1^i(w_i)$ maximizes expected present and discounted future payoff, taking into account the influence of π_1^i on second period's inflation expectations and on beliefs of agents and j,

iv) inflation expectations in the first period are rational given the strategies $\pi_1^i(w_i)$, $\pi_2^i(I^{F,i})$, and

v) beliefs are updated using Bayes' rule when it is possible.

If a reference to beliefs given a particular type of strategy profile σ is needed, we will use the following notation: $\mu_2^P(I_2^{F,P};\sigma)$.

4.2. Separating equilibria

We focus the analysis on separating equilibria, in which each type proposes a different inflation rate in each period. Later, we will also introduce a refinement, based on the assumption that it is known that a strong policymaker does the minimum necessary to convince the public that she is strong.

Let $\pi_1^{i,F}(\omega)$ denote inflation rate proposal for period 1 by policymaker i having type ω under institutional framework $F \in \{O,T\}$.

It follows from the definition of a PBE (condition 1) that for each ω_i and π_1^j, $\pi_2^i(\omega_i,\pi_1^i)$ maximizes (recall that the probability of being pivotal is $1/2$)

$$\frac{1}{2}\mathop{\mathrm{E}}_{\omega_j}\left[W\left(\pi_2^i,\omega_i,\pi_2^e\right)+W\left(\pi_2^j,\omega_i,\pi_2^e\right)|\,\omega_i,\pi_1^j\right]$$

given $\mu_2^A\left(\omega_A,\pi_1^B\right)$ and taking π_2^e as given. Note that

$$\operatorname*{arg\,max}_{\pi_2^i}\frac{1}{2}\mathop{\mathrm{E}}_{\omega_B}\left[W\left(\pi_2^i,\omega_i,\pi_2^e\right)+W\left(\pi_2^j,\omega_i,\pi_2^e\right)|\,\omega_i,\pi_1^j\right]$$

$$=\operatorname*{arg\,max}_{\pi_2^i}W\left(\pi_2^i,\omega_i,\pi_2^e\right)$$

(uncertainty about type of j does not matter). Thus in both transparency and opacity cases, each type of MPC member has

a dominating strategy for the second period: for every π_2^e, she proposes her myopic inflation rate:

$$\pi_2^{i,F}\left(\omega_S\right)=\omega_S<\omega_W=\pi_2^{i,F}\left(\omega_W\right).$$

Since in the second period a strong policymaker proposes a lower inflation rate than a weak policymaker, strong policymakers have an incentive to signal their type in the first period, perhaps proposing a lower inflation rate than the myopic one, while weak policymakers have an incentive to conceal their type (recall that $W\left(\pi_t,\omega,\pi_t^e\right)$ is decreasing in π_t^e). A separating equilibrium exists if there is a set S_F of values for π such that a strong type chooses to propose an inflation rate in S_F and a weak type chooses to propose an inflation rate out of S_F. The subindex makes explicit that the set S_F depends on the institutional framework.

Under transparency both proposals are made public, so two proposals in S_T signal to the the public that both policymakers in office are strong, while two proposals out of S_T signals that both policymakers in office are weak; if one proposal is in S_T and the other proposal is out of S_T, this signals that the committee is conformed by both types of policymakers.

In the first period, a strong policymaker is pivotal with probability $(1-p)$ and a weak policymaker is pivotal with probability p. That is, in any equilibrium,

$$\mu_1^P=p.$$

Let x,y be the proposals for the first period, so $I^{T,P}=(x,y)$. Denote with $\gamma_T(x,y)$ the probability (as assessed by the public) that a weak policymaker will be pivotal in the second period, given that proposals in the first period are $\pi_1^A=x$, and $\pi_1^B=y$, the institutional framework is transparency, and policymakers' separating strategy profile is σ_{sep}^T (with the set S_T being the separating set). That is, public beliefs for the second period are $\mu_2^P(I^{T,P};\sigma_{sep}^T\equiv\gamma_T(x,y)$. Then

$$\gamma_T(x,y)=\begin{cases}0 & \text{if both } x,y\in S_T\\ 1 & \text{if both } x,y\in S_T\\ 1/2 & \text{if only } x \text{ or only } y \in S_T\end{cases}$$

Accordingly, separating equilibrium's public expectations for the second period under transparency are

$$\pi_{2,T}^e(x,y) = \gamma_T(x,y)w_W + [1-\gamma_T(x,y)]w_S$$

$$= \begin{cases} w_S & \text{if both } x,y \in S_T \\ w_W & \text{if both } x,y \notin S_T \\ (w_W+w_S)/2 \equiv \overline{w} & \text{if only } x \text{ or only } y \in S_T \end{cases}$$

Under opacity, only the final decision is published. An inflation rate in set S_O, signals to the public that at least one committee member is strong, while an inflation rate outside S_O signals that at least one committee member is weak. Let x be the policy decision for the first period, so $I^{O,P} = (x)$. Denote with $\gamma_O(x)$ the probability (as assessed by the public) that the weak type will be pivotal in the second period, given that chosen inflation rate for the first period is $\pi_1 = x$ and policymakers' separating strategy profile is σ_{sep}^O; that is, public beliefs are $\mu_2^P(I^{O,P};\sigma_{sep}^O) = \gamma_O(x)$. The following lemma gives an expression for $\gamma_O(x)$ (see Appendix A for the proof).

Lemma 1. $\gamma_O(x) = \begin{cases} \dfrac{1}{2}p & \text{if } x \in S_O \\ \dfrac{1}{2}(1+p) & \text{if } x \notin S_O \end{cases}$.

It follows from lemma 1 that expectations for the second period are

$$\pi_2^e(x) = \gamma_O(x)\omega_W + (1-\gamma_O(x))\omega_S$$

$$= \begin{cases} \dfrac{1}{2}p\omega_W + \left(1-\dfrac{1}{2}p\right)\omega_S & \text{if } x \in S_O \\ \dfrac{1}{2}(\omega_W+\omega_S+p\omega_W-p\omega_S) & \text{if } x \notin S_O \end{cases}.$$

Let $g[y(x_A), y(x_B), i, F]$ denote the public's expected inflation rate for the second period, when A proposes x_A which signals that A's type is $y(x_A)$, B proposes x_B which signals that B's type is $y(x_B)$, i is pivotal in the first period and institutional framework is $F \in \{T,O\}$.

Under transparency,

$$g\big[\,y(x_A),y(x_B),i,T\,\big]=\begin{cases}\omega_S & \text{if} & x_A,x_B\in S_T\\[4pt]\omega_W & \text{if} & x_A,x_B\notin S_T\\[4pt]\bar{\omega} & \text{if} & x_A\text{ or }x_B\in S_T\text{ (but not both)}\end{cases},$$

and under opacity,

$$g\big[\,y(x_A),y(x_B),i,O\,\big]=\begin{cases}\dfrac{1}{2}p\omega_W+\left(1-\dfrac{1}{2}p\right)\omega_S & \text{if} & x_A,x_B\in S_O\\[8pt]\dfrac{1}{2}(\omega_W+\omega_S+p\omega_W-p\omega_S) & \text{if} & x_A,x_B\notin S_O\\[8pt]\dfrac{1}{2}p\omega_W+\left(1-\dfrac{1}{2}p\right)\omega_S & \text{if only} & x_i\in S_O\text{ and }i\text{ is pivotal}\\[8pt]\dfrac{1}{2}(\omega_W+\omega_S+p\omega_W-p\omega_S) & \text{if only} & x_i\in S_O\text{ and }j\text{ is pivotal}\end{cases}.$$

   To characterize the set S_F it is useful to define $V_i^F[x,y_i(x);\omega_i]$ as interim expected welfare (i.e. expected welfare after policymaker i knows her type w_i but before first period voting takes place) of policymaker i under institutional framework F, when she proposes inflation rate x for the first period, and this proposal is intended to signal that her type is $y_i(x)$, and j uses the equilibrium strategy. An expression for $V_i^F[x,y_i(x);w_i]$ is the following (see Appendix B for a detailed derivation):

(2) $$V_i^F[x,y_i(x);\omega_i]=-\frac{1}{2}x^2+\omega_i\big[x-2\beta\Pi_i^F\big(y_i(x)\big)\big],$$

where

(3) $$\Pi_i^F\big(y_i(x)\big)\equiv\frac{1}{2}\Big\{E_{\omega_j}g\big[y_i(x),\omega_j,i,F\big]+E_{\omega_j}g\big[y_i(x),\omega_j,j,F\big]\Big\}.$$

   The first term inside the brackets at the right hand side of (3) is policymaker i's expectation (taken over j's types) of the inflation rate that the public will expect for period two when i proposes x which signals $y_i(x)$, policymaker j uses the equilibrium strategy (and thus, she proposes x_j (w_j) signaling her own type i.e. $y_j[x_j(w_j)=w_j]$, and i is pivotal in the first period under institutional framework F. Similarly for the second term but with policymaker j being pivotal in the first period. Hence, $\Pi_i^F[y_i(x)]$ is i's expectation (taken over j's types) of the inflation rate that the public will expect for period two when i proposes x which signals y_i (x), and j plays a separating

strategy, under framework F. Recall that $\frac{1}{2}$ is the probability of being pivotal.

The best a policymaker can do if the public is going to believe that she is weak is to propose her myopic inflation rate. Thus, an inflation proposal k for the strong type policymaker under framework F will be part of a separating equilibrium only if

(4) $$V_i^F(k,w_s;w_s) \geq V_S^F(w_s,w_W;w_s).$$

Similarly, an inflation proposal w_W for the weak type policymaker will be part of a separating equilibrium only if

(5) $$V_i^F\left(k',\omega_S;\omega_W\right) \leq V_W^F\left(\omega_W,\omega_W;\omega_W\right)$$

for any choice k' such that $y(k') = w_S$.

Let K_S^F and K_W^F be the lower values for k and k' that satisfy the above conditions (4) and (5) with equality. In view of (2) and (3), it can be shown (see Appendix D) that these values are

$$K_S^F = w_s - 2\sqrt{\beta w_s \Delta^F} \quad \text{and} \quad K_W^F = w_W - 2\sqrt{\beta w_W \Delta^F}$$

where $\Delta^F \equiv \Pi^F(w_W) - \Pi^F(w_S)$ is i's expected rise of the inflation rate that the public will expect for period two, if i signals weakness instead of strength, and j does not deviate from the separating strategy. In appendix C it is shown that in each institutional framework, Δ^F is

$$\Delta^T = \frac{1}{2}(w_W - w_S) > \Delta^O = \frac{1}{4}(w_W - w_S).$$

Thus, expected effect of signaling weakness instead of strength on public's inflation expectations for period two is higher under transparency than under opacity. Intuitively, signaling is more costly for a policymaker under transparency, because complete revelation of policymaker's types (in a separating equilibrium) results in more extreme values for interim expected inflation rate for the second period. An important consequence of the inequality above is that under transparency, a strong policymaker will choose a lower inflation rate than under opacity. We will show below that opacity may mitigate the need to propose recessionary policies in order to signal strength, thus making opacity socially desirable.

4.2.1. Existence of a separating equilibrium

For convenience, we define the following measure of preference heterogeneity: $\phi \equiv \Delta w / w_W$. Note that $0 < \varphi < 1$ and that φ rises with the difference $\Delta \omega$. The following lemma (which extends proposition 16.3 in Cukierman (1992) to our committee framework) states that under opacity a separating equilibrium always exists, and gives sufficient conditions for the existence of a separating equilibrium under transparency (see Appendix E for the proof).

Lemma 2. *i)* $K_W^O \geq K_S^O$; *ii)* Suppose that $\beta > 1/2$ and that $\varphi < \frac{8\beta}{(2\beta+1)^2}$; then $K_W^T \geq K_S^T$ for all $p \in (0,1)$.

Conditions of the previous lemma require a not too low discount factor and a not too high preference heterogeneity. It is clear that under these conditions the set

$$S_F \equiv \{ \pi \in \mathbb{R} : K_S^F \leq \pi \leq K_W^F \}$$

is non empty.[2] Figure (2), which is adapted from figure 1 in Vickers (1986), illustrates the set S_F; indifference curves are of the form

$$-\frac{1}{2}(\pi_1)^2 + w_i(\pi_1 - 2\beta\pi_2^e) = \overline{V(w)},$$

where $w = w_S$ for the strong policymaker and $w = w_W$ for the weak policymaker. The constant $\overline{V(w)}$ satisfies

$$\overline{V(w)} = -\frac{1}{2}(w_W)^2 + w_W[w_W - 2\beta\Pi^F(w_W)]$$

and

$$\overline{V(w)} = -\frac{1}{2}(w_S)^2 + w_S[w_S - 2\beta\Pi^F(w_S)]$$

That is, $\overline{VV(w)}$ is interim expected utility of policymaker i when she proposes w as the inflation for the first period, and public expects $\Pi^F(w_W)$ for the second period. The strong

---

[2] If differences in relative preferences between types are too high, there are values of β such that it is too costly for a strong policymaker to signal his type, because signaling requires the choice of an inflation rate that is too low relative to the strong policymaker's myopic inflation rate.

FIGURE 2. THE SET S_F
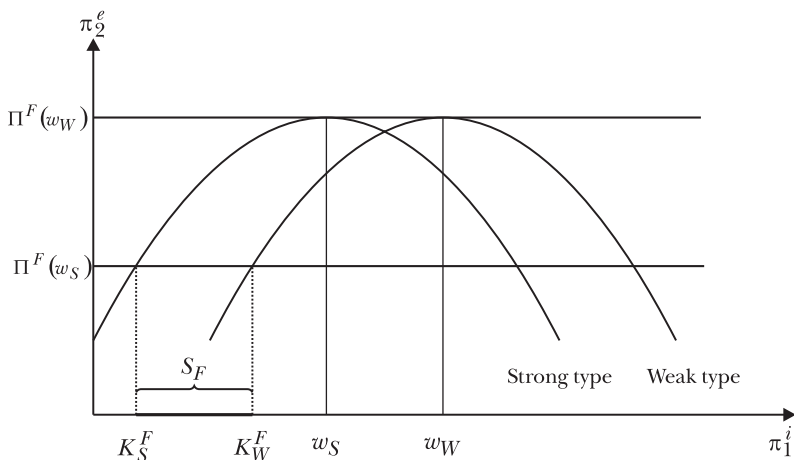
policymaker is indifferent between proposing K_S^F and expectations for the second period being $\Pi^F(w_S)$ (on an expected basis, because she does not know yet how the other policymaker is going to vote) or proposing her myopic inflation rate w_S and expectations for the second period being $\Pi^F(\omega_W)$. Similarly, the weak policymaker is indifferent between proposing K_W^F and expectations for the second period being $\Pi^F(\omega_S)$ (on an expected basis) or proposing her myopic inflation rate ω_W and expectations for the second period being $\Pi^F(\omega_W)$.

Pick values $k_T \in S_T$ and $k_O \in S_O$ and consider the following public expectations for the second period inflation rate under transparency and under opacity:

$$\pi_2^{e,T}(\pi_1^A,\pi_1^B)=\begin{cases} w_S \text{ if } \pi_1^A \leq k_T \text{ and } \pi_1^B \leq k_T \\ \overline{w} \text{ if } \pi_1^A \leq k_T \text{ and } \pi_1^B > k_T \\ \overline{w} \text{ if } \pi_1^A > k_T \text{ and } \pi_1^B \leq k_T \\ w_W \text{ if } \pi_1^A > k_T \text{ and } \pi_1^B > k_T \end{cases}$$

and

$$\pi_2^{e,O}(\pi_1)=\begin{cases} \dfrac{1}{2}pw_W +(1-\tfrac{1}{2}p)w_S = w_S + p\Delta w / 2 \text{ if } \pi_1 \leq k_O \\ \dfrac{1}{2}(w_W +w_S + pw_S) = \overline{w} + p\Delta w / 2 \text{ if } \pi_1 \leq k_O \end{cases},$$

which is consistent with the expectations in lemma 1. These expectations are not the only one that support a separating equilibrium, but they are reasonable in the sense that expectations are weakly increasing in first period's proposals. We refer to these beliefs as *natural* beliefs.

Given these expectations, strong policymakers find it optimal to propose ω_W for the first period, and given these proposal strategies for the first period, beliefs are correct in equilibrium. This is stated formally in the following proposition. Figure (3) illustrates.

FIGURE 3. A SEPARATING EQUILIBRIUM. STRONG POLICYMAKER CHOOSES $\pi_1^i(w_S) = k \in S_F$ AND WEAK POLICYMAKER CHOOSES $\pi_1^i(w_W) = w_W$

Proposition 1. Assume that conditions (i) and (ii) of lemma 2 hold. Then,

i) for any $k_T \in S_T$ there exists a separating equilibrium under transparency in which

$$\pi_1^i(\omega_S) = k_T \quad i = A, B,$$

$$\pi_1^i(\omega_W) = \omega_W \quad i = A, B,$$

$$\pi_2^i(\omega, \pi) = \omega \quad \forall \pi \quad i = A, B \quad \omega = \omega_S, \omega_W,$$

$$\pi_1^e = (1 - p)k_T + p\omega_W,$$

and

$$\pi_2^e(\pi_1^A,\pi_1^B)=\begin{cases} w_S \text{ if } \pi_1^A \le k_T \text{ and } \pi_1^B \le k_T \\ \overline{w} \text{ if } \pi_1^A \le k_T \text{ and } \pi_1^B > k_T \\ \overline{w} \text{ if } \pi_1^A > k_T \text{ and } \pi_1^B \le k_T \\ w_W \text{ if } \pi_1^A > k_T \text{ and } \pi_1^B > k_T \end{cases}$$
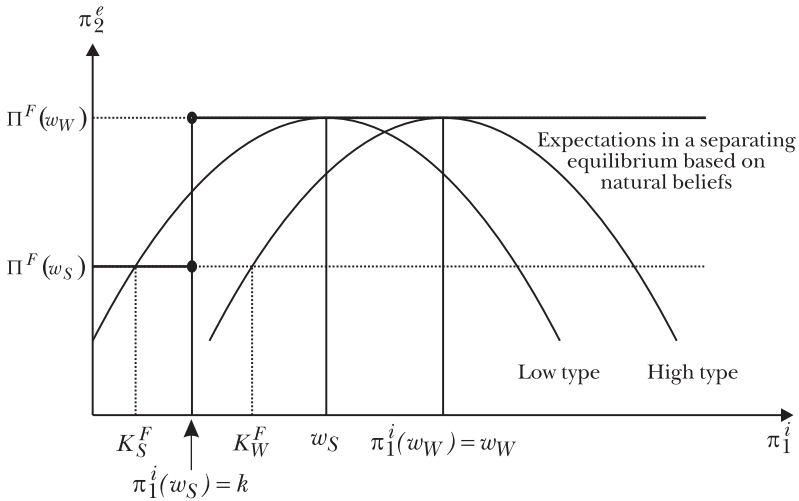
ii) for any $k_O \in S_O$ there exists a separating equilibrium under opacity in which

$$\pi_1^i(w_S)=k_O \quad i=A,B,$$

$$\pi_1^i(w_W)=w_W \quad i=A,B,$$

$$\pi_2^i(w,\pi)=w \quad \forall \pi \quad i=A,B \quad w=w_S,w_W,$$

$$\pi_1^e=(1-p)k_O+pw_W,$$

and

$$\pi_2^e(\pi_1)=\begin{cases} \dfrac{1}{2}pw_W+(1-\frac{1}{2}p)w_S=w_S+p\Delta w\,/\,2 \text{ if } \pi_1 \le k_O \\ \dfrac{1}{2}(w_W+w_S+pw_W-pw_S)=\overline{w}+p\Delta w\,/\,2 \text{ if } \pi_1 \le k_O \end{cases}.$$

4.3. Least costly separating equilibrium

The last proposition implies that there is a continuum of separating equilibria in each framework. Each of them correspond to a value $k_F \in S_F$. But note that the best beliefs from the strong policymaker's point of view are those stated above with $k_F = \min\{\omega_S,K_W^F\}$. The closer is k_F to this value, the smaller is the cost of separation for a strong policymaker (i.e. the closer is k_F to $\min\{\omega_S,K_W^F\}$, the higher is her first period's welfare, which achieves a maximum at ω_S). Under this refinement, a strong policymaker does not propose an inflation rate π if there exists another inflation rate π' that allows her to separate herself from a weak policymaker and gives her a higher expected welfare than π. Suppose that a strong policymaker proposes $k \in S_F$ and suppose that $k < K_W^F < w_S$. By choosing k' such that $k < k' < K_W^F$, her payoff increases, and public will still believe that she is strong, because a weak policymaker would never choose $k' \in S_F$ even if she could

convince the public that she is strong. (By the construction of S_F.) If $w_S \in S_F$, a similar reasoning applies: by proposing $w_S \in S_F$ instead of $k' = w_S \in S_F$, her payoff increases and public will still believe in his strength because a weak policymaker would never choose that value even if she could convince the public that she is strong. This refinement is due to Cho and Kreps (1987) and is also used in Vicker's (1986) model of signaling in monetary policy with a single policymaker. We call this equilibrium Least Costly Separating Equilibrium (LCSE). Using proposition 1 and lemma 1 we can state

Corollary 1

i) There exists a least costly separating equilibrium under opacity in which

$$\pi_1^i(\omega_S) = k_O^* \quad i = A, B,$$

$$\pi_1^i(\omega_W) = \omega_W \quad i = A, B,$$

$$\pi_2^i(\omega, \pi) = \omega \quad \forall \pi \quad i = A, B \quad \omega = \omega_S, \omega_W,$$

$$\pi_1^e = (1 - p)k_O^* + p\omega_W,$$

and

$$\pi_2^e(\pi_1) = \begin{cases} \dfrac{1}{2}p w_W + (1 - \tfrac{1}{2}p)w_S = w_S + p\Delta w / 2 \text{ if } \pi_1 \le k_O^* \\ \dfrac{1}{2}(w_W + w_S + p w_W - p w_S) = \overline{w} + p\Delta w / 2 \text{ if } \pi_1 > k_O^* \end{cases}$$

ii) Assume that conditions of lemma 2 part (ii) hold, and let

$$k_F^* \equiv \min\{w_S, w_W - 2\sqrt{\beta w_W \Delta^F}\} \quad \text{with} \quad \Delta^T = \frac{1}{2}(w_W - w_S) \quad \text{and}$$

$$\Delta^O = \frac{1}{4}(w_W - w_S). \text{ Then, there exists a least costly separat-}$$

ing equilibrium under transparency in which

$$\pi_1^i(\omega_S) = k_T^* \quad i = A, B,$$

$$\pi_1^i(\omega_W) = \omega_W \quad i = A, B,$$

$$\pi_2^i(\omega, \pi) = \omega \quad \forall \pi \quad i = A, B \quad \omega = \omega_S, \omega_W,$$

$$\pi_1^e = (1 - p)k_T^* + p\omega_W,$$

and

$$\pi_2^e(\pi_1^A, \pi_1^B) = \begin{cases} w_S \text{ if } \pi_1^A \leq k_T^* \text{ and } \pi_1^B \leq k_T^* \\ \overline{w} \text{ if } \pi_1^A \leq k_T^* \text{ and } \pi_1^B > k_T^* \\ \overline{w} \text{ if } \pi_1^A > k_T^* \text{ and } \pi_1^B \leq k_T^* \\ w_W \text{ if } \pi_1^A > k_T^* \text{ and } \pi_1^B > k_T^* \end{cases}$$

Figure (4) illustrates the proposition above.

FIGURE 4. A LEAST COSTLY SEPARATING EQUILIBRIUM. STRONG POLICY-MAKER CHOOSES $\pi_1^i(w_S) = K_W^F$, WHICH IS THE CLOSEST VALUE TO w_S THAT ALLOWS HER TO SEPARATE FROM THE WEAK POLICYMAKER
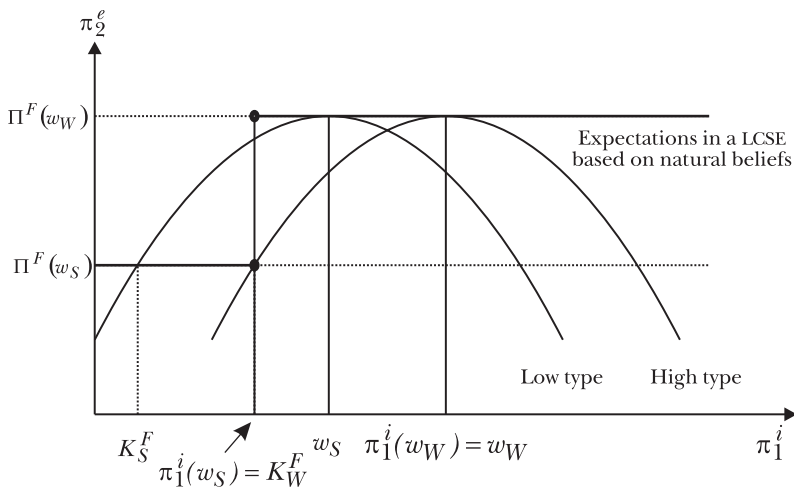
Expected effect of signaling strength on public's inflation expectations for period two is higher under transparency than under opacity; thus, we have that in a LCSE, a strong policymaker proposes under transparency a lower inflation rate than under opacity in order to signal her type. This is stated in the following lemma (see Appendix F for the proof).

Lemma 3. $k_T^* < k_O^*$.

Recall that we placed a restriction on the discount factor and on ϕ (see lemma 2). In particular, we assumed $\beta > 1/2$ which in turn implies that

$$\omega_S > \omega_W - 2\sqrt{\beta \omega_W \Delta \omega / 2},$$

thus, we have

$$k_T^* = \omega_W - 2\sqrt{\beta\omega_W\Delta\omega/2}.$$

Intuitively, a high enough discount factor allows separation under transparency, but only at a cost. (The strong policymaker cannot signal her strength proposing her myopic inflationrate ω_S.) However, under opacity there exist combinations of parameters such that a strong type policymaker does not need to propose a different (lower) inflation rate than ω_S, her myopic proposal.

Lemma 4. Let $\beta > 1/2$ and $\phi \leq 1 - \left(\frac{2\beta-1}{2\beta+1}\right)^2$. *i)* If $\beta > \phi$, then signaling for a strong policymaker is costly under opacity, that is, a strong type proposes a different (lower) inflation rate than ω_S, her myopic inflation rate; *ii)* if $\beta < \phi$,, then signaling for a strong policymaker is costless under opacity; that is, a strong type proposes ω_S, which is her myopic inflation rate; *iii)* under transparency, signaling for the strong type is always costly; that is, a strong type policymaker proposes a different (lower) inflation rate than ω_S.

This lemma is illustrated in figure (5). At the northwest of the line $\varphi = \beta$, signaling is costless under opacity. At the southeast, it is costly. Transparency is always costly. The area which is not shadowed (at the northeast of the line $\varphi = 1 - \left(\frac{2\beta-1}{2\beta+1}\right)^2$) shows the combination of parameters for which a separating equilibrium under transparency does not exist.

FIGURE 5. COSTLESS AND COSTLY SIGNALING UNDER OPACITY
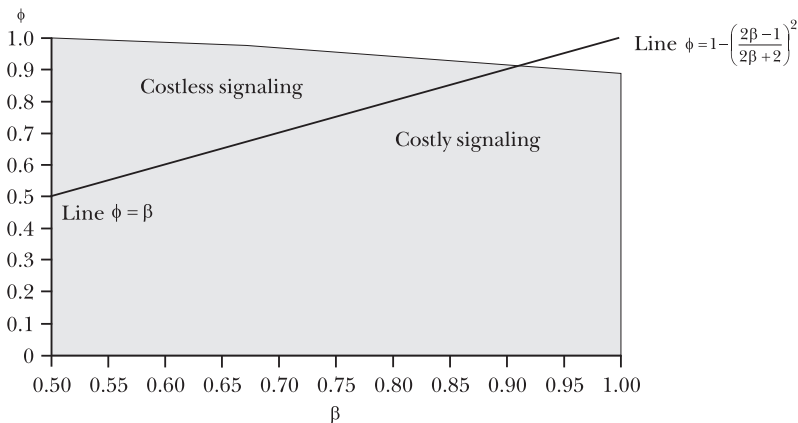
5. WELFARE COMPARISONS

In this section we characterize ex ante welfare under both disclosure rules and give conditions under which a country would choose opacity or transparency. In order to do this, we show (see appendix G) that there is no difference in expected welfare for the second period between opacity and transparency ($EW_2^O = EW_2^T$). The reason is that both types of policymakers have a dominant strategy for the second period, which entails proposing their myopic inflation rate, in both institutional frameworks, so on an expected basis, there is no difference between inflation expectations under transparency and under opacity. Then, we only need to examine first period's welfare under each framework, compare them, and give conditions under which each disclosure rule dominates the other.

Recall that in each period, policy is decided by a strong policymaker with probability

$$(1-p)^2 + p(1-p) = 1-p,$$

and by a weak policymaker with probability p. So in a LCSE, expected welfare for period 1 under institutional framework F is

$$EW_1^F = pW(w_W, \chi, \pi_1^{e,F}) + (1-p)W(k_F^*, \chi, \pi_1^{e,F})$$
$$= -\frac{1}{2}[p(w_W)^2 + (1-p)(k_F^*)^2].$$

In a LCSE only the strong type policymaker can propose a different inflation rate; a weak type proposes ω_W in both institutional frameworks; thus, difference in expected welfare between transparency and opacity is (see appendix F for a detailed derivation)

$$EW^O - EW^T = EW_1^O - EW_1^T = \frac{1}{2}(1-p)\left[\left(k_T^*\right)^2 - \left(k_O^*\right)^2\right].$$

This difference depends on deviations from the target of strong type's proposals in opacity and in transparency. In this period there is no output boosting on an expected basis in either framework.

We consider two cases:

i) $\beta < \varphi$. In this case, signaling is costly under transparency but not under opacity. A strong type proposes $\omega_W - 2\sqrt{\beta\omega_W\Delta^T}$ under transparency, and ω_S under opacity. Difference in expected welfare for the first period is

$$EW^O - EW^T = \frac{1}{2}(1-p)\left[\left(\omega_W - 2\sqrt{\beta\omega_W\Delta^T}\right)^2 - (\omega_S)^2\right].$$

ii) $\beta > \varphi$. At higher discount factors, signaling is costly in both frameworks, so a strong type proposes $\omega_W - 2\sqrt{\beta\omega_W\Delta^F}$ under transparency ($F = T$) and opacity ($F = O$), so

$$EW^O - EW^T = \frac{1}{2}(1-p)[(\omega_W - 2\sqrt{\beta\omega_W\Delta^T})^2 - (\omega_W - 2\sqrt{\beta\omega_W\Delta^O})^2].$$

Define $\quad\quad\quad \beta_C \equiv 2(\sqrt{2}-1)(= 0.8284) \quad\quad\quad$ and $\Omega(\beta,\varphi) \equiv \frac{\varphi}{2}\left(1+\beta-\frac{\varphi}{2}\right)^2 - \beta$.

Proposition 2. Let $\beta > 1/2$ and $\varphi \le 1 - \left(\frac{2\beta-1}{2\beta+1}\right)^2$.

i) If $\beta < \beta_C$, then,

(6) $EW^O \gtreqqless EW^T \Leftrightarrow \Omega(\beta,\varphi) \gtreqqless 0;$

ii) If $\beta \ge \beta_C$, then

(7) $EW^O \gtreqqless EW^T \Leftrightarrow \sqrt{\beta\varphi} \gtreqqless \beta_C.$

The proof is provided in appendix H to this paper. The proposition states that the difference $EW^O - EW^T$ has the same sign as $\Omega(\beta,\phi)$ when signaling is costless under opacity, and that it has the same sign as $\sqrt{\beta\varphi} - \beta_C$ when signaling is costly under opacity. Both equations $\Omega(\beta,\phi) = 0$ and $\sqrt{\beta\varphi} - \beta_C = 0$ have a negative slope. Moreover, at the northeast of each equation graph, the left hand side is positive, and at the southwest, the left hand side is negative, which means that opacity is desirable at high values of the discount factor and at high values of ϕ, which is a measure of preference heterogeneity. At low values of β or ϕ, transparency is desirable. Figure (6) illustrates. The prior p and the society's preference parameter χ do not affect desirability of each information disclosure rule, i.e. the sign of $EW^O - EW^T$ do not depend on p or χ.[3]

---

[3] However, the value of $EW^O - EW^T$ does depend on p. In particular,

FIGURE 6. DESIRABILITY OF OPACITY AND TRANSPARENCY. RECALL THAT $\phi = \Delta w / w_W$ IS A MEASURE OF PREFERENCE HETEROGENEITY
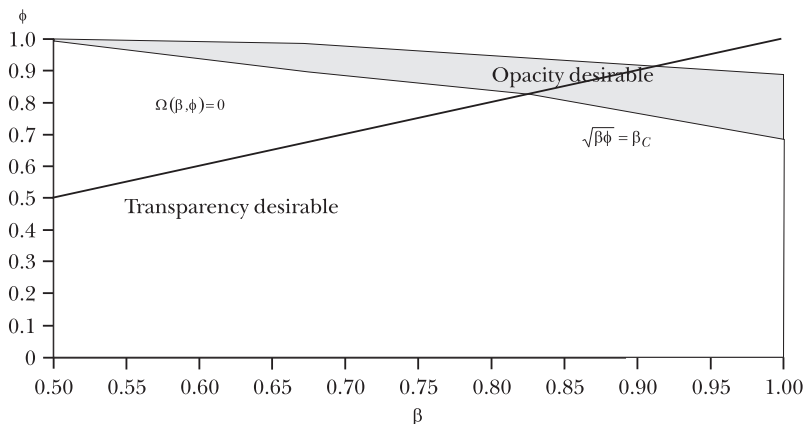
In both cases, difference in expected welfare between frameworks can be positive or negative depending on which term is closer to the inflation target. We have shown above that $\Delta^T > \Delta^O$, so $\omega_W - 2\sqrt{\beta\omega_W}\Delta^T < \omega_W - 2\sqrt{\beta\omega_W}\Delta^O$. That is, under transparency, a strong policymaker proposes a lower inflation rate than under opacity. This is illustrated in figure (7), where it can be seen that $K_W^T < K_W^O$ because complete revelation of policymaker's types results in more extreme values for expected inflation rate for the second period. Differences in expected inflation rates are $\Delta^F = \Pi^F(w_W) - \Pi^F(w_S)$. These values are $\Delta^T = \Delta w / 2$ under transparency and $\Delta^O = \Delta w / 4$ under opacity.

We have showed that desirability of opacity or transparency depends on patience and with heterogeneity among committee members. We already argued in the introduction that more heterogeneous and patient committees should be observed in more heterogeneous and patient countries. Thus, an empirical prediction of the model is that opaque monetary policy committees should be found in more heterogeneous or patient societies. We test this prediction in the following section.

―――――

the absolute value of this difference rises with the prior probability that a policymaker is of strong type. This means that at higher priors that a policymaker is strong, the issue of opacity vs transparency becomes more relevant.

FIGURE 7. EXPECTED INATION RATE UNDER OPACITY AND TRANSPARENCY
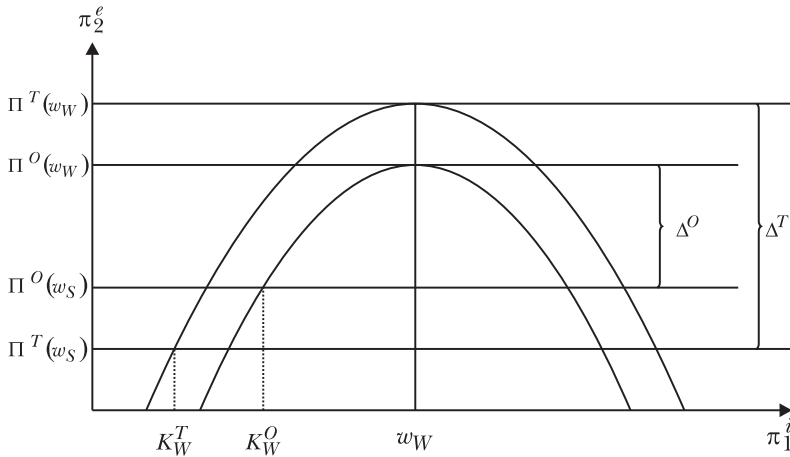
6. EMPIRICAL FINDINGS

6.1. Data and methodology

Our sample is composed by thirty six central banks making monetary policy decisions by committees, and it is the result of merging the data exhibited in Tuladhar (2005), Maier (2007) and Fujiki (2005).

In all of the banks of the sample except New Zealand, the committee expressly makes the decision, either through voting –28 central banks– or consensus –7 central banks. New Zealand's monetary policy committee convenes to advice the Governor on the setting of the monetary policy instrument, but decision-making responsibility rests solely with the Governor. Only 9 of these central banks (25%) publish minutes which include voting records or individual opinions regarding the appropriate value for the monetary policy instrument. The variable *vrec* captures this distinction. (vrec = 1 if voting records are published).

The dependent variable is the probability that the country's MPC publishes voting records or individual opinions. We employ a Probit method since *vrec* is binary. Thus, we estimate

(8) $$P(vrec = 1 \mid \mathbf{x}) = \Phi(\beta_c + \beta_r r + \beta_h h),$$

where $\mathbf{x} = (r, h)$ is the vector of covariates. The first covariate is a measure of the degree of impatience of the monetary policy committee. For this proxy, we use the difference of the real interest rate of the country versus the average real interest rate of the group of similar countries included in the sample. The second covariate is a measure of the degree of heterogeneity of the monetary policy committees. We consider two groups of proxies for this variable: proxies of the political polarization of the country and proxies of the cultural diversity of the country. The following indices are an annual average of years 1994 to 2003. Anual values have been taken from Norri's (2009) political database.

6.1.1. Political polarization

We consider the following indices:

i) Number of seats largest party. The original source is Arthur Banks Cross-National Time-Series Database. We conjecture that a a higher number of seats of the largest party in the legislature is associated with a lower political polarization. Thus, we expect a positive marginal effect of this covariate.

ii) Years in office governing party, which measures how long has executive party been in office. It is taken from Norris political database but the original source is the DPI Database of Political Institutions (Beck et al., 2001). Based on the conjecture that political polarization is inversely related to the average period the executive party has been in office, we expect a positive marginal effect of this covariate, as a lower political polarization increases the probability that the voting records are published.

iii) Number of seats governing coalition. The original source is also the DPI Database of Political Institutions (Beck et al., 2001). A higher number of seats of governing coalition is presumably associated with a lower degree of political polarization. Thus, we also expect a positive marginal efect of this covariate.

6.1.2. Cultural diversity

As measures of cultural diversity, we consider the following indices:

i) Ethnical fractionalization. The original source is Alesina et al. (2003). This index measures the probability that any two members of the society belong to different ethnic groups. We conjecture that a higher ethnic diversity is associated with a higher cultural (and maybe political) diversity of the society, which is presumably related to a higher preference heterogeneity of the country's MPC. Thus, we expect a negative marginal effect of this covariate.

ii) Linguistic fractionalization. The original source is also [?]. This index measures the probability that any two members of the society speak different languages. We also conjecture that a higher linguistic diversity is associated with a higher cultural (and maybe political) diversity of the society, which is presumably related to a higher preference heterogeneity of the country's MPC. Thus, we expect a negative marginal effect of this covariate.

In the following subsection we provide results of estimation (8).

6.2. Results

Table 1 exhibits marginal effects of political heterogeneity covariates, which have the expected positive sign (recall that higher value of the indices are related to lower heterogeneity) and are significantly different from zero. These results suggest that greater political polarization is associated with a lower probability that a monetary policy committee makes public the voting records or the policy proposals of each member.

Table 2 shows marginal effects of cultural diversity covariates, which also have the (negative) expected signal and are significantly different from zero. These results indicate that the probability that a monetary policy committee makes public its voting records or individual policy proposals is lower in more culturally diverse countries. Differential real interest rate

TABLE 1. PUBLICATION OF VOTING RECORDS AND POLITICAL HETERO-GENEITY: MARGINAL EFFECTS OF PROBIT ESTIMATES

	mfx1 b/p	mfx2 b/p	mfx3 b/p
Differential real interest rate	−0.720 (0.569)	−0.806 (0.580)	−1.189 (0.292)
Number of seats largest party	0.003[b] (0.008)		
Years in office governing party		0.003[a] (0.048)	
Number of seats governing coalition			0.002[a] (0.017)
Observations	36	36	36
Overall model significance (p-value)	0.006	0.082	0.033

NOTES: Dependent variable is the probability that the central bank's MPC makes public the voting records; and standard errors in parenthesis.
[a] Denotes significance at 0.05 while. [b] Denotes significance at 0.01.

has the expected sign in all of the models but it is not significant. Thus, empirical results do not confirm that more patient societies prefer to appoint opaque committees.

TABLE 2. PUBLICATION OF VOTING RECORDS AND CULTURAL DIVERSITY: MARGINAL EFFECTS OF PROBIT ESTIMATES

	mfx1 b/p	mfx2 b/p
Differential real interest rate	−1.264 (0.376)	−0.759 (0.360)
Ethnical fractionalization	−0.806[a] (0.010)	
Linguistic fractionalization		−0.869[b] (0.002)
Observations	36	36
Overall model significance (p-value)	0.021	0.004

NOTES: Dependent variable is the probability that the central bank's MPC makes public the voting records; and standard errors in parenthesis.
[a] Denotes significance at 0.05 while. [b] Denotes significance at 0.01.

European Central Bank (ECB) was not included in the sample, because polarization and diversity indices are not available for the European Union as a whole. However, it is worth noting that ECB's monetary policy committee does not

publishes minutes of its meetings, and it is presumably a highly heterogeneous committee, with representatives of most of euro zone countries. We believe that the inclusion of ECB in the sample would not alter the empirical findings.

7. CONCLUDING REMARKS

In this paper we consider the signaling problem in discretionary monetary policy when decisions are made by a committee, and analyze the welfare properties of two alternative institutional frameworks, each characterized by a different information disclosure rule: transparency, in which proposals of each committee member are made public along with the policy decision, and opacity, in which only the policy decision is made public. After showing that many separating equilibria exist, we focus on one of them, the least costly separating equilibrium, in which the strong policymaker does the minimum necessary to separate from the weak policymaker. We also analyze the welfare properties of both disclosure rules. In particular, we find that opacity dominates transparency for high values of patience and heterogeneity among committee members. Thus, an empirical prediction of the model is that opaque monetary policy committees should be found in more heterogeneous or patient societies. (Who will presumably appoint more heterogeneous or patient committees.)

Using a sample of thirty six central banks in which a committee is directly or indirectly involved in setting the monetary policy instrument, we estimate a Probit specification for the probability that voting records are published, employing as covariates several measures of cultural and political heterogeneity, and a proxy for society's degree of impatience. The prediction that more heterogeneous societies are more prone to appoint opaque committees is confirmed by the data. However, we cannot confirm the hypothesis that more patient societies will appoint opaque committees.

Appendix A

Proof of lemma 1

Proof. Suppose that in a separating equilibrium under opacity, $x \in S_O$. Then, at least one policymaker is strong, because only strong types choose inflation rates in S_O. Then

$$\gamma_O(x) = \frac{1}{2}\Pr(\omega_A = \omega_W, \omega_B = \omega_S \mid x \in S_O) + \frac{1}{2}\Pr(\omega_A = \omega_S, \omega_B = \omega_W \mid x \in S_O)$$

$$= \frac{1}{2}\left[\frac{(1/2)p(1-p)}{\Pr(x \in S_O)} + \frac{(1/2)(1-p)p}{\Pr(x \in S_O)} \right] = \frac{1}{2}\frac{p(1-p)}{\Pr(x \in S_O)} = \frac{1}{2}p\frac{1-p}{1-p} = \frac{1}{2}p.$$

Now suppose that in a separating equilibrium under opacity, $x \notin S_O$. Then, at least one policymaker is weak, because only weak types choose inflation rates outside S_O. In what follows, $x \notin S_O$ denotes the event "at least one policymaker is weak". Recall that this probability is $\Pr(x \notin S_O) = p$. Then

$$\gamma_O(x) = \Pr(\omega_A = \omega_W, \omega_B = \omega_S \mid x \notin S_O)\Pr(A \text{ is pivotal})$$

$$+ \Pr(\omega_A = \omega_S, \omega_B = \omega_W \mid x \notin S_O)\Pr(B \text{ is pivotal})$$

$$+ \Pr(\omega_A = \omega_W, \omega_B = \omega_W \mid x \notin S_O)$$

$$= \frac{1}{2}\frac{p(1-p)}{\Pr(x \notin S_O)} + \frac{p^2}{\Pr(x \notin S_O)} = \frac{1}{2} + \frac{1}{2}p.$$

Appendix B

An expression for $V_i^F(x, y_i(x))$

Suppose that i proposes x signaling $y_i(x)$ and suppose that j plays a separating equilibrium, in which case her first period proposal is intended to signal her type: $y_j[\pi_1^j(w_j)] = w_j$. Public's expectations for the second period when $h \in \{i, j\}$ is pivotal under institutional framework F is $g[y_i(x_i), w_j, h, F]$ Then, interim expected utility (i.e. expected welfare after policymaker i knows her type w but before first period voting takes place) of policymaker i under institutional framework F, when she proposes inflation rate x for the first period, and

this proposal is intended to signal that her type is $y_i(x)$, and j uses a separating equilibrium, is

$$\Lambda_i^F[x, y_i(x)]$$

$$=\frac{1}{4}\mathop{E}_{w_j|w_i}\left\{\begin{matrix}W(x,w_i,\pi_1^e)+\beta W\{\pi_2^i[w_i,\pi_i^j(w_j)],w_i,g[y_i(x),w_j,i,F]\}\\+W(x,w_i,\pi_1^e)+\beta W\{\pi_2^j(w_j,x),w_i,g[y_i(x),w_j,i,F]\}\\+W[\pi_1^j(w_j),w_i,\pi_1^e]+\beta W\{\pi_2^i[w_i,\pi_i^j(wj)],w_i,g[y_i(x),w_j,j,F]\}\\+W[\pi_1^j(w_j),w_i,\pi_1^e]+\beta W\{\pi_2^j(w_B,x),w_i,g[y_i,(x),w_j,j,F]\}\end{matrix}\right.$$

The expression above can be simplified to

$$=\frac{1}{2}\left[-\frac{1}{2}(x)^2+w_i(x-\pi_1^e)\right]$$

$$+\frac{1}{2}\mathop{E}_{w_j|w_i}\left\{\begin{matrix}-\beta w_i g[y_i(x),w_j,i,F]-\beta w_i g[y_i(x),w_j,j,F]\\-\frac{1}{2}\beta[\pi_2^j(w_j,x)]^2+\beta w_i\pi_2^j(w_j,x)\end{matrix}\right\}$$

where A_F does not depend on x. Note that in any equilibrium, j has a dominant strategy for the second period: $\pi_2^j(\omega_j,x)=\omega_j$ for every x. Thus,

$$\Lambda_i^F(x,y_i(x))=\frac{1}{2}\left[-\frac{1}{2}(x)^2+\omega_i\left(x-\pi_1^e\right)\right]$$

$$-\beta\omega_i\frac{1}{2}\mathop{E}_{\omega_j|\omega_i}\left\{g\left[y_i(x),\omega_j,i,F\right]+g\left[y_i(x),\omega_j,j,F\right]\right\}$$

$$+\frac{1}{2}\mathop{E}_{\omega_j|\omega_i}\left\{-\frac{1}{2}\beta(\omega_j)^2+\beta\omega_i(\omega_j)\right\}+A_F$$

When choosing x, we can considering policymaker i as maximizing the following affine transformation of $\Lambda_i^F(x,y_i(x))$, where we omit those summands where x is not present:

$$V_i^F(x,y_i(x))$$

$$=-\frac{1}{2}(x)^2+\omega_i(x)-\beta\omega_i\mathop{E}_{\omega_j|\omega_i}\left\{g\left[y_i(x),\omega_j,i,F\right]+g\left[y_i(x),\omega_j,j,F\right]\right\}$$

Letting

$$\frac{1}{2} \underset{\omega_j | \omega_i}{E} \{g\big[y_i(x),\omega_j,i,F\big]+g\big[y_i(x),\omega_j,j,F\big]\} \equiv \Pi_i^F\big(y_i(x)\big)$$

we have

$$V_i^F\big(x,y_i(x)\big) = -\frac{1}{2}(x)^2 + \omega_i\big[x - 2\beta\Pi_i^F\big(y_i(x)\big)\big]$$

which is the expression in the main body of the paper.

Appendix C

Expressions for Δ^F

Under transparency we have the following expression for public's expectations when i proposes x_i signaling $y(x_i)$ and i is pivotal:

$$g\big[y(x_A),y(x_B),i,T\big] = \begin{cases} \omega_S & \text{if} & x_A,x_B \in S_T \\ \omega_W & \text{if} & x_A,x_B \notin S_T \\ \bar{\omega} & \text{if} & x_A \text{ or } x_B \in S_T \text{ (but not both)} \end{cases},$$

Similarly, under opacity, we have

$$g\big[y(x_A),y(x_B),i,O\big] = \begin{cases} \dfrac{1}{2}p\omega_W + \left(1-\dfrac{1}{2}p\right)\omega_S & \text{if} & x_A,x_B \in S_O \\[2ex] \dfrac{1}{2}(\omega_W + \omega_S + p\omega_W - p\omega_S) & \text{if} & x_A,x_B \notin S_O \\[2ex] \dfrac{1}{2}p\omega_W + \left(1-\dfrac{1}{2}p\right)\omega_S & \text{if only } x_i \in S_O \text{ and } i \text{ is pivotal} \\[2ex] \dfrac{1}{2}(\omega_W + \omega_S + p\omega_W - p\omega_S) & \text{if only } x_i \in S_O \text{ and } j \text{ is pivotal} \end{cases}.$$

Thus, i's expectation (taken over j's types) of the inflation rate that the public will expect for period two when i proposes $x \notin S_F$ (thus, signaling weakness), and j plays a separating strategy, under framework F, is

$$\Pi^F(\omega_W) = \frac{1}{2}\begin{Bmatrix} pg\big[\omega_W,\omega_W,i,F\big]+(1-p)g\big[\omega_W,\omega_S,i,F\big] \\ +pg\big[\omega_W,\omega_W,j,F\big]+(1-p)g\big[\omega_W,\omega_S,j,F\big] \end{Bmatrix}.$$

Similarly, i's expectation (taken over j's types) of the inflation rate that the public will expect for period two when i

proposes $x \in S_F$ (thus, signaling strength), and j plays a separating strategy, under framework F, is

$$\Pi^F(\omega_S) = \frac{1}{2}\left\{\begin{array}{l} pg[\omega_S,\omega_W,i,F] + (1-p)g[\omega_S,\omega_S,i,F] \\ + pg[\omega_S,\omega_j,j,F] + (1-p)g[\omega_S,\omega_S,j,F] \end{array}\right\}$$

We have $\Pi^T(\omega_W) = p\omega_W + (1-p)\bar{\omega}$ and $\Pi^T(\omega_S) = p\bar{\omega} + (1-p)\omega_S$, so under transparency, i's expected rise of the inflation rate that the public will expect for period two, if i signals weakness instead of strength, and j does not deviate from the separating strategy is $\Pi^T(\omega_W) - \Pi^T(\omega_S) = \frac{\Delta\omega}{2}$. Similarly, under opacity, using lemma 1 we have

$$\Pi^O(\omega_W) = \frac{1}{2}p\bar{\omega} + \frac{1}{2}\bar{\omega} + \frac{1}{2}p\Delta\omega + \frac{1}{2}\omega_S - \frac{1}{2}p\omega_S$$

and

$$\Pi^O(\omega_S) = -\frac{1}{2}p\omega_S + \frac{1}{2}p\Delta\omega + \frac{1}{2}p\bar{\omega} + \omega_S$$

so under opacity, i's expected rise of the inflation rate that the public will expect for period two, if i signals weakness instead of strength, and j does not deviate from the separating strategy is $\Pi^O(w_W) - \Pi^O(w_S) = \frac{\Delta w}{4}$, which is lower than $\Pi^T(w_W) - \Pi^T(w_S)$.

Appendix D

Derivation of k_i^F

Let k_i^F be the lowest value of x that satisfies the equation $V_i^F(x,w_S) = V_i^F(w_S,w_W)$. In view of the definition of V_i^F, we have the following quadratic equation:

$$-\frac{1}{2}x^2 + w_i[x - 2\beta\Pi^F(w_S)] = -\frac{1}{2}w_i^2 + w_i[w_i - 2\beta\Pi^F(w_W)]$$

Rearranging terms we have

$$\frac{1}{2}x^2 - w_i x + \frac{1}{2}w_i^2 - 2\beta w_i \Delta^F = 0,$$

were we used the notation $[\Pi^F(w_W)-\Pi^F(w_S)]\equiv\Delta^F$ that was defined in the main text. Solving for the lower root gives $k_i^F = w_i - 2\sqrt{\beta w_i \Delta^F}$.

Appendix E

Proof of lemma 2

Proof. Recall that $S_F \equiv \{\pi \in \mathbb{R} : K_S^F \le \pi \le K_W^F\}$ with $K_S^F = \omega_S - 2\sqrt{\beta\omega_S\Delta^F}$ and $K_W^F = w_W - 2\sqrt{\beta w_W\Delta^F}$, so this set is not empty if $K_W^F \ge K_S^F$. That is, if $\frac{\Delta w}{2} \ge \sqrt{\beta w_W\Delta^F} - \sqrt{\beta w_S\Delta^F}$. Let $\Delta^F = \Delta w b_F / 2$ where $b_F = 1$ under transparency, and $b_F = 1/2$ under opacity, and define $R \equiv w_W / w_S$, which is higher than 1. Then, the above inequality becomes $R(2\beta b_F - 1) - 4\beta b_F\sqrt{R} + 1 + 2\beta b_F \le 0$. We further define $a_F \equiv 2\beta b_F$ and $r \equiv \sqrt{R}$, so we get the following polinomial inequality:

$$P_F(r) \equiv r^2(a_F - 1) - 2a_F r + 1 + a_F \le 0.$$

Under opacity, $a_O = \beta$ so the coefficient of the quadratic term is negative and polinomial $P_O(r)$ has a maximum. Roots are 1 and $-\left(\frac{1+\beta}{1-\beta}\right)$. Thus, under opacity, a sufficient condition for the set S_O to exist is $r > 1 \Leftrightarrow R > 1$ for every β. But $R > 1$ by construction, so S_O always exists. Under transparency, $a_T \equiv 2\beta$ so the coefficient of the quadratic term is positive if $\beta > 1/2$. In this case, polinomial $P_T(r)$ has a minimum. Roots are 1 and $\frac{2\beta+1}{2\beta-1}$. A sufficient condition for the set S_T to exist is $\beta > 1/2$ and $\phi < \frac{8\beta}{(2\beta+1)^2}$.

Appendix F

Proof of lemma 3

Proof. First, note that $\Delta^T = \frac{1}{2}\Delta w > \Delta^O = \frac{1}{4}\Delta w$, which implies $K_W^T = w_W - 2\sqrt{\beta w_W\Delta^T} < w_W - 2\sqrt{\beta w_W\Delta^O} = K_W^O$. From the definition of k_F^* it follows that $k_T^* \le k_O^*$. Now, note that $w_S > K_W^T$ if and only if $w_S > w_W - 2\sqrt{\beta_{w_W}\Delta^T}$, that is, in and only if $2\beta \ge \phi$,

and recall that $\phi < 1$. Thus, $\beta > 1/2$ which implies $2\beta > 1 > \phi$ which in turn implies $K_W^T < w_W$. Also, by definition, $k_T^* \equiv \min\{w_W, K_W^T\} = K_W^T$. We already know that it cannot be $k_T^* > k_O^*$, so it suffices to suppose that $k_T^* = k_O^*$ and look for a contradiction. If $k_O^* = k_T^*$, then, by definition of k_O^*, we have $K_W^T = k_T^* = k_O^* \equiv \min\{\omega_S, K_W^O\}$, that is, $K_W^T = \min\{\omega_S, K_W^O\}$. This is a contradiction because we already proved that $K_W^T < w_S$ and that $K_W^T < K_W^O$.

Appendix G

Expressions for welfare comparisons

In this appendix we give expressions for $EW_t^O - EW_t^T$ where EW_t^F is expected welfare for period t under framework F. In what follows $W_t^F(\omega_A, \omega_B)$ denotes period t's expected welfare for society, when types of policymakers are (w_A, w_B), institutional framework is F, and both policymakers plays the least costly separating strategy.

If both policymakers are strong, we have the following expressions for first period's welfare under a LCSE:

$$W_1^T(L,L) = -\frac{1}{2}(k_T^*)^2 + \chi p(k_T^* - \omega_W)$$

under transparency, and

$$W_1^O(L,L) = -\frac{1}{2}(k_O^*)^2 + \chi p(k_O^* - \omega_W)$$

under opacity. Thus, difference in first period's welfare between opacity and transparency, if both policymakers are strong, is

$$W_1^O(L,L) - W_1^T(L,L) = \frac{1}{2}(k_T^*)^2 - \frac{1}{2}(k_O^*)^2 + \chi p(k_O^* - k_T^*)$$

Similarly, if one policymaker is strong and the other is weak, we have

$$W_1^T(L,H) = \frac{1}{2}\left[-\frac{1}{2}(k_T^*)^2 + \chi(k_T^* - (1-p)k_T^* - p(\omega_W)) \right]$$

$$+ \frac{1}{2}\left[-\frac{1}{2}(\omega_W)^2 + \chi(1-p)(\omega_W - k_T^*) \right]$$

under transparency, and

$$W_1^O(L,H) = \frac{1}{2}\left[-\frac{1}{2}(k_O^*)^2 + \chi p(k_O^* - \omega_W)\right] + \frac{1}{2}\left[-\frac{1}{2}(\omega_W)^2 + \chi(1-p)(\omega_W - k_O^*)\right]$$

under opacity, so difference in first period's welfare between opacity and transparency, if one policymaker is strong and the other is weak, is

$$W_1^O(L,H) - W_1^T(L,H) = \frac{1}{2}\left[\frac{1}{2}(k_T^*)^2 - \frac{1}{2}(k_O^*)^2\right] + \frac{1}{2}\chi(k_O^* - k_T^*)(2p-1)$$

Finally, if both policymakers are weak, we have

$$W_1^T(H,H) = -\frac{1}{2}(w_W)^2 + \chi\left[w_W - (1-p)k_T^* - p(w_W)\right] - \frac{1}{2}(w_W)^2 + (1-p)\chi(w_W - k_T^*)$$

under transparency, and

$$W_1^O(H,H) = -\frac{1}{2}(w_W)^2 + (1-p)\chi(w_W - k_O^*)$$

under opacity, so difference in first period's welfare between opacity and transparency, if one policymaker is strong and the other is weak, is

$$W_1^O(H,H)_1^T - W_1^T(H,H) = (1-p)\chi(k_T^* - k_O^*)$$

Given that both policymakers are strong with probability $(1-p)^2$, both are weak with probability p^2, and one is strong and the other weak with probability $p(1-p)$, difference in expected welfare for the first period is

$$EW_1^O - EW_1^T = (1-p)\frac{1}{2}\left[(k_T^*)^2 - (k_O^*)^2\right].$$

Under transparency, we have the following expressions for second period's welfare under a LCSE:

$$W_2^T(L,L) = -\frac{1}{2}(w_S)^2 + \chi(w_S - w_S) = -\frac{1}{2}(w_S)^2,$$

if both policymakers are strong;

$$W_2^T(L,H) = -\frac{1}{2}\frac{1}{2}(w_S)^2 - \frac{1}{2}\frac{1}{2}(w_W)^2,$$

if one is strong and the other is weak; and

$$W_2^T(H,H) = -\frac{1}{2}(w_W)^2 + \chi(w_W - w_W) = -\frac{1}{2}(w_w)^2$$

if both are weak. Similarly, under opacity, we have the following expressions for second period's welfare under a LCSE:

$$W_2^O(L,L) = -\frac{1}{2}(w_S)^2 + \chi(w_S - \tilde{w}_W(p))$$

if both policymakers are strong;

$$W_2^O(L,H) = \frac{1}{2}\left[-\frac{1}{2}(w_S)^2 + \chi(w_S - \tilde{w}_S(p)) - \frac{1}{2}(w_W)^2 + \chi(w_W - \tilde{w}_W(p))\right]$$

if one is strong and the other is weak; and

$$W_2^O(H,H) = -\frac{1}{2}(\omega_W)^2 + \chi(\omega_W - \tilde{\omega}_W(p))$$

if both are weak. Thus, difference in expected welfare for period two is

$$EW_2^O - EW_2^T = \chi\left[-p(1-p)\Delta\omega/2 + p(1-p)\Delta\omega/2\right] = 0,$$

so on an expected basis, there is no difference in period two's welfare between transparency and opacity.

Appendix H

Proof of proposition 3

Proof. If signaling under opacity is costless, then

$$EW^O \gtreqless EW^T$$

$$\Leftrightarrow (\omega_W + \omega_S)\Delta\omega - 4\omega_W\sqrt{\beta\omega_W\frac{\Delta\omega}{2}} + 4\beta\omega_W\frac{\Delta\omega}{2}0 \text{ (using definition of } \Delta^T)$$

$$\Leftrightarrow \sqrt{\beta\varphi} - \beta_C \gtreqless 0.$$

REFERENCES

Alesina, A., A. Devleeschauwer, W. Easterly and S. Kurlat

(2003), "Fractionalization", *Journal of Economic Growth,* Vol. 8, No. 2, pp. 155-94.

Barro, R. J., and D. B. Gordon (1983), "Rules, discretion and reputation in a model of monetary policy", *Journal of Monetary Economics*, Vol. 12, No. 1, pp. 101-121.

Beck, T., G. Clarke, A. Groff, P. Keefer and P. Walsh (2001), "New tools in comparative political economy: The database of political institutions", *World Bank Economic Review*, Vol. 15, No. 1, pp. 165-176.

Besley, T., N. Meads and P. Surico (2008), "Insiders versus outsiders in monetary policymaking", *American Economic Review,* Vol. 98, No. 2, pp. 218-23.

Blanchard, O., G. Dell'Ariccia and P. Mauro (2010), *Rethinking macroeconomic policy*, International Monetary Fund (IMF Staff Position Note).

Blinder, A. S. (1999), *Central Banking in Theory and Practice,* Vol 1, MIT Press Books, The MIT Press.

Blinder, A. S., and J. Morgan (2005), "Are two heads better than one? an experimental analysis of group versus individual decision making", *Journal of Money Credit and Banking,* Vol. 37, No. 5.

Blinder, A. S., and J. Morgan (2007), *Leadership in groups: A monetary policy experiment,* Center for Economic Policy Studies, July (Working Paper Series, No. 151)

Buiter, W. (1999), *Alice in euroland*, Centre for Economic Performance, LSE (Discussion Papers, No. 0423).

Cho, I. K., and D. M. Kreps (1987), "Signaling games and stable equilibria", *The Quarterly Journal of Economics,* Vol. 102, No. 2, pp. 179-221.

Cukierman, A. (1992), *Central Bank Strategy, Credibility, and Independence: Theory and Evidence,* Vol 1., MIT Press Books, The MIT Press.

Cukierman, A., and A. H. Meltzer (1986), "A theory of ambiguity, credibility, and inflation under discretion and asymmetric information", *Econometrica*, Vol. 54, No. 5, pp. 1099-1128.

Eggertsson, G. B., and M. Woodford (2003), "The zero bound on interest rates and optimal monetary policy", *Brookings Papers on Economic Activity,* Vol. 34, No. 1, pp. 139-235.

Ehrmann, M., and M. Fratzscher (2009), "Purdah-on the rationale for central bank silence around policy Meetings",

Journal of Money, Credit and Banking, Vol. 41, Nos. 2-3, pp. 517-528.

Felgenhauer, M., and H. P. Grüner (2008), "Committees and special interests", *Journal of Public Economic Theory,* Vol. 10, No. 2, pp. 219-243.

Fry, M. J., D. Julius, L. Mahadeva, S. Roger and G. Sterne (2000), "Key issues in the choice of monetary policy framework", in L. Mahadeva and G. Sterne (eds.), *Monetary policy frameworks in a global context,* Routledge, London.

Fujiki, H. (2005), "The monetary policy committee and the incentive problem: A selective survey", *Monetary and Economic Studies* (Institute for Monetary and Economic Studies Bank of Japan), Vol. 23, No. 1, pp. 37-82.

Gerlach-Kristen, P. (2003), "Insiders and outsiders at the Bank of England", *Central Banking,* Vol. 14. No. 1, pp. 96-102.

Gerlach-Kristen, P. (2004), "Is the MPC's voting record informative about future UK monetary policy?", *Scandinavian Journal of Economics,* Vol. 106, No. 2, pp. 299-313.

Gerlach-Kristen, P. (2007), *The MPC at ten: The voting pattern of insiders and outsiders,* University of Basel (Working Paper).

Gersbach, H., and V. Hahn (2009), "Voting transparency in a monetary union", *Journal of Money, Credit and Banking,* Vol. 41, No. 5, pp. 831-853.

Hahn, V. (2002), "Transparency in monetary policy: A survey", *ifo Studien,* Vol. 48, No. 3, pp. 429-455.

Issing, O. (1999), "The eurosystem: Transparent and accountable or 'willem in euroland'", *Journal of Common Market Studies,* Vol. 37, No. 3, pp. 503-519.

Kydland, F., and E. Prescott (1977), "Rules rather than discretion: the inconsistency of optimal plans", *Journal of Political Economy,* Vol. 85, pp. 473-491.

Lybek, T., and J. Morris (2004), *Central bank governance: A survey of boards and arrangements,* International Monetary Fund (Working Paper, No. 04).

Maier, P. (2007), *How central banks take decisions: An analysis of monetary policy meetings,* Mimeo, Bank of Canada.

McCallum, B. T. (1995), "Two fallacies concerning central-bank independence", *American Economic Review,* Vol. 85, No. 2, pp. 207-11.

Meade, E. E., and N. Sheets (2005), "Regional influences on fomc voting patterns", *Journal of Money Credit and Banking,* Vol. 37, No. 4, pp. 661-678.

Mihov, I., and A. Sibert (2006), "Credibility and flexibility with independent monetary policy committees", *Journal of Money, Credit and Banking,* Vol. 38, No. 1, pp. 23-46.

Norris, P. (2009), *Democracy timeseries data release 3.0,* january.

Rogoff, K. (1985), "The optimal degree of commitment to an intermediate monetary target", *The Quarterly Journal of Economics,* Vol. 100, No. 4, pp. 1169-89.

Romer, C. D., and D. H. Romer (2008), "The fomc versus the staff: Where can monetary policymakers add value?", *American Economic Review,* Vol. 98, No. 2, pp. 230-35.

Sibert, A. (2003), "Monetary policy committees: Individual and collective reputations", *Review of Economic Studies,* Vol. 70, pp. 649-666.

Sibert, A. (2009), "Is transparency about central bank plans desirable?", *Journal of the European Economic Association,* Vol. 7, No. 4, pp. 831-857.

Tuladhar, A. (2005), *Governance structures and decision-making roles in inflation targeting central banks*, International Monetary Fund (IMF Working Papers, No. 05/183).

Vickers, J. (1986), "Signalling in a model of monetary policy with incomplete information", *Oxford Economic Papers,* Vol. 38, No. 3, pp. 443-55.

Weber, A. (2010), *Monetary policy committees, learning, and communication,* International Monetary Fund (IMF Working Papers, No. 10/85).

Jorge Ponce

A normative analysis of banking supervision: independence, legal protection and accountability

1. INTRODUCTION

The institutional organization of banking supervision[1] has been attracting the interest of academics and policymakers in

[1] I use the term *banking supervision* in a broad sense. It includes not only supervisory policies but also the institutional arrangements that are in charge of conducting them.

the last years.[2] Goodhart (1998), Lastra (1996) and Quintyn and Taylor (2003) were among the first scholars to stress the need for independent supervisory agencies. The Basel Committee on Banking Supervision (1997, 2006) has put the need for independent, accountable and legally protected bank supervisors in its Core Principles for Effective Banking Supervision. However, policymakers have been reluctant to give a substantial degree of effective independence to supervisory authorities and to enact appropriate accountability arrangements.[3] Moreover, non-conclusive empirical evidence on the effects of different supervisory arrangements on the outcomes of the banking sector have been presented. On the one hand, Das et al. (2004) find that better supervisory governance (of which independence is a key component) tends to improve the solvency of banks and to reduce the ratio of non-performing loans. On the other hand, Barth et al. (2004, 2006) find that supervisory independence is not related to bank development or the level of non-performing loans.

Which are the characteristics that the institutional arrangements for banking sector supervision should have to effectively implement an efficient supervisory policy? This is the topic addressed in this paper. I provide a formal model of a bank supervisor that allows to derive policy implications on the optimal institutional arrangements for effective banking supervision.[4] I

---

[2] According to Masciandaro and Quintyn (2007), structure, organization and governance of banking sector supervision was not a topic for an animated debate two decades ago. Financial systems around the world were heavily regulated (i.e., repressed); by whom and how they were supervised was not a topic that stirred great commotion. Since then, financial liberalization has profoundly altered the banking sector and the nature of its operations, triggering big challenges to bank supervisors. Moreover, a series of systemic banking crises in recent years have put in evidence the importance of counting with appropriately designed regulatory and supervisory arrangements (see, for example, Rochet, 2008).

[3] Quintyn et al. (2007) analyze recent changes in legal and institutional frameworks for supervision in 32 countries and find strong evidence that the endorsement of independence to bank supervisors remains half-hearted and overcompensated on the accountability side. I find that around 30% of the countries in the data set I use in section 5 fail to enact adequate levels of independence and accountability to their supervisors (see section 5.3 for details).

[4] In broad terms, banking supervision is *effective* when it is adequate to accomplish the purposes of improving banking stability and strengthening

find that bank supervisors should have political independence, and that independence should be complemented by legal protection and accountability arrangements for bank supervisors. I provide empirical evidence supporting these theoretical findings: the existence of an independent, legally protected and accountable bank supervisor substantially reduces the average probability of banks' loans default. Moreover, the existence of appropriate accountability arrangements and legal protection for bank supervisors are the most important elements to reduce the riskiness of banks.

In the model, banking supervision is necessary to avoid excessive risk taking by a banker. A supervisory policy characterized by closing excessively risky banks is effective. However, politicians, who seek to maximize social welfare, cannot credibly commit to this policy. As in Mailath and Mester (1994), politicians confront a dynamic commitment problem: they find optimal ex post not to punish a banker that has taken excessive risks (i.e., to close the bank) even though it is optimal ex ante to commit to this policy. In turn, the banker will take excessive risks. This provides a rationale for giving political independence to the bank supervisor.

Delegation of authority to a self-interested agent is not without its difficulties. First, the independent bank supervisor may prefer to shirk rather than to supervise banks. Second, bankers may *capture* the bank supervisor through side-contracts (e.g., monetary bribes, in-kind favors, presents and future job offers) as for the latter not to enforce a supervisory policy.[5] Third, some characteristics of supervisory information (e.g., opaqueness, complexity and confidentiality) may imply that the terms of the contract between society (e.g., a constitutional framer or legislative body seeking to maximize social welfare) and the independent bank supervisor may not be properly enforced. The Parliament or a Court of Law may find it impossible to verify whether the bank supervisor has evaded his responsibilities when they have access only to public information about banks. However, the bank supervisor may be able, and should be willing, to show hard, verifiable

_____

the banking sector. In this paper's formal model, these purposes are accomplished when a banker abstains from taking excessive risks.

[5] I will use the expressions *capture* and *side-contract* interchangeably.

information (e.g., audited bank's balance sheets and technical reports on the riskiness of a bank).

I characterize the optimal contract between society and the independent bank supervisor: the contract that gives the latter incentives to effectively supervise the bank at the lowest cost to the former. The optimal contract can be implemented by law: a bank supervisor's charter law or statute. In addition to set up a politically independent bank supervisor, this law should protect the bank supervisor for the exercise of his duties in good faith and should specify accountability arrangements.

Legal protection is good for incentives. A bank closure may imply high costs to the banker. In turn, the banker may sue the bank supervisor. If the outcome of such a lawsuit implies punishment to the bank supervisor even though he shows hard evidence that the bank was indeed excessively risky, then his incentives to close the bank down will weaken and his incentives to accept a side-contract from the banker will strengthen. Thus, legal protection (i.e., that the bank supervisor cannot be punished if he proves that he has closed down an excessively risky bank) reduces the scope for capture. Legal protection also makes it easier to hire competent supervisors. Indeed, the lack of legal protection would have to be compensated by higher revenues accruing to the supervisor. Consequently, enacting legal protection reduces the pecuniary cost of appointing an independent bank supervisor.

Accountability is good for incentives. Accountability implies answerability and responsibility: the bank supervisor must be prepared to justify his actions (e.g., by showing hard information to a judge) and he is liable to be blamed for the outcome of his actions. Without an appropriately designed accountability arrangement, the bank supervisor will not have incentives to supervise banks. Moreover, he will have incentives to accept side-contracts from bankers, and even to blackmail them by using closure as a threat.

The design of accountability arrangements matters. First, rewards and penalties accruing to the bank supervisor have to be contingent on the information he provides and on the assessment of the actions he has taken. Second, tough accountability arrangements specifying high expected penalties are better for incentives but they discourage bank supervisors to

participate. Consequently, the policymaker should trade
these effects off.

The theoretical analysis has the following testable implica-
tion: the probability of banks' loans default (i.e., a measure of
the riskiness of the banking sector) would be lower when the
institutional arrangement for banking supervision is charac-
terized by independent, legally protected and accountable
bank supervisors. I use data collected by the Financial Sector
Assessment Program (FSAP)[6] on 81 countries around the
world for the period 1999-2009 to test that hypothesis. The
results from the analysis of the data are consistent with pre-
dictions. Moreover, the estimates imply that the probability of
bank's loans default significantly reduces from 10% to 3%
(approximately) when the supervisory arrangement has the
characteristics described before.

In addition to quantify the effect of supervisory arrange-
ments on the riskiness of banks, the empirical part of this pa-
per sheds some light on the relative importance of different
components of the supervisory arrangement. Adequate ac-
countability arrangements and legal protection for bank su-
pervisors are key elements to reduce the riskiness of the bank-
ing sector.

Around 30% of the countries in the sample fail to enact
appropriate independence and accountability arrangements,
and more than 50% of the bank supervisors are not legally
protected. Hence, the results in this paper imply that policy-
makers should be persuaded of the benefits of enacting ar-
rangements for banking sector supervision along the lines
suggested in this paper.

The theoretical literature on independence and, more
broadly, governance of banking sector supervisors has built
up on the formal models of the literature on central banks'
independence.[7] Quintyn and Taylor (2003, 2007) argue that

---

[6] The Financial Sector Assessment Program (http://www.imf.org/
external/np/ fsap/fsap.asp) is jointly conducted by the International
Monetary Fund and the World Bank since 1999 with the aim, among oth-
ers, of identifying the strenghts and vulnerabilities of a country's financial
system by assessing its observance of relevant financial sector standards and
codes.

[7] See, for example, Rogoff (1985), Cukierman (1992), Lohmann (1992),
Walsh (1995), and Gabillon and Martimort (2004).

the independence of supervisory agencies matters for banking stability for many of the same reasons that the independence of central banks matters for monetary stability, and that accountability arrangements should complement independence arrangements in order to make banking supervision effective. Rochet (2008) concludes that banking crises are largely amplified by political interference and that the key to successful reform is independence and accountability of bank supervisors. This paper provides a model formalizing the optimal contract for a bank supervisor. Independence, accountability arrangements and legal protection for bank supervisors emerge as necessary conditions to implement the optimal contract.

So far, empirical work has obtained non-conclusive results. Das et al. (2004) use FSAP data to construct an index of regulatory governance and find that it has a significant positive effects on their index of financial system soundness. Barth et al. (2004, 2006) construct a data set via surveys to document the relationship between several supervisory practices and banking sector outcomes. They find that supervisory independence is not related to bank development or efficiency or the level of non-performing loans.

Differently from these papers, the theoretical analysis in this paper provides a framework to test the causal effect of supervisory arrangements on the riskiness of the banking sector. It also allows the quantification of this effect and the uncovering of the key components of a supervisory arrangement for effective banking supervision.

The next section describes the model and its benchmark. Section 3 analyzes the key elements on a bank supervisor's contract. Section 4 characterizes the optimal contract for an independent bank supervisor and derives policy implications. Section 5 presents the empirical results and section 6 concludes. Technical proofs and tables are in the Appendix.

2. THE MODEL AND ITS BENCHMARK

2.1. Agents, Technologies and Preferences

This model describes the relationship between a banker, a

bank supervisor and politicians in a risk neutral environment.

Banker. The banker collects (fully insured) retail deposits in amount *D*, and invests in risky loans. The banker is the residual claimant of the bank's assets and is protected by limited liability. Deposits are paid the risk-free interest rate, which is normalized to zero. For simplicity, the size of the bank's balance sheet is normalized to one: $D = 1$.

The banker has access to a risky investment technology (i.e., bank loans). This technology yields a random, gross return $\tilde{R}$ at maturity or a deterministic, gross return $R^l < 1$ if it is liquidated before maturity. $\tilde{R}$ is contingent on the state of the world at maturity, which is perfectly verifiable. For simplicity, I assume that there are three states of the world (*up*per, *m*iddle and *d*efault) with corresponding returns $R^u > R^m > 1 > R^d = 0$. There is no time discounting.

The distribution of probabilities of the bank's loans return, $\tilde{R}$, depends on the banker's private behavior: she can take excessive risks, leading to a deterioration of the distribution of probabilities on the returns in the sense of second-order stochastic dominance (see table 1). Third parties may observe the riskiness of the bank's loans only through supervision. I assume that excessive risk-taking implies a mean-preserving spread on the distribution of probabilities of $\tilde{R}$. Hence, if π denotes the expected net present value of the bank's loans, we have: $\pi^{benchmark} = \theta^u R^u + \theta^m R^m - 1$, $\pi^{risk-taking} = (\theta^u + \alpha) R^u + (\theta^m - \alpha - \beta) R^m - 1$, and $\pi = \pi^{benchmark} = \pi^{risk-taking}$. Banking activities add to social welfare: $\pi > 0$.

TABLE 1. EFFECTS OF THE BANKER'S BEHAVIOR ON THE DISTRIBUTION OF PROBABILITIES OF $\tilde{R}$

Behavior	$PR\,(R^U)$	$PR(R^m)$	$PR\,(R^d)$
Benchmark	θ^u	θ^m	θ^d
Risk-taking	$\theta^u + \alpha$	$\theta^m - \alpha - \beta$	$\theta^d + \beta$

The banker maximizes her expected profit, denoted *B*. If the banker does not take excessive risks, then. $B^{benchmark} = \theta^u (R^u - 1) + \theta^m (R^m - 1)$. These two terms are the expected residual values of the bank's assets (i.e., the return on loans net of the reimbursement to depositors) when bank loans' returns are R^u and R^m respectively. Limited liability implies that the

banker gets zero when $\tilde{R} = R^d = 0$. Rearranging terms and using the definition of the expected net present value of the bank's loans (i.e., $\pi = \theta^u R^u + \theta^m R^m - 1$),

$$B^{benchmark} = \pi + \theta^d.$$

The banker's expected profit when she takes excessive risks can be computed in the same way:

$$B^{risk-taking} = \pi + \theta^d + \beta.$$

The banker prefers to take excessive risks. If she takes excessive risks, then the probability of the upper and the default states will increase. So, the banker will benefit more frequently from high returns but her bank will also fail with a higher probability. However, limited liability implies that the banker does not internalize the downside losses. Otherwise stated, limited liability provides the banker with an incentive to gamble with depositors' money; excessive risk-taking reports an additional expected profit $B^{risk-taking} - B^{benchmark} = \beta$ to the banker.[8]

Bank Supervisor. The bank supervisor has the authority to gather private information from the bank and to penalize the banker by closing her bank down; if the bank is closed, the banker receives nothing.

The bank supervisor has access to a supervisory technology which is characterized as follows. If he exerts some unobservable

---

[8] By increasing the stake of bank shareholders, capital regulation would boost their incentives to ensure that the bank is not taking excessive risks (see Santos, 2001, for a review of the literature). However, Kashyap et al. (2008) discuss a series of factors that put limits to the alignment-of-incentives function of bank capital before the subprime crisis. Moreover, Rochet (1992) makes an extensive study of the consequences of capital regulations on the portfolio choices of commercial banks and concludes that "capital regulations (at least of the usual type) are a very poor instrument for controlling the risk of banks: they give incentives for choosing 'extreme' asset allocations, and are relatively inefficient for reducing the risk of bank failures." (page 1160) In the model, I am taking seriously these arguments. I assume that capital regulations are not effective to prevent excessive risk taking by bankers, and then that banks have no capital. Hence, I focus the analysis on the optimal institutional design of banking supervision aimed at preventing banks' excessive risk taking. Nonetheless, the interaction between capital regulation and optimal design of bank supervision should be analyzed by future research.

effort, he will gather hard, verifiable information about the riskiness of the bank's loans with probability $\mu \in (0, 1)$. He will get no information with probability $1 - \mu$. For example, he might conduct on-site inspections with the aim of certifying the bank's loans quality, and he might process financial information with the aim of proving that the bank is indeed excessively risky. If the bank supervisor shirks, he will gather no information and he will get a private benefit B. I assume that

$\mu \geq \dfrac{\beta}{\pi + \theta^d + \beta}$. Thus, if the bank supervisor commits to close

the bank whenever he gets information certifying excessive risk-taking by the banker, the banker will abstain from taking excessive risks.[9]

The bank supervisor is a self-interested agent and is protected by limited liability. He receives an incentive scheme from society:[10] he gets a transfer w and is subject to monitoring. The transfer can be viewed as the budget of the bank supervisor. It can also be viewed as a proxy for his private benefits, his prestige, or the size of the staff that the supervisor gets when holding office. Monitoring works as follows: a judge (e.g., a legislature or a court of law) demands the bank supervisor to show hard information in support of his actions, and punishes him (e.g., the supervisor is fired and forbidden to work in the banking sector) with probability $p \in [0, 1]$. This probability may be contingent on the information (if any) that is provided by the bank supervisor and on the assessment of the actions that he has taken. If punishment occurs, the bank supervisor will not receive the transfer w; he will suffer from an exogenous, non-pecuniary (e.g., reputational) cost c instead. Thus, the bank supervisor's utility function can be written as:

$$S = w - p(w + c).$$

---

[9] Indeed, if the banker takes excessive risks, her expected profit will be $(1 - \mu) B^{risk-taking}$. If she does not take excessive risks, her expected profit will be $B^{benchmark}$. Simple algebra shows that the latter is larger than the former when $\mu \geq \dfrac{\beta}{\pi + \theta^d + \beta}$.

[10] In this model, society can be viewed as a social planner in the form of a constitutional framer or legislature.

The parameters w and p are endogenous and will be optimally determined in section 4.

Politicians. Politicians can be thought of as the executive branch of the government. They seek to maximize social welfare.

2.2. Capture

To keep her additional expected profit because of excessive risk-taking, $B^{risk-taking} - B^{benchmark} = \beta$, the banker may offer side contracts to the bank supervisor in order the latter does not close the bank (i.e., in order to capture the supervisor).[11] Because of the illegal nature of capture, the sidecontract between the banker and the bank supervisor is subject to transaction costs: transferring β units of bribes to the bank supervisor only increases his utility by an amount $b < \beta$; $\beta - b$ represents the transaction costs of side-transferring.[12] The bank supervisor has all the bargaining power at the capture stage, so that he can extract all the additional expected profit, β, from the banker. Thus, b represents the increase in the bank supervisor's utility when he is captured by the banker.

2.3. Legal Status of the Bank Supervisor

The bank supervisor has political independence when he can decide to close the bank without requiring approval from politicians. The bank supervisor is under political control when he cannot decide to close the bank. In this case, such a decision is made by politicians.

2.4. Systemic Effects of a Bank Failure

The failure of the bank, either when the bank supervisor closes the bank down or when he does not but the bank's loans default (i.e., when $\tilde{R} = R^d = 0$), has systemic effects: it generates a social cost f. This cost comprises, for example,

---

[11] Making this assumption is an helpful modeling short-cut since these side contracts may take the form of various in-kind or implicit favors, presents or job offers.

[12] See Tirole (1992) for a discussion of the origins of these costs.

contagion effects, the break-up of valuable lenderborrower relationships, the disruption on the payment system and the costs associated to the reimbursement of insured depositors.

2.5. Timing

The timing unfolds as follows:

— *Investment:* the banker collects deposits, decides whether or not to take excessive risks, and invests.

— *Supervision 1 (information gathering):* the bank supervisor decides whether or not to exert unobservable effort to gather private information from the bank.

— *Capture:* the bank supervisor decides whether or not to accept a sidecontract from the banker.

— *Supervision 2 (closure decision):* if the bank supervisor has political independence, he decides whether or not to close the bank down. Under political control, politicians make such a decision. If the bank is closed down, its assets are liquidated and depositors reimbursed.

— *Returns:* if the bank was not closed down before, its loans' return realizes. Depositors are reimbursed. The banker receives her payoff.

— *Monitoring:* the monitoring technology is applied. The bank supervisor decides whether to show or to hide supervisory information (when he has got it).

2.6. Benchmark: the First-best Outcome

For future references, I derive the first-best outcome that would be implemented by a social planner who keeps full control on banking supervision (i.e., does not rely on the bank supervisor), and has the ability to commit to its supervisory policy before the banker makes her risk-taking decision.

Expected social welfare is given by:

$$W = \pi - (\theta^d + 1_{\{risk-taking\}}\beta)\,f,$$

where $1_{\{risk-taking\}}$ is equal to one if the banker takes excessive risks and equal to zero otherwise, and f is the systemic effect

of a bank failure. Expected social welfare is equal to the bank's net present value, π, net of the expected social cost of a bank failure. The latter is contingent on the banker's risk-taking behavior because the probability of bank's loans default, $Pr(R^d)$, will increase by β if excessive risks are taken. Thus, it is first-best optimal that the banker abstains from taking excessive risks.

To implement this outcome, the social planner has to commit to gather private information from the bank and to close it down when the banker has taken excessive risks. Indeed, this supervisory policy satisfies the participation and the incentive compatibility constraints for the banker. The banker's participation constraint is $B^{benchmark} = \pi + \theta^d \geqslant 0$, which is satisfied because $\pi > 0$ and $\theta^d > 0$. The banker's incentive compatibility constraint is $B^{benchmark} = \pi + \theta^d \geqslant (1 - \mu)(\pi + \theta^d + \beta)$ $= (1 - \mu) B^{risk-taking}$ because the bank will never be closed down if the banker does not take excessive risks but it will be closed, and its banker will get zero, with probability μ (the probability of getting information about the riskiness of the bank's loans) if the banker does take excessive risks. This incentive compatibility constraint is satisfied because $\mu \geq \dfrac{\beta}{\pi + \theta^d + \beta}$.

2.7. The Problem of the Social Planner

When the social planner does not keep full control on banking supervision, it has to give incentives to the bank supervisor in order he effectively supervises the bank; i.e., in order he gathers private information from the bank and closes it down when the banker takes excessive risks. I adopt a normative viewpoint. I will characterize the optimal contract to be offered to the bank supervisor: the contract that gives the bank supervisor incentives to effectively supervise the bank at the lowest cost to the social planner.

It is natural to assume that the loss in expected social welfare because of excessive risk-taking by the banker, $W^{benchmark} -W^{risk-taking} = \beta f$, is larger than the maximum contracting cost of appointing a bank supervisor. Thus, in this model, banking supervision is (second-best) socially optimal.

3. THE KEY ELEMENTS ON THE BANK SUPERVISOR'S
CONTRACT

In this section, I analyze the elements that are essential on the
bank supervisor's contract for banking supervision to be ef-
fective: political independence, accountability arrangements
and legal protection.

3.1. Political Independence

Assume first that the bank supervisor is under political con-
trol (i.e., politicians are the ones who decide whether the
bank should be closed down or not), and that politicians have
received hard evidence that the banker has taken excessive
risks. At the closure stage, politicians should close the bank
down. However, welfare-maximizer politicians always prefer
to keep the bank open: if they keep the bank open, expected
social welfare is $W^{risk-taking} = \pi - (\theta^d + \beta)f$. If they close the bank
down, expected social welfare is $W^{closure} = R^l - 1 - f$ because the
bank's loans are liquidated for an amount R^l, depositors are
reimbursed and society suffers from the systemic costs im-
posed by the failure of the bank. $W^{risk-taking} - W^{closure} = \pi + (1 - \theta^d$
$- \beta)f + (1 - R^l) > 0$ because $\pi > 0$, $\theta^d - \beta > 0$, and $R^l < 1$.[13]
Welfare-maximizer politicians confront a dynamic com-
mitment problem that makes non-credible the threat of clos-
ing the bank down: they find optimal ex post not to close a
bank whose banker has taken excessive risks even though it is
optimal ex ante to commit to this policy. In turn, the banker
will engage in excessively risky investments. This provides a
rationale for giving political independence to the bank su-
pervisor. The followingproposition summarizes this result.

Proposition 1. The bank supervisor should have political in-
dependence. Without political independence, the threat of
closing down an excessively risky bank is not credible and the
banker always takes excessive risks.

[13] This result does not depend on the use of the closure policy. It is still
valid under other policies as, for example, recapitalization and fines be-
cause none of them reduce the probability with which the bank fails given
that the banker has taken excessive risks, nor the associated expected wel-
fare cost due to a bank failure, $(\theta^f + \beta)f$.

3.2. Accountability Arrangements

According to the Collins English Dictionary, "If you are accountable to someone for something that you do, you are responsible for it and must be prepared to justify your actions to that person". Responsible is defined as "legally or morally obliged to take care of something or to carry out a duty; liable to be blamed for loss or failure." In this model, the bank supervisor is accountable when he must justify his actions (e.g., by showing hard evidence to a judge) and when he is liable to be blamed for the outcome of his actions: when he is punished with some probability $p > 0$.

Assume that the bank supervisor has political independence and that he is not accountable: $p = 0$. Thus, he receives the monetary transfer w with certainty: $S|_{p=0} = w$. In this setting, the bank supervisor does not have incentives to gather private information from the bank. First, his payoff is not contingent on being able to show hard information on the riskiness of the bank's loans. Second, the bank supervisor gets a private benefit B by shirking rather than exerting effort to gather information from the bank. Moreover, the bank supervisor has strong incentives to offer a side-contract to the banker. Since he gets no punishment for letting open an excessively risky bank nor for closing down a non-excessively risky one, the bank supervisor have incentives to blackmail the banker using closure as a threat. Consequently, accountability arrangements are necessary to give the bank supervisor incentives to effectively supervise the bank.

The design of the accountability arrangements matters: the probability p has to be contingent on the information that is provided by the bank supervisor and on the assessment of the actions that he has taken. Assume instead that p is non-contingent. If $p > 0$, the bank supervisor gets a payoff $S = w - p(w + c)$, which is not contingent on the information he may be able to show nor in the actions he may have taken. As in the case in which $p = 0$, this non-contingent payoff does not give the bank supervisor incentives to gather private information from the bank but it does give him incentives to blackmail the banker.

3.3. Legal Protection

If the bank supervisor closes down an excessively risky bank, the banker may sue the bank supervisor for the losses she suffers from. Legal protection means that such a lawsuit will imply no punishment to the bank supervisor when he is able to show hard evidence proving that it was indeed an excessively risky bank (i.e., $p = 0$ in this case).

Assume that the bank supervisor has political independence, that he is accountable and that he gets hard information that the banker has taken excessive risks. The bank supervisor should close the bank down. Assume however that the bank supervisor is not protected: if he closes the bank and shows hard evidence, he is punished with probability $p_1 > 0$. He is punished with probability $p_2 > p_1$ otherwise. In this setting, if the bank supervisor closes the bank down, he gets $S|p_1 = w - p_1(w + c)$. If the bank supervisor is captured by the banker, he gets $S|p_2 + b = w - p_2(w + c) + b$ (i.e., the sum of his expected payoff and of the benefits from being captured). Simple algebra shows that the bank supervisor prefers to be captured by the banker if $p_1 \geq p_2 - \dfrac{b}{w+c}$. Consequently, legal protection (i.e., $p_1 = 0$) reduces the scope for capture.

4. THE OPTIMAL CONTRACT WITH AN INDEPENDENT BANK SUPERVISOR

In the previous section, I show that the bank supervisor has to have political independence. Otherwise, the politicians' dynamic commitment problem undermines the credibility of the bank closure policy and the banker takes excessive risks. In this section, I characterize the contract that the social planner should offer to an independent bank supervisor: the incentive scheme $\{w^*, p^*\}$ that gives the bank supervisor incentives to effectively supervise the bank at the lowest cost to the social planner.

4.1. The Optimal Contract

The bank supervisor should be rewarded when he has

made a right closure decision, i.e. when "the bank supervisor
has closed down an excessively risky bank, or he has kept
open a non-excessively risky bank" (I denote e_2 this event).
However, the judge in charge of monitoring the supervisor
will not be able to verify whether this event (i.e., e_2) is satisfied
or not if it does not get hard information on the riskiness of
the bank's loans from the bank supervisor (see figure 1).[14]
Moreover, the bank supervisor may prefer not to give such in-
formation to the judge. First, if the supervisor gets hard evi-
dence that the bank is excessively risky and is captured by the
banker, he may prefer to hide such information to the judge.
Second, if the supervisor shirks in the information gathering
activity, he has no information to show. Hence, the judge
should rely of the event "the bank supervisor shows hard evi-
dence on the riskiness of the bank's loans" (which I denote
e_1)[15] to assess the actions taken by the bank supervisor. For the
stake of brevity, denote e_1^c and e_2^c the complementary events
to e_1 and e_2 respectively, and $p(e_1, e_2)$, $p(e_1,$ policy maker) and
$p(e_1^c)$ the probabilities with which the bank supervisor is pun-
ished when e_1 and e_2 occur, when e1 occurs and e_2 does not,
and when e_1 does not occur, respectively.

FIGURE 1. INFORMATION
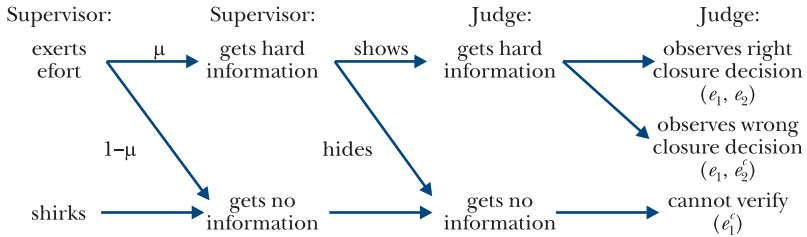
The bank supervisor has to get incentives to gather private
information from the bank, to show such information to the
judge, and to abstain from offering a side-contract to the
banker (i.e., to close an excessively risky bank and to keep
open a non-excessively risky one). A priori, seven incentive

---

[14] A judge cannot do better by using (public) information on the real-
ized return of the bank's loans because the returns R^u, R^m, R^d and R^l are
non-contingent on the behavior of the banker.

[15] The occurrence of this event implies that the bank supervisor has ex-
erted effort gathering the information from the bank.

compatibility conditions have to be satisfied: three of them prevent deviations in only one direction, three others prevent deviations in two directions simultaneously, and the last one prevents the deviation in the three directions simultaneously.[16] However, some of them are redundant. Only two are relevant: the one stating that the bank supervisor does not have interest to offer a side-contract to the banker (i.e., he is not captured), and the one expressing that he has interest to exert effort to gather private information from the bank and simultaneously does not want to be captured. The bank supervisor should also accept the incentive scheme. The three relevant constraints (the two relevant incentive compatibility conditions and the participation constraint) can be written as:[17]

$$(\text{IC-3}) \qquad p(e_1, e_2^c) - p(e_1 e_2) \geq \frac{b}{\mu(w+c)},$$

$$(\text{IC-5}) \qquad p(e_1^c) - p(e_1, e_2) \geq \frac{B+b}{\mu(w+c)},$$

$$(\text{PC}) \qquad p(e_1^c) + \frac{\mu}{1-\mu} p(e_1, e_2) \geq \frac{w}{(1-\mu)(w+c)}.$$

To reduce $p(e_1, e_2)$ is good for participation and for incentives: it relaxes the participation constraint (PC), and the relevant incentive compatibility conditions (IC-3) and (IC-5). Indeed, the bank supervisor is more willing to participate and to effectively supervise the bank if he is rewarded with certainty for that (i.e., if he receives the transfer w and is never penalized). Thus, it is optimal to set $p^*(e_1, e_2) = 0$.

To set $p(e_1, e_2^c)$ as large as possible is good for incentives: it relaxes (IC-3). Indeed, the fact that the bank supervisor does not close an excessively risky bank is a clear signal that he has been captured by the banker. To preserve incentives, the bank supervisor should be punished with probability one: $p^*(e_1, e_2^c) = 1$.

Two cases, depending on the value of the parameters, have

---

[16] There also are some technical conditions to be satisfied because p is a probability.

[17] I am presenting here an sketch of the proof of Proposition 2. See Appendix A for the complete proof.

to be considered to determine the optimal transfer, w^*, and the optimal probability of punishment, $p^*(e_2^c)$. In the first case, the private cost that the bank supervisor suffers from when he is punished, c, is lower than the sum of the benefits from shirking in the information gathering activity and from being captured by the banker: $c < B + b$. In this case, to punish the bank supervisor with probability one when he does not show hard information, $p^*(e_2^c) = 1$, is not enough to restore incentives. Moreover, the bank supervisor always participates (i.e., despite the transfer w is zero) because he gets a private benefit $B + b - c > 0$ with certainty. The social planner has to offer a large enough transfer to the bank supervisor in w^* order to restore incentives: has to satisfied $\mu w^* - (1 - \mu)c = B + b - c$, where the left-hand side is the bank supervisor's expected payoff if he behaves[18] and the right-hand side is his private benefit from deviating. Thus, $w^* = \dfrac{B+b}{\mu} - c$.

If $c \geqslant B + b$, the incentive compatibility conditions are less demanding than in the previous case: to set $p(e_1^c) = 1$ is not necessary to provide incentives. Moreover, it implies that the bank supervisor has to be compensated with a larger than necessary transfer, w, in order to ensure the participation of the bank supervisor. The optimal value for $p(e_1^c)$ is

$$p^*(e_1^c) = \frac{B+b}{(1-\mu)(B+b)+\mu c} < 1,$$ and the optimal value for w is

$$w^* = \frac{1-\mu}{\mu}(B+b),$$ which is lower than the transfer that is re-

quired when $p(e_1^c) = 1$: $w = \dfrac{B+b}{\mu} - c$.

The following proposition summarizes these results.

Proposition 2. The optimal contract to be offered to a politically independent bank supervisor in order that he effectively supervises the bank (i.e., he exerts effort to gather private

---

[18] If the bank supervisor exerts effort to gather private information from the bank, he obtains it with probability μ. Thus, if he exerts effort to gather information and he is not captured by the banker, he will get w with probability μ (because $p^*(e_1, e_2) = 0$) and he will suffer from the cost c with probability $1 - \mu$ (because $p^*(e_1^c) = 1$).

information from the bank, he closes down an excessively risky bank and he keeps open a non-excessively risky one) is characterized by the following incentive scheme:

— a transfer to the bank supervisor if he is not punished:

$$w^* = \begin{cases} \dfrac{B+b}{\mu} - c & \text{if } c < B+b \\ \dfrac{1-\mu}{\mu}(B+b) & \text{if } c \geq B+b \end{cases} ; \text{ and}$$

— probabilities of punishment:

$$p^*(e_1, e_2) = 0,$$

$$p^*(e_1, e_2^c) = 1,$$

$$p^*(e_1^c) = \begin{cases} 1 & \text{if } c < B+b \\ \dfrac{B+b}{(1-\mu)(B+b)+\mu c} & \text{if } c \geq B+b \end{cases};$$

where e_1 stands for the event "the bank supervisor shows hard evidence on the riskiness of the bank's loans", e_2 stands for the event "the bank supervisor has closed down an excessively risky bank, or he has kept open a non-excessively risky bank", and e_1^c and e_2^c stand for the complementary events to e_1 and e_2 respectively. (Proof: the proof is in Appendix A.)

4.2. Policy Implications

In this section, I offer some reflections on the ways in which the optimal contract characterized in proposition 2 can be implemented by an adequate institutional arrangement for banking supervision.

The optimal contract should be enacted by a statute or charter law for the bank supervisor. To enact the contract by law has the following advantages: first, since a law can only be replaced by another law, and laws generally require long, costly and complex processes to be passed, then to enact the contract by law reduces the scope for renegotiation. Second,

the natural way to enforce laws is through the judicial branch of the government, then the enforcement of the contract is strengthened. Otherwise stated, the execution of the terms of the supervisor's charter law will be not only subject to the surveillance of the legislature (who offers the contract), but also to judicial review.

The charter law should provide political independence for the bank supervisor. It should also give an adequate budget to him (i.e., he should be rewarded according to w^*). The optimal contract implies that the bank supervisor cannot be punished when he has effectively supervised the bank (i.e., the probability of punishment when the bank supervisor shows hard evidence that he has closed down an excessively risky bank is equal to zero: $p^*(e_1, e_2) = 0$). Thus, the charter law should provide legal protection for the bank supervisor. Finally, the optimal contract implies that $p^*(e_1, e_2^c) = 1$ and that $p^*(e_1^c) > 0$. The bank supervisor has to justify his decisions by showing hard evidence to the judge and he is responsible for the outcome of his actions. Thus, the charter law should specify accountability arrangements.[19]

To summarize, the optimal contract characterized in proposition 2 can be implemented by a bank supervisor's charter law or statute that:

— provides political independence for the bank supervisor and gives him an adequate budget;

— provides legal protection for the bank supervisor; and

— specifies accountability arrangements for the bank supervisor.

5. EMPIRICAL EVIDENCE

In this section, I provide empirical evidence supporting the policy implications of the theoretical model.

---

[19] Hüpkes et al. (2005, 2006) give operational content to the concept of accountability. They also discuss specific arrangements that can best secure the objectives of bank supervisors' accountability: regular and ad hoc reports to the legislative and the executive branches of the government, as well as to the public in general, judicial review, and supervisor's liability for faulty supervision.

5.1. Empirical Strategy

The optimal contract characterized in proposition 2 gives the bank supervisor incentives to effectively supervise the bank. In turn, the banker abstains from taking excessive risks. Thus, the theoretical model has the following testable implication: the probability of bank's loans default, $\Pr(R^d)$, would be lower when the bank supervisor is independent, legally protected and accountable.

To test this implication I use the following cross-country linear regression model:

(Model 1) $$NPL_i = \alpha_1 + \alpha_2 \times CP1_i + \epsilon_i,$$

where NPL_i (the ratio of non-performing loans to total loans in the banking system of country i) is an estimation of the probability of default of banks' loans in country i (i.e., $\Pr(R^d_i) \equiv NPL_i - \epsilon_i$; ϵ_i is the estimation error), $CP1_i$ is the observed compliance of country i with the supervisory arrangement characterized in section 4 (see table B.1 in the Appendix for a precise definition), and a_1 and a_2 are parameters to be estimated. Under the assumptions that ϵ is uncorrelated with $CP1$ and that the variance of $CP1$ is different from zero, the parameters in model 1 are identified:

$$\theta^f = a_1 + a_2, \text{ and } \beta = -a_2.$$

To test the individual contribution of independence, legal protection and accountability, I use the following cross-country linear regression models:

(Models 2.4) $$NPL_i = a_1^j + a_2^j \times CP1_i^j + \epsilon_i,$$

where $CP1^j_i$ is the observed compliance of country's i supervisory arrangement with key element j, $j \in \{$independence, legal protection, accountability$\}$, and a^j_1 and a^j_2 are parameters to be estimated. Under the assumptions that ε is uncorrelated with $CP1^j$ and that the variance of $CP1^j$ is different from zero, these parameters are identified.

5.2. Data Set

The Financial Sector Assessment Program (FSAP) conducted since 1999 by the International Monetary Fund and

the World Bank is the main source of data. Every time that a FSAP is conducted for an individual country, a Report on its Observation of Standards and Codes (ROSC) is published. In particular, ROSCs summarize the extent to which countries observe the Core Principles for Effective Banking Supervision (Core Principles thereafter), a framework of minimum standards for sound supervisory practices that are considered universally applicable (Basel Committee on Banking Supervision, 2006).

Table B.2 in the Appendix shows the FSAP's data for the three key elements on Core Principle 1:[20] (independence) "Each [authority involved in the supervision of banks] should possess operational independence, transparent processes, sound governance and adequate resources (...)"; (legal protection) "A suitable legal framework for banking supervision is also necessary, including legal protection for supervisors"; and (accountability) "Each such authority should (...) be accountable for the overall exercise of its duties." These data allow the construction of a variable (named *CP*1) which accounts for the overall compliance of individual countries with these key elements.[21]

The data set contains information for all countries for which the FSAP had reported at least one ROSC as for January 2010 (i.e., for the period 1999-2009): 81 countries in total. Many countries present missing values for some of the key elements of *CP*1 (see table B.2 for details). For the analysis in

---

[20] Following the methodology proposed by the Basel Committee on Banking Supervision (1999), the assessment of compliance with each element of the Core Principles is done using a four point grading scale. The four grades reported on the ROSCs are: 0) non-compliant, implying no substantive implementation of the Principle; 1) materially non-compliant, if there are severe shortcomings, despite the existence of formal rules, regulations and procedures, and there is evidence that supervision has clearly not been effective; 2) largely compliant, whenever only minor shortcomings are observed which do not raise any concerns about the authority's ability and clear intent to achieve full compliance; and 3) compliant, when all essential criteria are met without any significant deficiencies.

[21] There may be many ways of constructing *CP*1. I use the following: $CP1_i = 1$ if country i is largely or fully compliant with each of the three key elements, otherwise $CP1_i = 0$. Table B.1 in the Appendix shows alternative definitions for *CP*1, and section 5.5 shows that the results are robust to changes in the definition of *CP*1.

the next two sections I consider countries with information for all key elements of *CP*1 (i.e., I assume that observations are missing at random). The robustness of the results is checked in section 5.5. The ratio of nonperforming loans to total loans (*NPL*), as well as other variables that are described in table B.1 in the Appendix, are averages over the period 1999-2009.

5.3. Descriptive Analysis

Summary statistics are presented in table B.4 in the Appendix. Around 30% of the countries in the sample fail to give adequate levels of independence to their bank supervisors and to enact appropriate accountability arrangements. Moreover, more than 50% of the countries in the sample do not provide legal protection to their bank supervisors.

The cross-correlation table B.3 in the Appendix shows a negative relationship between the ratio of non-performing loans to total loans (*NPL*) and *CP*1. It also shows negative relationships between *NPL* and each of the key elements of *CP*1.

5.4. Regression Results

Table 2, column (1), shows the regression coefficients for a_1 and a_2 in model 1 estimated by using ordinary least squares (OLS).[22] Both coefficients are significant at the 1% level and have the expected sign: $\hat{a}_1 > 0$ and $\hat{a}_2 < 0$; thus, the estimates of the parameters of interest do not violate the theoretical restrictions imposed by the model.

The point estimation for β is $\hat{\beta}$ = 7.251, and the point estimation for θ^f is $\hat{\theta}^f$ =3.179. This means that the existence of an independent, legally protected and accountable bank supervisor reduces the average probability of banks' loans default from 10% to 3% approximately. This is the main empirical result.

Columns (2) to (4) in table 2 attempt to analyze the individual contribution of the key elements of *CP*1 to the previous result (models 2 to 4). The coefficient of independence is

---

[22] Each regression in table 2 uses heteroskedasticity-consistent standard errors. Tests for heteroskedasticity (not reported) were conducted for all regressions. The null hypothesis of constant variance of the error term was always rejected.

TABLE 2. OLS REGRESSIONS. DEPENDENT VARIABLE: NON-PERFORMING
LOANS TO TOTAL LOANS (percentage)

	Model 1 (1)	*Model 2* (2)	*Model 3* (3)	*Model 4* (4)
CP1	-7.251^{a}			
	(0.000)			
Independence		-4.324^{b}		
		(0.053)		
Legal protection			-7.764^{a}	
			(0.000)	
Accountability				-7.458^{a}
				(0.006)
Constant	10.430^{a}	11.749^{a}	12.086^{a}	12.456^{a}
	(0.000)	(0.000)	(0.000)	(0.000)
N	44	75	63	52
Adjusted R^2	0.351	0.047	0.273	0.196

NOTES: *p*-values for Ho: the coefficient is equal to zero are in parentheses below
the estimated coefficients. Each regression uses heteroskedasticity-consistent stan-
dard errors from an OLS model.
[a] Significant at the 0.01 level. [b] Significant at the 0.10 level.

significant at the 5.3% level, and the coefficients of legal pro-
tection and accountability are significant at the 1% level. All
estimated coefficients have the expected sign: compliance
with the component parts of *CP*1 individually reduces the av-
erage probability of banks' loans default. The coefficients of
legal protection and accountability are larger (in absolute
value) than the coefficient of independence. Their explana-
tory power is also larger (the adjusted R^2s are larger). Conse-
quently, legal protection and accountability are the most im-
portant elements on a supervisory arrangement.

To summarize, the empirical implications of this paper
are not rejected by FSAP's data. The existence of an inde-
pendent, legally protected and accountable bank supervisor
significatively reduces the average probability with which
banks' loans default. Moreover, while all three elements indi-
vidually contribute to the previous result, the existence of ac-
countability arrangements and legal protection for bank su-
pervisors are the most important elements to reduce the
riskiness of the banking sector.

5.5. Robustness Checks

The empirical results presented in the previous section are robust to a series of checks. In this section I make brief comments about these robustness checks.

Different construction of CP1. Column (1) in table B.5 in the Appendix shows the regression results of estimating model 1 using a different definition for the explanatory variable (*CP1_1*, see table B.1 for details). The different construction of the explanatory variable implies only slight differences in the estimated coefficients but it does not change the qualitative results.

Statutory information. Columns (2) to (5) in table B.5 in the Appendix reproduce the regressions in table 2 using an enlarged data set. The concern that I analyze is whether the small size of the main data set affects the results. I enlarge the main data set by replacing its missing values by an assessment of the compliance with Core Principle 1 that is based on the revision of statutory information for bank supervisors: I read the charter laws of bank supervisors and assigned a grade to each particular country in each component part of Core Principle 1 (that were missing in the main data set) according to the methodology published by Basel Committee on Banking Supervision (1999) (bold figures in table B.2 show the information coming from this source). A possible caveat with these data is that they reflect declared compliance (e.g., the legislator's desired level of supervisory independence and accountability) but do not account for the existence of shortcomings that prevent its implementation. The coefficients in columns (2) to (5) in table B.5 differ only slightly from those that are in table 2. Thus, the size of the main data set does not affect the results.

Control variables. Recent theoretical and empirical work suggests a number of factors that may affect the riskiness of a banking sector. Table B.6 in the Appendix shows the results for the following cross-country linear regression models:

(Models 5-8) $$NPL_i = a_1^k + a_2^k \times CP1_i + a_3^k X^k + \varepsilon_i,$$

where X^k contains exogenous determinant of the riskiness of banks, and a_3^k is a vector of parameter to be estimated. The

coefficients for *CP*1 estimated using models 5 to 8 slightly differ from the coefficient for *CP*1 estimated using model 1. Moreover, the introduction of exogenous control variables does not reduce the explanatory power of *CP*1. Thus, the empirical results in the last section are robust to the introduction of exogenous control variables.[23]

Das et al. (2004) suggest that macroeconomic factors as the government's fiscal position, the rate of inflation and the short-term real interest rate may affect the quality of bank loans. Column (1) in table B.6 shows the regression results when X^k is the short-term real interest rate (*RIR*, model 5). Its coefficient has a positive sign, suggesting that higher real interest rates make it harder for borrowers to honor their loans, but it is not significant. Similar results (not reported) are obtained when controlling for the government's fiscal deficit as a percentage of the gross domestic product, the rate of inflation, the rate of growth of the gross domestic product and the gross domestic product per capita.

Column (2) in table B.6 shows the regression results when controlling for an indicator of the institutional and governance environment (model 6). Kaufmann et al. (2006) construct a Regulatory Quality (*RQ*) indicator as a measure of the ability of the government to formulate and implement sound policies and regulations. The higher the global quality of regulation in a country, the lower the level of non-performing loans in its banking sector: the coefficient of *RQ* is negative and significant at the 6% level. However, controlling for the *RQ* indicator does not reduce the explanatory power of *CP*1. Similar results (not reported) are obtained if the *RQ* indicator is replaced by an indicator of the quality of the civil service and the degree of its independence from political pressures, and by an indicator of the quality of contract enforcement, property rights, the police and the courts (Kaufmann et al.'s Government Effectiveness and Rule of Law indicators respectively).

Column (3) in table B.6 shows the regression results when controlling for an indicator of the structure of the banking

---

[23] The results for models 2 to 4 are also robust to the introduction of exogenous control variables. Regression results, no reported, are available upon request.

system (model 7): the percentage of the banking system's assets that is held by state-owned banks (SOB). Barth et al. (2006) suggest that it is important to control for this variable because government ownership may distort the application of different supervisory approaches. The SOB's coefficient is not significant. Moreover, controlling for SOB (as well as for the degree of foreign-owned banks and for a measure of the concentration in the banking industry —these results are not reported) does not change the results with respect to CP1.

Finally, La Porta et al. (1998; 1999) argue that historically determined differences in countries' legal systems help explain international differences in financial markets today. They find that countries whose legislation is inspired by the French Commercial Code and the Socialist Law are more willing to exhibit inferior government performance (La Porta et al. 1999) and inferior creditors' protection (La Porta et al. 1998) than those countries whose legislation is inspired by the English Common Law. Thus, the former group of countries should show higher levels of non-performing loans than the latter group. Column (4) in table B.6 confirms this hypothesis. However, the introduction of dummy variables to account for the legal origin of countries (model 8) does not affect the results with respect to *CP*1.

*Instrumental variables. CP*1 and ε might be correlated. First, since the estimation of the probability with which country's i bank loans default (i.e., *NPL$_i$*) is done by country's i supervisor, then country's i compliance with Core Principle 1 might affect this estimation, leading to a measurement error problem. Second, although one can think that supervisory institutions cannot be easily changed as a result of the current or past level of non-performing loans (because it is costly and complex to change institutions), one cannot rule out a series of *third factors* explaining both the supervisory arrangements and the level of non-performing loans. This leads to an endogeneity problem. I run instrumental variable regressions to check the robustness of the previous section results to these problems.

To select instrumental variables for *CP*1 I use recent theoretical and empirical work. First, some argue that geography influences economic institutions (see Barth et al. 2004, p.

241, and 2006, p. 193, and the references therein). According to these work, countries with rich natural endowments are particularly conducive to the development of complex economic institutions. However, countries with poor climates (in particular the tropics) may be less likely to develop a wide array of institutions, including bank supervisory institutions. Thus, I use latitudinal distance from the equator as an instrument. Second, La Porta et al. (1998, 1999) argue that differences in the legal origin of countries may influence the strength of governments and its relationship with economic and financial institutions. Thus, I also use dummy variables accounting for the country's legal origin as instruments. Importantly, the first stage regressions always reject the null hypothesis that these variables do not explain the cross-country variation in *CP*1.

Table B.7 in the Appendix shows the results of the instrumental variables regressions using a two-stage least squares estimator. The estimated coefficients for a_1 and a_2 in model 1 (column 1) are significant at the 1% level and have the expected sign. Thus, the results obtained in the previous section are robust to potential measurement errors and endogeneity issues. Moreover, they are robust to both possible endogeneity and the consideration of exogenous factors (i.e., control variables) affecting the amount of non-performing loans simultaneously (columns 2 to 4 show the regression results for models 5 to 7 respectively).

The second part of table B.7 shows that the instruments pass a series of tests [the Sargan (1958)-Hansen (1982) test of over identifying restrictions, and two versions of the Kleibergen and Paap's (2006) rank statistic to test for under and weak identification], confirming that the instruments are strongly correlated with the potentially endogenous regressors.

6. CONCLUDING REMARKS

This paper formalizes an optimal contract for a bank supervisor and derives policy implications. The results imply that political independence for the bank supervisor is necessary to ensure the credibility of a supervisory policy. Moreover,

independence arrangements should be complemented by accountability arrangements (i.e., the bank supervisor should be answerable and responsible for the outcome of his actions), and by legal protection for the bank supervisor.

The theoretical analysis implies testable implications about the consequences of supervisory arrangements on the riskiness of the banking sector. The model allows the quantification of this effect on data coming from the Financial System Assessment Program: the existence of independent, legally protected and accountable bank supervisors significantly reduces the average probability of banks' loans default from 10% to 3% approximately.

The empirical part of this paper also uncovers the key elements of a supervisory arrangement for effective banking supervision: legal protection and accountability. Around 30% of the countries in the sample fail to enact appropriate independence and accountability arrangements, and more than 50% of the bank supervisors are not legally protected. Hence, the results in this paper imply that policymakers should be persuaded of the benefits of enacting institutional arrangements for banking sector supervision along the lines suggested in this paper.

Appendix

A. Proof of Proposition 2

A priori, seven incentive compatibility conditions have to be satisfied. However, two of them are no relevant because the bank supervisor has no information to hide if he has not exerted effort to gather it (see figure 1). The other incentive compatibility conditions can be written as follows.

Show information. The incentive compatibility condition under which the bank supervisor does not hide information on the riskiness of the bank is:

$$\mu[w - p(e_1, e_2)(w+c)] + (1-\mu)[w - p(e_1^c)(w+c)] \geq w - p(e_1^c)(w+c),$$

where the left-hand side is the bank supervisor's expected payoff if he exerts effort to gather the information from the bank, he shows it and he does not engage on a side-contract

with the banker (if the bank supervisor behaves, thereafter), and the right-hand side is his expected payoff if he hides the information. This incentive compatibility condition can be rewritten as:

(IC-1) $$p(e_1^c) - p(e_1, e_2) \geq 0.$$

Gather information. The incentive compatibility condition under which the bank supervisor exerts effort to gather private information from the bank is:

$$\mu[w - p(e_1, e_2)(w + c)] + (1 - \mu)[w - p(e_1^c)(w + c)] \geq w - p(e_1^c)(w + c) + B,$$

where the left-hand side is the bank supervisor's expected payoff if he behaves, and the right-hand side is the sum of his expected payoff if he shirks and of the benefits from shirking. This incentive compatibility condition can be rewritten as:

(IC-2) $$p(e_1^c) - p(e_1, e_2) \geq \frac{B}{\mu(w + c)}.$$

No side-contracts. The incentive compatibility condition under which the bank supervisor is not captured by the banker is:

$$\mu[w - p(e_1, e_2)(w + c)] + (1 - \mu)[w - p(e_1^c)(w + c)]$$
$$\geq \mu[w - p(e_1, e_2^c)(w + c)] + (1 - \mu)[w - p(e_1^c)(w + c)] + b,$$

where the left-hand side is the bank supervisor's expected payoff if he behaves, and the right-hand side is the sum of his expected payoff if he engages on a side-contract with the banker and of the benefits from being captured. This incentive compatibility conditions can be rewritten as:

(IC-3) $$p(e_1, e_2^c) - p(e_1, e_2) \geq \frac{b}{\mu(w + c)}.$$

Show information and no side-contracts. The incentive compatibility condition under which the bank supervisor does not hide information and is not captured by the banker is:

$$\mu[w - p(e_1, e_2)(w + c)] + (1 - \mu)[w - p(e_1^c)(w + c)] \geq w - p(e_1^c)(w + c) + b,$$

where the left-hand side is the bank supervisor's expected

payoff if he behaves, and the right-hand side is the sum of his expected payoff if he hides information and of the benefits from being captured. This incentive compatibility condition can be rewritten as:

$$\text{(IC-4)} \qquad p(e_1^c) - p(e_1, e_2) \geq \frac{b}{\mu(w+c)}.$$

Gather information and no side-contracts. Finally, the incentive compatibility condition under which the bank supervisor exerts effort to gather private information from the bank and is not captured by the banker is:

$$\mu[w - p(e_1, e_2)(w+c)] + (1-\mu)[w - p(e_1^c)(w+c)] \geq w - p(e_1^c)(w+c) + B + b,$$

where the left-hand side is the bank supervisor's expected payoff if he behaves, and the right-hand side is the sum of his expected payoff if he shirks and of the benefits from shirking and from being captured. This incentive compatibility condition can be rewritten as:

$$\text{(IC-5)} \qquad p(e_1^c) - p(e_1, e_2) \geq \frac{B+b}{\mu(w+c)}.$$

Condition (IC-5) implies conditions (IC-1), (IC-2), and (IC-4). Thus, the latter three incentive compatibility conditions are redundant. The relevant incentive compatibility conditions are (IC-3) and (IC-5).

The bank supervisor has to be willing to accept the incentive scheme. His participation constraint is:

$$\mu[w - p(e_1, e_2)(w+c)] + (1-\mu)[w - p(e_1^c)(w+c)] \geq 0.$$

Rearranging terms, it can be rewritten as:

$$\text{(PC)} \qquad p(e_1^c) + \frac{\mu}{1-\mu} p(e_1, e_2) \leq \frac{\mu}{(1-\mu)(w+c)}.$$

Three technical constraints are introduced because p is a probability:

$$\text{(T1)} \qquad 0 \leq p(e_1, e_2) \leq 1,$$

$$\text{(T2)} \qquad 0 \leq p(e_1, e_2^c) \leq 1,$$

$$\text{(T3)} \qquad 0 \leq p(e_1^c) \leq 1.$$

To reduce $p(e_1, e_2)$ is good for participation and for incentives: it relaxes the participation constraint (PC), and the relevant incentive compatibility conditions (IC-3) and (IC-5). Thus, it is optimal to set $p^*(e_1, e_2) = 0$.

The participation constraint (PC), and the relevant incentive compatibility constraints (IC-3) and (IC-5) can be rewritten as:

(PC') $$p(e_1^c) \leq \frac{w}{(1-\mu)(w+c)},$$

(IC-3') $$p(e_1, e_2^c) \geq \frac{b}{\mu(w+c)},$$

(IC-5') $$p(e_1^c) \geq \frac{B+b}{\mu(w+c)}.$$

To set $p(e_1, e_2)$ as large as possible is good for incentives (it relaxes $(IC) = 1$. Given $p^*(e_1, e_2^c) = 1$, (IC-3') can be rewritten as:

(IC-3'') $$w \geq \frac{b}{\mu} - c.$$

Next, I combine conditions (PC'), (IC-5'), and (T3). Combining (PC') and (T3) implies:

(PC-T3) $$w \geqslant 0.$$

Combining (IC-5') and (T3) implies:

(IC5-T3) $$w \geq \frac{B+b}{\mu} - c.$$

Finally, combining (PC') and (IC-5') implies:

(PC-IC5) $$w \geq \frac{1-\mu}{\mu}(B+b).$$

Condition (IC5-T3) implies condition (IC-3''), and condition (PC-IC5) implies condition (PC-T3). Thus, the relevant conditions are (IC5-T3) and (PC-IC5).

In order to minimize the transfer to the bank supervisor (and preserve incentives), $w^* = \max\left\{\frac{1-\mu}{\mu}(B+b), \frac{B+b}{\mu} - c\right\}$. The

optimal values for $p(e_1^c)$ are obtained by replacing w^* into (PC') and (IC-5'): $p^*(e_2^c) = 1$ if $c < B + b$, and

$$p^*(e_1^c) = \frac{B+b}{(1-\mu)(B+b)+\mu c} \text{ if } c \geqslant B + b.$$

B. Tables

TABLE B.1. DEFINITIONS AND DATA SOURCES FOR VARIABLES

Variable	Definition	Source
Independence	Compliance "Each such authority should possess operational independence, transparent processes, sound governance and adequate resources (...)"	IMF: FSA Principle 1 (2)
Legal protection	Compliance with "A suitable legal framework for banking supervision is also necessary including legal protection for supervisors."	IMF: FSA Principle 1 (2)
Accountability	Compliance with "Each such authority should (...) be accountable for the overall exercise of its duties."	IMF: FSA Principle 1 (2)
CP1	Compliance with Core Principle 1 (Independence, Legal protection and Accountability). *If all three component parts are equal to 1, then CP1 = 1; otherwise, CP1 = 0*	Author's calculation
CP1_1	Compliance with Core Principle 1 (Independence, Legal Protection and Accountability). *(1) CP1_1 aux = (Ind.+Legal Pro.+Acc)/3; (2) if CP1_1 aux ≤ median of CP1_1 aux, then CP1_1 = 0; (3) otherwise, CP1_1 = 1.*	Author's calculation
CP1_2	Compliance with Core Principle 1 (Independence, Legal protection and Accountability). *If all three component parts are equal to 1, then CP1_2 = 1; otherwise, CP1_2 = 0. Statutory information (i.e., Charter Laws for bank supervisors) is used to replace missing values of Independence, Legal Protection and Accountability*	Author's calculation
NPL	Non–performing loans to total loans (percentage). *Average 1999 – 2009.*	IMF: FSAP
RIR	Real interest rate. *Nominal lending rate (IFS's line 60P) minus the contemporaneous rate of ination (IFS's line 64: CPI). Average 1999 – 2009.*	IMF: IFS
RQ	Regulatory quality indicator. *Average 2000, 2002–2005.*	Kaufmann *et.al.* (2006)

TABLE B.1 *(continuum)*

Variable	Definition	Source
SOB	Percentage of assets in State–owned banks. *Question 3.8.1. Average 2001, 2005.*	Barth *et. al.* (2004, 2008)
Common, French, Socialist, German	Legal origins. *Dummy variables. Common=English Common Law, French = French Commercial Code, Socialist = Socialist Law and German = German Commercial Code.*	La Porta *et.al* (1999)
Latitude	Absolute value of the latitude of the capital city	La Porta *et.al* (1999)

NOTE: Independence, Legal protection and Accountability are coded: 0=Non–compliant, 1 = Materially non–compliant, 2 = Largely compliant, 3 = Compliant. For regression purposes, 0 and 1 are recoded to 0, and 2 and 3 are recoded to 1.

TABLE B.2. FINANCIAL SECTOR ASSESSMENT PROGRAM'S AND STATUTORY DATA

Country	Year	Ind.	Pro.	Acc.
Albania	2005	3	0	3
Algeria	2004	1	0	1
Antigua and Barbuda	2004	2	3	2
Australia	2006	3	3	3
Austria	2004	3	3	3
Bahrain	2006	1	1	1
Barbados	2009	1		
Belarus	2009	1	3	0
Belgium	2006	2		**2**
Boznia and Herzegovina	2006	1	0	1
Bulgaria	2002	3	3	2
Cameroon	2000	1	3	**1**
Canada	2000	3	3	3
Chile	2004	2	1	1
Colombia	2005	1	0	**1**
Costa Rica	2003	**1**	0	**1**
Croatia	2002	3	0	**2**
Cyprus	2006	2		
Czech Republic	2001	2	1	0
Denmark	2006	2	3	3
Estonia	2009	2	3	**2**
Finland	2001	1	**2**	1
France	2004	3	3	3
Gabon	2001	1	2	1
Georgia	2001	3	0	**2**
Germany	2003	2	2	3
Ghana	2003	1	**2**	**1**
Greece	2006	3	0	2
Haiti	2009	1		0
Hong Kong	2003	2	1	2
Hungary	2002	2	3	3
Iceland	2003	3	2	2
Ireland	2006	3	2	3
Israel	2001	2	2	2

TABLE B.2 (*continuum*)

Country	Year	Ind.	Pro.	Acc.
Italy	2006	2	0	2
Jamaica	2006	0	3	**0**
Japan	2003	0	**2**	1
Kazakhstan	2004	1	3	1
Korea	2003	1	0	2
Kuwait	2004	2	2	2
Kyrgystan	2003	2	0	2
Latvia	2002	3	2	2
Lithuania	2002	1	0	1
Luxembourg	2002	3	3	2
Macedonia	2003	2	1	**2**
Madagascar	2006	2	0	1
Malta	2003	2	**3**	2
Mauritius	2003	2	0	2
Mexico	2006	2	3	2
Moldova	2008	2	0	2
Mongolia	2008	2	0	
Morocco	2003	1	**1**	**1**
Mozambique	2004	2	0	**0**
Namibia	2007	2	3	**2**
Netherlands	2004	2	**2**	2
New Zealand	2004	3	3	3
Norway	2005	3	3	3
Pakistan	2004	2	3	**2**
Panama	2007	3	0	**1**
Philippines	2004	**3**	1	**2**
Poland	2001	2	1	2
Portugal	2006	3	3	2
Romania	2003	3	1	**3**
Russia	2003	1	**1**	**2**
Rwanda	2005	1	**1**	1
Saudi Arabia	2006	2	0	**2**
Serbia and Montenegro	2006	2	0	**2**
Singapore	2004	2	2	2
Slovakia	2002	2	2	2
Slovenia	2004	3	0	2
Spain	2006	3	3	3
Sweden	2002	3	2	3
Switzerland	2002	2	3	2
Tajikistan	2008	1	0	
Trinidad and Tobago	2006	2	3	2
Tunisia	2002	1	1	1
Turkey	2007	1	3	1
Ukraine	2003	3	1	**1**
United Arab Emirates	2003	3	0	**0**
United Kingdom	2003	2	**2**	3
Uruguay	2006	1	0	1

SOURCE: Financial Sector Assessment Program (FSAP, ⟨http://www.imf.org/external/np/fsap/fsap.asp⟩), December 31 2009. Bold figures have been assigned by the author based on statutory information (i.e., charter laws for bank regulators).

NOTES: 0 = Non–compliant, 1 = Materially non–compliant, 2 = Largely compliant and 3 = Compliant.

TABLE B. 3. CROSS.CORRELATIONS

Variables	NPL	Ind.	Pro.	Acc.	CP1	CP1_1	CP1_2	RIE	RQ	SOB
Independence	−0.231	1.000								
	(0.053)									
Legal protection	−0.525	0.182	1.000							
	(0.000)	(0.158)								
Accountability	−0.464	0.817	0.472	1.000						
	(0.001)	(0.000)	(0.001)							
CP1	−0.610	0.547	0.915	0.617	1.000					
	(0.000)	(0.002)	(0.000)	(0.000)						
CP1_1	−0.617	0.457	0.765	0.515	0.836	1.000				
	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)					
CP1_2	−0.486	0.513	0.881	0.667	1.000	0.836	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(1.000)	(0.000)				
RIR	0.219	0.034	−0.170	0.013	−0.124	−0.110	−0.223	1.000		
	(0.090)	(0.790)	(0.219)	(0.933)	(0.454)	(0.505)	(0.079)			
RQ	−0.639	0.452	0.413	0.486	0.581	0.541	0.556	0.049	1.000	
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.610)		
SOB	0.241	−0.343	−0.334	−0.280	−0.378	−0.361	−0.321	−0.022	−0.301	1.000
	(0.048)	(0.004)	(0.009)	(0.049)	(0.011)	(0.016)	(0.007)	(0.823)	(0.000)	
Latitude	−0.064	0.090	−0.111	0.104	−0.151	−0.117	−0.078	0.083	0.228	−0.118
	(0.592)	(0.440)	(0.383)	(0.463)	(0.323)	(0.442)	(0.508)	(0.365)	(0.006)	(0.164)

NOTE: p-values are in parenthesis below the correlation coefficients.

TABLE B. 4. SUMMARY STATISTICS

Variable	Mean	Std. Dev.	Obs.
Independence	0.716	0.454	81
Legal Protection	0.507	0.504	69
Accountability	0.696	0.464	56
CP1	0.542	0.504	48
CP1_1	0.458	0.504	48
CP1_2	0.421	0.497	76
NPL	8.752	8.050	76
RIR	0.070	0.092	66
RQ	0.550	0.915	77
SOB	13.789	19.412	75

TABLE B. 5. ROBUSTNESS: DIFFERENT CONSTRUCTION OF CP1 AND STATU-TORY INFORMATION (i.e., CHARTER LAWS FOR BANK REGULATORS). OLS REGRESSIONS. DEPENDENT VARIABLE: NON-PERFORMING LOANS TO TO-TAL LOANS (percentage)

	Model 1 (1)	Model 1 (2)	Model 2 (3)	Model 3 (4)	Model 4 (5)
CP1_1	-7.527^a (0.000)				
CP1_2		-8.130^a (0.000)			
Independence[c]			-5.011^b (0.021)		
Legal protection[c]				-8.043^a (0.000)	
Accountability[c]					-6.333^a (0.003)
Constant	9.883^a (0.000)	12.175^a (0.000)	12.312^a (0.000)	12.971^a (0.000)	12.843^a (0.000)
N	44	71	76	73	73
Adjusted R^2	0.366	0.228	0.068	0.235	0.128

NOTES: p-values for Ho: the coefficient is equal to zero, are in parentheses below the estimated coefficients. Each regression uses heteroskedasticity-consistent standard errors from an OLS model.
[a] Significant at the 0.01 level. [b] Significant at the 0.05 level. [c] Indicates the variables for which the missing values from the main data set (i.e., the Financial Sector Assessment Program) have been replaced by statutory information (i.e., charter laws for bank regulators).

TABLE B. 6. ROBUSTNESS: CONTROL VARIABLES. OLS REGRESSIONS. DE-
PENDENT VARIABLE: NONPERFORMING LOANS TO TOTAL LOANS (PER-
CENTAGE)

	Model 5 (1)	*Model 6* (2)	*Model 7* (3)	*Model 8* (4)
CP1	−6.799[a] (0.000)	−5.211[a] (0.002)	−6.108[a] (0.000)	−5.780[a] (0.001)
RIR	7.245[b] (0.028)			
RQ		−1.977 (0.141)		
SOB			0.067 (0.263)	
Common				0.728 (0.454)
French				3.397[b] (0.022)
Socialist				3.606[c] (0.051)
German				0.078 (0.946)
Constant	9.733[a] (0.000)	10.897[a] (0.000)	8.880[a] (0.000)	7.331[a] (0.000)
N	39	44	43	44
Adjusted R^2	0.358	0.394	0.376	0.337

NOTES: *p*-values for Ho: the coefficient is equal to zero, are in parentheses below
the estimated coefficients. Each regression uses heteroskedasticity-consistent stan-
dard errors from an OLS model.
[a] Significant at the 0.01 level. [b] Significant at the 0.05 level. [c] Significant at the
0.10 level.

REFERENCES

Barth, J. R., G. Caprio and R. Levine (2004), "Bank regula-
    tion and supervision: What works best?", *Journal of Financial
    Intermediation*, Vol. 13, pp. 205-48.
Barth, J. R., G. Caprio and R. Levine (2006), *Rethinking Bank
    Regulation: Till Angels Govern,* Cambridge University Press,
    Cambridge.
Barth, J. R., G. Caprio and R. Levine (2008), "Bank regulations

are changing: For better or worse?", *Comparative Economic Studies*, Vol. 50, pp. 537-63.

Basel Committee on Banking Supervision (1997), *Core principles for effective banking supervision*, Bank for International Settlements, Basel.

Basel Committee on Banking Supervision (1999), *Core principles methodology*, Bank for International Settlements, Basel.

Basel Committee on Banking Supervision (2006), *Core principles for effective banking supervision (revision)*, Bank for International Settlements, Basel.

Cukierman, A. (1992), *Central Bank Strategy, Credibility, and Independence: Theory and Evidence*, The MIT Press, Cambridge.

Das, U. S., M. Quintyn and K. Chenard (2004), *Does regulatory governance matter for financial system stability? an empirical analysis*, International Monetary Fund (Working Paper, No. 89).

Gabillon, E., and D. Martimort (2004), "The benefits of central bank's political independence", *European Economic Review*, Vol. 48, pp. 353-78.

Goodhart, C. (ed.) (1998), *The Emerging Framework of Financial Regulation*, a collection of papers compiled by the Financial Market Group of the London School of Economics Central, Banking Publications Ltd., London.

Hansen, L. P. (1982), "Large sample properties of generalized method of moments estimators*", Econometrica*, Vol. 50, No. 4, pp. 1029-54.

Hüpkes, E., M. Quintyn and M. W. Taylor (2005), *The accountability of financial sector supervisors: Principles and practice*, International Monetary Fund (Working Paper, No. 51).

Hüpkes, E., M. Quintyn and M. W. Taylor (2006), *Accountability arrangements for financial sector regulators*, International Monetary Fund (Economic Issues, No. 39).

Kashyap, A. K., R. G. Rajan, and J. C. Stein (2008), *Rethinking capital regulation*, paper presented at the Federal Reserve Bank of Kansas City symposium on "Maintaining Stability in a Changing Financial System".

Kaufmann, D., A. Kraay, and M., Mastruzzi (2006), *Governance matters V: Aggregate and individual governance indicators for 1996-2005*, The World Bank (Working Paper).

Kleibergen, F., and R. Paap (2006), "Generalized reduced

rank tests using the singular value decomposition", *Journal of Econometrics,* Vol. 133, pp. 97-126.

La Porta, R., F. López de Silanes, A. Shleifer and R. Vishny (1998), "Law and finance", *Journal of Political Economy*, Vol. 106, No. 6, pp. 1113-55.

La Porta, R., F. López de Silanes, A. Shleifer and R. Vishny (1999), "The quality of government", *Journal of Law, Economics and Organization*, Vol. 15, No. 1, pp. 222-79.

Lastra, R. M. (1996), *Central Banking and Banking Regulation,* LSE, Financial Markets Group, London.

Lohmann, S. (1992), "Optimal commitment in monetary policy: Credibility versus flexibility", *American Economic Review,* Vol. 82, No. 1, pp. 273-86.

Mailath, G. J., and L. J. Mester (1994), "A positive analysis of bank closure", *Journal of Financial Intermediation,* Vol. 3, pp. 272-99.

Masciandaro, D., and M. Quintyn (eds.) (2007), *Designing Financial Supervision Institutions: Independence, Accountability and Governance,* Edward Elgar, Cheltenham.

Quintyn, M., S. Ramirez and M. W. Taylor (2007), "The fear of freedom: Politicians and the independence and accountability of financial sector supervisors in practice", in D. Masciandaro and M. Quintyn (eds.), *Designing Financial Supervision Institutions: Independence, Accountability and Governance,* Edward Elgar, Cheltenham, pp. 63-116.

Quintyn, M., and M. W. Taylor (2003), "Regulatory and supervisory independence and financial stability", *CESifo Economic Studies*, Vol. 49, No. 2, pp. 259-95.

Quintyn, M., and M. W. Taylor (2007), "Robust regulators and their political masters: Independence and accountability in theory", in D. Masciandaro and M. Quintyn (eds.), *Designing Financial Supervision Institutions M.: Independence, Accountability and Governance,* Edward Elgar, Cheltenham, pp. 3-40.

Rochet, J.-C. (1992), "Capital requirements and the behavior of commercial banks", *European Economic Review*, Vol. 36, pp. 1137-78.

Rochet, J.-C. (2008), *Why Are There So Many Banking Crises? The Politics and Policy of Bank Regulation*, Princeton University Press.

Rogoff, K. (1985), "The optimal degree of commitment to an intermediate monetary target", *Quarterly Journal of Economics*, Vol. 100, No. 4, pp. 1169-89.

Santos, J. A. (2001), "Bank capital regulation in contemporary banking theory: A review of the literature", *Financial Markets, Institutions & Instruments*, Vol. 10, No. 2, pp. 41–84.

Sargan, J. D. (1958), "The estimation of economic relationships using instrumental variables", *Econometrica*, Vol. 26, No. 3, pp. 393-415.

Stock, J., and M. Yogo (2005), *Testing for weak instruments in linear iv regression*, NBER (Working Paper, No. 284).

Tirole, J. (1992), "Collusion and the theory of organizations", in J.-J. Laffont (ed.), *Advances in Economic Theory*, Vol. 2, Cambridge University Press, pp. 151-206.

Walsh, C. E. (1995), "Optimal contracts for central bankers", *The American Economic Review*, Vol. 85, No. 1, pp. 150-67.

Kevin Greenidge
Lisa Drakes

Tax policy and macroeconomic activity in Barbados

1. INTRODUCTION

It is generally accepted that fiscal policy can be used to influence economic activity. It is thought that changes in government expenditure and in the level of taxation can stabilise the economy, promote growth and development, and make the distribution of income more equitable. Measurement of the desired economic impacts of fiscal policy is central in determining its effectiveness. Moreover, it would be useful to identify any of its *side effects*. This paper focuses specifically on tax policies, and investigates the effects of tax changes on economic growth in Barbados. It employs an index of taxation developed in Greenidge and Drakes (2009) and, using a standard growth regression along with cointegration analysis, examines the relationship between taxation and economic growth over the period 1970-2007.

Since this study not only analyses the effects of changes in the overall level of taxation, but the effects of changes in specific taxes as well, its findings are expected to aid the Government of Barbados in its formulation of tax policies. Additionally, the use of the Greenidge and Drakes (2009) index of taxation, rather than the commonly used tax ratio, should yield more unbiased results than the latter measure, which tends to be correlated with variables such as economic output. Simple measures such as the tax ratio are also incapable of capturing the multifaceted nature of the tax system, and do no allow for the distinction between the effects of specific taxes or of direct or indirect taxation. More importantly, as observed by Romer and Romer (2007), a change observed in tax revenue may not be indicative of a tax policy change but could have been the result of a fluctuation in the tax base, which usually varies with the level of income, or with movements in stock prices, the price level, or a number of other factors.

The remainder of the paper is structured as follows. The next section discusses the theoretical and empirical literature. Section 3 outlines the way in which the growth effects of taxation are modelled, while Section 4 presents the estimation technique, along with the results. Section 5 concludes and provides some policy implications.

2. THE MACROECONOMIC EFFECTS OF TAX POLICY

2.1. Theoretical perspectives

Based on the Keynesian view, fiscal instruments can be used to compensate for autonomous variations in investment and export demand, and in so doing, they can stabilise aggregate demand (Goode, 1984). A fiscal expansion can be used to stimulate aggregate demand and output, as it has a multiplier effect on these two variables; this effect is greater for an increase in expenditure than for a reduction in taxes (Hemming, Kell, and Mahfouz, 2002). The opposite is suggested for cases when there is excessive demand, which would, if left unchecked, lead to inflation and balance-of-payments imbalances (Goode, 1984). However, these fiscal

actions can have distortionary effects on the economy (Blanchard and Fischer, 1989).

In the Keynesian model fiscal expansions have a crowding-out effect for several reasons, which makes fiscal multipliers smaller but still positive, according to Hemming *et al.* (2002). In an open economy, there can be crowding out if the rise in aggregate demand results in import growth. A fiscal expansion can also crowd out investment, as higher government borrowing raises interest rates.[1] Moreover, as espoused by the Mundell-Fleming model, crowding out can occur via the exchange rate. When interest rates arise in, as explained above, attracts capital inflows, leading to an appreciation of the exchange rate and, as a result, to a worsening of the external current account position.[2] It is also worthy to note that neo-Keynesian models take into account price flexibility, where, in a closed economy, fiscal expansion results in price increases, which, along with higher interest rates, limit the growth of aggregate demand (Hemming *et al.*, 2002).[3]

In addressing the likely macroeconomic effects of taxation, the life-cycle model emphasises that the timing of taxes affects the behaviour of those alive today. If there is a tax cut, and therefore a decision to finance deficit, there will be an expansion in human wealth.[4] Consequently, there will be an increase in consumption and, by extension, in aggregate demand. Government may need to raise taxes in the future to

---

[1] However, the overall effect on output could still be large if there is a positive relationship between investment and income (Hemming *et al.,* 2002).

[2] If the exchange rate is flexible and capital is perfectly mobile, there is complete crowding out, which renders fiscal policy ineffective. When the exchange rate is fixed, the rise in interest rates is smaller than in a closed economy, and if capital is perfectly mobile, then fiscal policy is very effective (Hemming *et al.,* 2002).

[3] With an open economy and a flexible exchange rate, the appreciation mentioned above can lead to a reduction in prices, implying that there will be less crowding out by the appreciation than if prices were rigid. On the other hand, if the exchange rate were fixed, there would be more crowding out since the current account will worsen as a consequence of price increases resulting from an exchange rate appreciation (Hemming *et al.,* 2002).

[4] As noted by Blanchard and Fischer (1989), government debt is a form of wealth to those who hold it.

service this debt, but the longer this increase in taxes is de-
ferred, the greater the probability of persons alive today not
being alive later to pay it, and the larger the impact of the tax
reduction on human wealth (Blanchard and Fischer, 1989).

As Hemming *et al.* (2002) point out, new classical models
assume that prices clear markets. Therefore any fluctuations
in output are caused by supply-side shocks and not by varia-
tions in aggregate demand. According to Hemming *et al.*
(2002), Lucas (1975) and Sargent and Wallace (1975) were
the first to highlight that an implication of these models is
that only unanticipated policies affect growth. Policies can be
unanticipated if there are surprises by the government or if
there is imperfect information.

The Ricardian Equivalence Theorem proposes that if per-
sons are forward-looking and entirely aware of the govern-
ment's intertemporal budget constraint, they will anticipate
that a reduction in taxes, that is financed by borrowing, will
later lead to an increase in taxes for their infinitely lived
families. As a result, permanent income does not change,
and if there are no liquidity constraints and perfect capital
markets, consumption will not increase (Barro, 1974). This
theory suggests that the current generation will leave a be-
quest for future generations so that they be able to meet
their obligations when taxes be raised in the future. There-
fore, a tax reduction will be followed by an accumulation of
savings, rather than by an increase in spending (Blanchard
and Fischer, 1989). If there is perfect Ricardian equivalence,
then the decline in government saving caused by the tax re-
duction is completely offset by greater private saving, and
there is no change in aggregate demand (Hemming *et al.*,
2002).

Though some variants of the Keynesian model acknowl-
edge the role of expectations, they usually consider adaptive
expectations (Hemming *et al.*, 2002). Under the assumption
of rational expectations, individuals will consider the long-
run effects of fiscal policy in the short run. Therefore, if a
short-lived fiscal expansion has no long-term impacts it will
not influence expectations. However, if the expansion is
permanent there is additional crowding out and fiscal multi-
pliers could become negative if households and firms antici-
pate that the initial rise in interest rates and the exchange

rate appreciation will continue and possibly become larger (Goode, 1984; Krugman and Obstfeld, 1997).

The theoretical literature discusses other distortionary effects that fiscal policy can have on the economy. For instance, the use of import duties to protect local industries may be detrimental to export growth, if it raises the cost of inputs to exporters and diverts the limited amount of factors of production to the protected sectors (Goode, 1984). In addition, income taxes act as a disincentive to the supply of labour, while capital taxes can also negatively impact saving and investment; in both cases there are growth implications (Hemming *et al.*, 2002). Income taxes can also be discouraging to savings and, according to Goode (1984), it is possible, though theoretically inconclusive, that they are more discouraging than a consumption tax.[5] Heavy taxation of profits was identified as another disincentive to saving, as profit recipients tend to be high savers (Goode, 1984). In addition, it is noted by Goode (1984) that progressive taxation curbs savings and therefore capital formation, and also creates disincentives to work and invest. Therefore, many economists believe that there is a trade-off between equity and growth.

2.2. Empirical evidence

Findings from empirical work on the macroeconomic effects of fiscal policy are mixed, particularly those regarding the relationship between fiscal policy and growth. This perhaps indicates that there are country-specific factors at work and that the effects of fiscal policy need to be assessed on a case-by-case basis. This variation in the results of previous studies makes them difficult to summarise. However, instead of concentrating on past results, here we focus on the various measures of the level of taxation employed in previous research.

Tax revenue, often expressed in real terms, has been used in some studies, such as that done by Hatemi-J (2002) to

[5] This could be so because income tax is charged on income earned, as well as on the return of any portion of the person's income that has been saved, while with a consumption tax, there is no taxing of the returns on savings (Goode, 1984).

assess the sustainability of Sweden's fiscal policy. Hatemi-J (2002) also examines the effect of taxes on government expenditure,[6] using causality analysis. The author concluded that the hypothesis of bi-directional causality could not be rejected, implying that in Sweden taxes and spending move simultaneously. In a later study for 19 OECD countries for the 1970-2002 period, Tagkalakis (2008) also used total tax revenue as a tax measure, inclusive of social security contributions, in real per capita terms.[7] Tagkalakis (2008) found that fiscal policy has a greater effect on consumption during recessions than in booms, particularly for countries with less developed credit markets. This is likely to be the case since in a recession a greater proportion of firms and households are facing liquidity constraints.

Researchers have also used net taxes. Following the methodology proposed by Blanchard and Perotti (2002), de Castro and de Cos (2008) estimated the economic effects of Spain's fiscal policy within a VAR framework. The included tax measure was net taxes in real terms, calculated as government revenue minus transfers, deflated by the GDP deflator. Results showed that tax increases constrained economic activity and only temporarily improved the fiscal position. Net taxes were also divided into their direct and indirect components and, while indirect taxation seemed to have no impact on economic activity, direct taxation appeared to have a contractionary effect. The authors also found that increases in indirect taxes were inflationary, while direct taxes seemed to have no effect on prices. Using a similar approach for a study of Italian fiscal policy, Giordano *et al.* (2007) reported that net revenue had very negligible effects on real private GDP, inflation, employment and the long-term nominal interest rate.

A much more frequently used measure has been the tax ratio,[8] particularly in the more dated studies. For instance, for

---

[6] Hatemi-J (2002) identified four possible relationships between taxes and government spending and the rationale provided by the literature for each. For instance, Friedman (1971) put forward the notion that the amount of revenue a government generates determines how much it will spend.

[7] The deflator used by Tagkalakis (2008) was the GDP deflator.

[8] The tax ratio is defined as tax revenue, as a ratio of GDP, where the tax revenue is usually in real terms. In some cases, this measure has been seasonally adjusted.

16 OECD countries over the 1968-1985 period, Van Hoa (1986) conducted the J-test on a simple IS-LM model of inflation, the variables of which were money supply, taxes (measured as taxes to GDP), government spending and unemployment. His findings indicated that taxes, but not expenditure, had a very strong effect on inflation.

Recently, however, it has been increasingly emphasized in the literature that the use of the tax ratio is not ideal for several reasons. For instance, according to Bretschger and Hettich (2002) and Devereux *et al.*(2004), this and other simple measures are not good proxies for the *real* tax burden since they do not effectively account for the multifaceted nature of the tax system. Therefore, in addition to the tax ratio, Angelopoulos *et al.* (2007) employed other tax measures in estimating an endogenous growth model to examine the effects of *productive* and *non-productive* government expenditure, and the related tax burden, on economic growth for 23 OECD countries. These other measures, which yielded more robust results as it relates to expenditure, were the effective tax rates and statutory tax rates on capital and labour. The effective tax rate for a specific tax is calculated as a ratio of revenue to tax base. The tax ratio, referred to as average tax rate, was found to be negatively related to growth. Results also indicated that effective labour income tax rates are negatively correlated with growth, while effective tax rates on capital income and corporate income were found to have positive growth effects.

Mendoza *et al.* (1997) also note the shortcomings of commonly used measures, including the fact that they do not allow for the distinction between the effects of direct and indirect taxation, and of specific direct taxes. Therefore, they employ the effective tax rates, on consumption, labour income and capital income, which were formulated by Mendoza *et al.* (1994) by comparing aggregate post and pre-tax incomes and prices. Mendoza *et al.* (1997) used these rates in their estimates of cross-country panel regressions for the G7 countries and eleven OECD countries, the results of which gave support to Harberger's (1964) argument that, despite theory outlining how tax changes impact the long-run growth rate, in reality such changes have negligible effects on growth.

Forni *et al.* (2009), in their study of the macroeconomic

effects of fiscal policy in the euro area, estimated a dynamic stochastic general equilibrium model using Bayesian techniques. Using government data that was only available in most instances at an annual frequency, they constructed quarterly effective tax rates[9] for three individual taxes, namely taxes on labour income, capital income and consumption, rather than for total taxes. Tax shocks were found to have a greater macroeconomic impact than expenditure shocks. Results indicated that cuts in tax rates on labour income and on consumption have significant positive impacts on consumption and output. Additionally, decreases in tax rates on capital income were found to encourage investment and output in the medium term.

Recognising the drawbacks of commonly used approaches, Romer and Romer (2007) developed a new measure of fiscal shocks for use in a study on the USA; they found that tax increases were very contractionary, particularly due to the negative impact they have on investment. Romer and Romer (2007) made use of the narrative record, namely presidential speeches, the Economic Report of the President and Congressional reports, to distinguish between *endogenous*[10] and *exogenous* tax changes. The latter are tax changes such as those taken to reduce an inherited budget deficit or to encourage long-run growth. The narrative record is also used to identify the timing of tax changes, so as to construct a series of the changes in tax liabilities resulting from *exogenous* tax changes. Romer and Romer (2007) then regressed output growth on a constant term and the current value and twelve lags of their measure of exogenous tax changes. Other variations of this specification were also estimated, including those that added control variables such as lagged growth, monetary policy shocks and changes in government spending.

---

[9] These calculations were also based on the methodology of Mendoza, Razin and Tesar (1994).

[10] This refers to changes occurring as a result of economic conditions that are likely to exist in the future, such as countercyclical action and changes to tax policy to accommodate changes in government expenditure. These are likely to yield biased estimates of the effects of tax changes on economic activity, since they are taken to return output growth to normal. Therefore in this study, Romer and Romer (2007) use the tax changes, which are motivated by more exogenous reasons.

2.3. Summary of evidence

According to the Keynesian model, a tax increase can cause a reduction in aggregate demand and output, while a tax reduction can lead to an expansion in these variables. Keynesian theory states that this expansion can be limited because of crowding-out effects. The life-cycle model also identifies a negative relationship between taxes and aggregate demand, but also proposes that a tax increase will usually follow a tax cut and the longer this tax increase is deferred, the greater the impact of a tax reduction on aggregate demand. However, the Ricardian Equivalence theorem hypothesises that, given no liquidity constraints; there will be no effect on aggregate demand because individuals have a bequest motive. Other theoretical models, such as the new classical ones, propose that tax changes have no effect on output. With respect to other variables, taxes can theoretically have negative effects on savings, investment and the supply of labour, and could also have inflationary consequences.

A review of the empirical literature shows mixed results regarding the relationship between taxes and growth and other macroeconomic variables. With respect to growth, some studies have found taxes to have Keynesian effects, while one of the papers reviewed found specific taxes to have positive growth effects. On the other hand, some studies discovered that taxes have no or very negligible impacts on output. While one study found that taxes have a very strong effect on inflation, another found that only indirect taxes are inflationary, while yet another found that taxes had insignificant inflationary consequences.

3. MODELLING THE GROWTH EFFECTS OF TAXATION

Most empirical studies on taxation and growth begin with the standard growth regression, often referred to as the Barro regression following the pioneering work of Barro and Sala-i-Martin (1995), and add to this baseline model a tax burden indicator (t) and perhaps a number of interaction terms depending on what is being investigated (see Equation 1). The idea is to estimate the effects of taxes on growth, controlling

for other possible growth determinants. Note that this work-horse regression model of the growth literature, the Barro regression, is really that first proposed in the seminal work of Mankiw *et al.* (1992), *MRW*, but with additional explanatory variables.

Original model of Mankiw et al. (1982)

(1)
$$y_{i,t} = \gamma X_{i,t} + \varepsilon_{i,t} + \quad \pi Z_{i,t} + \varphi t_{i,t}$$

Barro regression

Here, *y* is growth in real GDP per capita and, as noted by Durlauf *et al.* (2004), *X* can be seen as representing those growth determinants suggested by the Solow growth model, while *Z* captures those determinants that lie outside the original Solow theory. In addition, whereas the *X* variables are quite common in empirical studies, the *Z* variables vary considerably across studies and also by country (Kenny and Williams, 2001). Moreover, there is an extensive list of such *Z* variables. The Durlauf *et al.* (2004) survey identifies 145 different regressors, the vast majority of which have been found to be statistically significant in at least one study using conventional standards. They note that one of the main reasons why so many alternative growth variables have been identified is due to measurement issues, and attribute the high percentage of statistically significant growth variables to publication bias and data mining.

Remaining with the empirical literature and accepting equation (1) as an appropriate framework for examining the growth effects of taxes, the question is how to choose among the vast number of possible growth determinants. This is far from an easy task as Durlauf *et al.* (2004) pointed out when they argued that the absence of consensus is one of the fundamental problems of the empirical growth literature.

The common approach to variable selection in the literature is to choose from among the *X* variables those that have been found to be robust across different studies, and to choose from *Z* those additional controls that the researcher wants to account for in our relation to the issue being investigated. In this regard, note that Levine and Renelt (1992) and Kalaitzidakis *et al.* (2000) concluded that the only robust

growth determinants among X are initial income and the share of investment in GDP.[11] Our approach is to survey the growth literature specific to the Caribbean region in terms of the variables employed and then to utilise a general-to-specific modelling procedure, which allows for a more robust method of selecting the variables.

3.1. A caribbean country growth model

As discussed above, a wide range of variables have been used in growth empirics; however, a number of these, such as ethno-linguistic fractionalisation (from Easterly and Levine, 1997; Sala-i-Martin, 1997a; Sala-i-Martin, 1997b) and assassinations (as in Dollar, 1992; Dollar and Kraay, 2001), are not applicable to the Caribbean. The choice of variables is arrived at by a survey of the literature as it relates to developing countries, in particular work done on the Caribbean region.[12] The following variables are revealed from the survey: human capital, government consumption expenditure, openness to international trade, financial development, inflation, physical capital and the population growth rate.

In the absence of continuous and consistent data on school enrolment and grades used to proxy *human capital*, the World Bank's (1994) procedure of interpolating and extrapolating the Barro and Lee (2000) measures of educational attainment is followed. In this regard, the percentage of the population that has successfully completed only the secondary school level and the percentage that has successfully completed a tertiary level are utilised to form an overall measure of human capital based on principal component analysis. This overall measure of human capital accounts for 99% of the individual components. *Government consumption expenditure* is measured by the ratio of government consumption to gross domestic product (GDP) which is obtained from the World

[11] Greenidge (2006) provides a survey of the growth literature and highlights the variables that are commonly used in X and Z.

[12] Specifically, works by Williams and Daniel (1991), the World Bank (1994), Boamah (1997), Lewis and Craigwell (1998), Peters (2001), Downes (2003), Greenidge (2006) and Craigwell *et al.* (2008). Note that a wider review of the literature on these variables is also contained in Greenidge (2006).

Development Indicators (WDI) CD ROM 2008. In terms of o*penness to international trade*, the share of exports in GDP is used to capture the effect of a more outward-looking trade regime. However, given that usually imports are most affected under a trade restrictive regime and usually stand to benefit most from greater openness to international trade, the share of imports to GDP is also employed as an alternative proxy. Additionally, the trade volume (merchandise exports plus imports) to GDP ratio is experimented with for comparison purposes. These data also come from the WDI 2008.

Financial development is measured by the ratio of broad money (M2) to GDP, and the inflation rate by the twelve-month moving average of changes in the consumer price index. However, since it is recognised in the literature that even in low inflation environments high inflation volatility can impede growth by generating uncertainty concerning future prices, this study experiments with the conditional standard deviation of the inflation rate as a measure of uncertainty (also employed as a determinant by Barro, 1997; Barro and Martin, 1999; Barro and Sala-i-Martin, 2004; Levine and Renelt, 1992; Sala-i-Martin, 1997a). This is obtained by estimating a generalised autoregressive conditional heteroscedasticity (GARCH) model of the inflation rate.[13] Finally, physical capital accumulation is given by the gross domestic investment.

As shown in Table 1 of the Appendix, several direct and indirect taxes exist or have existed in Barbados. Greenidge and Drakes (2009) developed a tax indicator for Barbados, which measures the level of taxation from 1969 to 2007, and it is this index that is the final variable included in the growth regression. In developing the index, 1969 represented the base year for each individual tax. Then, each time a policy change occurred in each specific tax regime, as indicated in the Central Bank of Barbados' Chronicle of Tax Policy, the percentage change in the burden is estimated. The index for

[13] The GARCH model, developed by Bollerslev (1986), is the most popular tool for modelling volatility as it permits precise time dependence estimates of the second moment of the variable in question (Serven, 1998; Bo and Sterken, 1999). A GARCH (1,1) model of the form $\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \varepsilon_t$ where $\sigma_t^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \sigma_{t-1}^2$ is used, where π is the inflation rate, σ_t^2 is the conditional variance of ε_t and the σ_t is taken as the measure of uncertainty.

each respective tax is adjusted in accordance with these percentage changes, to give a series of an index for each individual tax.

TABLE 1. DESCRIPTION OF DIRECT AND INDIRECT TAXES IN BARBADOS

Tax	Description
Direct	
Personal taxes	These are taxes charged on the taxable income (gross income minus personal, spouse, home and child allowances) of individuals. Barbados has a Pay As You Earn system and employers are required to withhold taxes from their workers' wages and salaries. Income tax is charged at a basic rate on an individual's taxable income up to and including a specified amount. Taxable income in excess of that specified amount is then taxed at the marginal rate. Deductions are also allowed for contributions to a savings or retirement plan, purchase of shares and for other investments.
Corporate taxes	These are taxes levied on profits of all companies operating in Barbados. International business companies face a significantly lower rate. Corporations also benefit from allowances, such as depreciation, export, and research and development allowances. Deductions, such as that for the cost of listing shares on the stock exchange, are also allowed.
Levies	These comprise employment, environmental, health, transport, betterment and training levies. None of these currently exist.
Stabilisation taxes	These were instituted in the early 1990s, as part of the structural adjustment programme to boost Government revenue. The rate was initially 1.5% of an individual's total income and on the profits of corporations but was increased periodically, depending on Government's need for revenue. Stabilisation taxes are no longer in existence.
Property taxes	This category mainly comprises land tax and property transfer tax, but also includes estate duties, rent registration, land development duties, and taxes on intellectual properties and corporate affairs. From 2006, also include in this category were taxes on income earned from rental of home accommodation. While land tax is paid annually, property transfer tax is payable by the seller a property is sold.
Other direct taxes	This category includes withholding taxes on interest earned on savings and securities, as well as taxes charged on dividends.
Indirect	
Consumption taxes	These are taxes levied on spending on goods and services. However, they have been replaced by the value added tax (VAT).
Stamp duties	In this study, these only refer to those stamp duties placed on imports. These have also been replaced by the VAT.

TABLE 1 *(continuum)*

Tax	Description
VAT	The VAT was introduced in 1997 and, so as to simplify the tax system, it replaced stamp duties, hotel and restaurant taxes and consumption taxes. The VAT (at a rate of 15%) is imposed on a wide range of goods and services supplied in, or imported into, the country; some goods and services, particularly essential ones, are however exempted or zero-rated. In addition, a lower rate of 7.5% is charged on the supply of tourist accommodation.
Excises	These were initially levied on only rum products. However, after the introduction of the VAT, they were charged on tobacco, spirits, petroleum products and motor vehicles.
Import duties	This category comprises custom duties, levied on a large variety of imported goods at various rates, with luxury goods being taxed at higher rates. This category also includes a cess, which was introduced in September 2005 for an eighteen-month period and imposed on extra-regional imports (certain items, particularly essential ones, were exempted).
Hotel and restaurant taxes	These were taxes levied on the revenue of hotels and restaurants, but they have been replaced by the VAT.
Other indirect taxes	This category encompasses an environmental levy and highway revenue. The environmental levy covers the cost of disposal of waste generated from the use of imported goods. There is a general rate of 1% of the CIF value of imports but some commodities, such as vehicles and refrigerators, are taxed at a specific nominal value per unit.

It would be preferable to include all the individual tax categories in the same model along with the various interaction terms but this may lead to problems of multicollinearity and seriously infringe on the degrees of freedom during estimation, resulting in unreliable inferences. Therefore, following the recommendation of Demetriades and Luintel (1996a, 1997), Greendige and Drakes (2009) use principal component analysis[14] to construct three summary indicators:

[14] The method of principal component (Lawley and Maxwell, 1971; Theil, 1971) involves the linear and orthogonal transformation of our set of (possibly correlated) variables into uncorrelated variables referred to as principal components, which are ordered in terms of their variance. Besides the fact that the resulting variables are uncorrelated, the other advantage of this procedure is that we can choose to work with all or a sub-set of the components (depending on the amount of variance that each explains), effectively reducing dimensionality of the data and therefore overcoming the econometric problems mentioned.

an index of direct taxation,[15] an index for indirect taxation[16] and an index of overall tax policies. An increase in each index represents a rise in the tax burden and a reduction indicates an easing of the tax burden. Each indicator is therefore expected to be indirectly related to economic growth.

4. METHODOLOGY AND RESULTS

4.1. Methodology

Our data set spans the period 1970 to 2007, giving us 38 data points and, as such, we opt for a single-equation estimation approach to co-integration analysis. At the same time we are mindful of issues of endogeneity in choosing our estimation procedure, since in the presence of simultaneity cointegration regressions may be biased in small samples even though they are consistent estimators (Stock and Watson, 1993). Therefore, we opted to use the Unrestricted Error Correction Model (UECM) approach proposed by Pesaran *et al.* (2001), where short and long-run effects are estimated jointly from a general autoregressive distributed-lag (ARDL) model. Pesaran *et al.* (2001) refers to this as the ARDL approach to cointegration modelling. This technique has two main advantages over the other common procedures to cointegration analysis, mainly the Engle and Granger two-step approach and the Johansen maximum likelihood framework. The first advantage stems from the fact that the other methods focused on the estimation of long-run relationships among *I(1)* variables, which inevitably involves a certain degree of pre-testing and thus introduces a further degree of uncertainty into the analysis of relationships between levels (Cavanagh, Elliott, and Stock, 1995; Pesaran, Shin, and Smith, 1996; Pesaran, Shin, and Smith, 2001). Moreover,

---

[15] Note that levies and *other* direct taxes are not included. Several levies have existed in the past but changes in these appear to have posed some difficulty in tracking, given the quality of information provided in the Tax Chronicle. The *other* direct tax category is relatively small and changes in this category were negligible.

[16] Note that for similar reasons excises and *other* indirect taxes are not included.

their widespread use has led to the common misconception that long-run relationships exist only in the context of cointegration among integrated variables (Greenidge, 2006; Loayza and Ranciere, 2006). With the UECM, cointegration analysis can be conducted irrespective of whether the explanatory variables are *I(0)*, *I(1)* or a mixture of both. The second advantage is that this technique improves upon the other methods since it is better at handling small sample and dynamic sources of bias. Pesaran and Shin (1998), Pesaran *et al.* (2001) and Haug (2002) show that the OLS estimators of the short-run parameters in the UECM are $\sqrt{T}$ - consistent and the long-run coefficients are super consistent in small sizes.

The UECM is specified:

$$(2) \qquad \Delta y_t = \phi_0 + \sum_{i=1}^{p-1} \gamma_i \Delta y_{t-i} + \sum_{i=0}^{q-1} \delta_i \Delta X_{t-i} + \alpha y_{t-1} + \beta_i X_{t-1} + \varepsilon_t$$

where X represents the set of growth determinants identified above, γ and δ are the short-run coefficients related to growth and its determinants, α and β are the level effects and thus the long-run coefficients are computed as $-(\beta_i/\alpha)$, α also represents the speed of adjustment to the long-run relation, ε_t is a disturbance term with the classical assumptions.

A long-run relation is said to exist between economic growth and its determinants if the coefficients on the lagged level variables are jointly significant. This is a standard F-statistic test; however its asymptotic distributions are non-standard. As such, Pesaran *et al.* (2001) provide two sets of asymptotic critical values; one set assuming that all the regressors are *I(1)*; and another set assuming that they are all *I(0)*. These two sets of critical values refer to two polar cases but actually provide a band covering all possible classifications of the regressors into *I(0)*, *I(1)* or even fractionally integrated. If the calculated F-statistic lies above the upper level of the band, the null is rejected, indicating cointegration. If it falls below the lower level of the band, the null cannot be rejected, indicating the lack of cointegration. If the calculated F-statistic falls within the band, a conclusive inference cannot be made.

4.2. Results

The results are presented in table 2. The first column shows the variables, the second column gives the final estimates for the standard growth model without the tax indicator, and each column thereafter displays the estimates with some measure of the tax indicator included. The diagnostics for each model are given in the lower panel of the respective column. In this regard, each model passes various diagnostic tests, including that for serial correlation of the residuals, functional form misspecification, non-normal residuals and heteroscedastic disturbances. Moreover, based on the coefficient of variation, each model is capable of explaining over 90% of the variability in economic growth over the period and thus can be taken as an adequate representation of the growth process in Barbados. In what follows, we first discuss the standard growth model and its determinants and then proceed to analyse the findings when the tax indicator is included.

In the standard model, the presence of a long-run equilibrium relationship between growth and its determinants is confirmed based on the result of the *bounds* test. The computed F-statistic on the exclusion test of the level variables is 31.39, which exceeds the asymptotic critical upper *bounds* value of 3.99 in Pesaran *et al.* [2001, table CII (iii)] for the existence of a cointegrating relationship, thus rejecting the null of no cointegration relationship at 5% level. This implies that growth in Barbados and its determinants are cointegrated or co-moving. Moreover, the coefficient on the lagged real GDP term, representing the implicit speed of adjustment towards equilibrium, is negative and highly significant, and implies that shocks to the economy will eventually dissipate and output will gravitate towards this equilibrium position. Moreover, the size of the coefficient indicates that approximately 16% of any deviation from the long-run equilibrium output level is corrected each year. There is relatively little change in these results for the models that include a tax indicator, although in some cases the speed of adjustment towards equilibrium increases.

The results in the standard model suggest that investment, financial development, the stock of human capital, government

TABLE 2. RESULTS OF FOR TAXATION AND GROWTH

Variable	Basic model	with Total tax	with Direct tax	with Indirect tax
ΔL(physical capital)	0.114[a]	0.108[a]	0.114[a]	0.111[a]
ΔL(physical capital)$_{t-2}$	−0.025[a]	−0.024[a]	−0.025[b]	−0.026[a]
ΔL(financial dev.)	0.090[a]	0.111[a]	0.078[b]	0.112[a]
ΔL(government consumption)	−0.289[a]	−0.287[a]	−0.258[a]	−0.286[a]
ΔL(government consumption)$_{t-1}$	0.087[a]	0.091[a]	0.076[b]	0.089[a]
ΔL(openness)$_{t-1}$	0.051[b]	0.070[a]	0.038	0.066[a]
ΔL(openness)$_{t-2}$	−0.077[b]	−0.087[a]	−0.081[a]	−0.089[b]
ΔL(human capital)	0.020[b]	0.024[a]	−0.199[a]	0.022[a]
L(real GDP)$_{t-1}$	−0.157[a]	−0.168[a]	0.165[a]	−0.173[a]
L(financial dev.)$_{t-1}$	0.186[a]	0.196[a]	−0.403[a]	0.198[a]
L(government consumption)$_{t-1}$	−0.461[a]	−0.481[a]	0.148[a]	−0.478[a]
L(openness)$_{t-1}$	0.144[a]	0.127[a]	−0.238[a]	0.130[a]
ΔL(inflation)	−0.274[a]	−0.227[a]	0.427[a]	−0.225[a]
ΔL(inflation)$_{t-1}$	0.441[a]	0.419[a]	−0.720[a]	0.428[a]
L(inflation)$_{t-1}$	−0.792[a]	−0.755[a]	0.029[a]	−0.753[a]
L(human capital)$_{t-1}$	0.035[a]	0.036[a]	−0.014[a]	0.035[a]
Δ(total tax)		−0.003[a]		
Δ(total tax)$_{t-1}$		−0.003[b]		
Δ(direct tax)			−0.006[c]	
Δ(direct tax)$_{t-1}$			0.011[c]	
Δ(indirect tax)				−0.012[a]
Δ(indirect tax)$_{t-1}$				−0.012[a]
R^2	0.965	0.977	0.972	0.976
F–statistic	31.39[a]	37.24[a]	30.85[a]	36.57[a]
DW	1.81	2.28	1.96	2.27
AR	0.372	1.831	0.658	1.853
	[0.695]	[0.197]	[0.533]	[0.193]
RESET	0.036	2.015	2.463	1.7693
	[0.852]	[0.176]	[0.137]	[0.203]
Norm	1.306	0.506	0.128	1.030
	[0.521]	[0.776]	[0.938]	[0.598]
ARCH	0.426	0.012	0.490	0.121
	[0.523]	[0.915]	[0.495]	[0.7329]

	Personal tax	corporate tax	Stabilisation tax	Property tax
ΔL(physical capital)	0.115[a]	0.112[a]	0.123[a]	0.112[a]
ΔL(physical capital)$_{t-2}$	−0.032[a]	−0.028[a]	−0.028[a]	−0.027[a]
ΔL(financial dev.)	0.053[c]	0.074[b]	0.085[a]	0.101[a]
ΔL(government consumption)	−0.255[a]	−0.252[a]	−0.300[a]	−0.293[a]
ΔL(government consumption)$_{t-1}$	0.036	0.051[b]	0.106[a]	0.099[a]
ΔL(openness)$_{t-1}$			0.059[a]	
ΔL(openness)$_{t-2}$	−0.084[a]	−0.114[a]	−0.058[c]	−0.096[a]
ΔL(human capital)			0.025[a]	

TABLE 2 *(continuum)*

	Personal tax	*corporate tax*	*Stabilisation tax*	*Property tax*
L(real GDP)$_{t-1}$	−0.142[a]	−0.175[a]	−0.173[a]	−0.190[a]
L(financial dev.)$_{t-1}$	0.172[a]	0.134[a]	0.195[a]	0.195[a]
L(government consumption)$_{t-1}$	−0.396[a]	−0.375[a]	−0.478[a]	−0.490[a]
L(openness)$_{t-1}$	0.160[a]	0.206[a]	0.125[a]	0.194[a]
ΔL(inflation)	−0.229[a]	−0.262[a]	−0.288[a]	−0.237[a]
ΔL(inflation)$_{t-1}$	0.417[a]	0.443[a]	0.439[a]	0.490[a]
L(inflation)$_{t-1}$	−0.741[a]	−0.810[a]	−0.783[a]	−0.805[a]
L(human capital)$_{t-1}$	0.026[a]	0.024[a]	0.035[a]	0.041[a]
Δ(personal tax)$_{t-1}$	0.233[a]			
(corporate tax)$_{t-1}$		−0.106[a]		
Δ(corporate tax)$_{t-1}$		0.090[a]		
(stabilisation tax)$_{t-1}$			−0.018[c]	
Δ(stabilisation tax)			−0.014[a]	
Δ(stabilisation tax)$_{t-1}$			0.020[c]	
(property tax)$_{t-1}$				−0.054[a]
Δ(property tax)$_{t-1}$				0.040[a]
R^2	0.965	0.967	0.971	0.969
F−statistic	35.39[a]	33.34[a]	27.00[a]	35.34[a]
DW	1.88	2.06	1.88	2.09
AR	0.215	0.730	0.416	0.973
	[0.809]	[0.497]	[0.668]	[0.399]
RESET	0.121	0.241	2.102	0.277
	[0.732]	[0.630]	[0.169]	[0.606]
Norm	0.488	1.218	1.355	1.929
	[0.783]	[0.544]	[0.508]	[0.310]
ARCH	0.702	0.065	0.108	0.032
	[0.414]	[0.802]	[0.748]	[0.859]

	Consumption tax	*Stamp duty*	*with VAT*	*with Import duty*	*Hotel and restaurant tax*
ΔL(physical capital)	0.111[a]	0.115[a]	0.114[a]	0.102[a]	0.107[a]
ΔL(physical capital)$_{t-2}$	−0.028[a]	−0.026[a]	−0.026[a]	−0.037[a]	−0.022[b]
ΔL(financial Dev.)	0.107[a]	0.108[a]	0.108[a]	0.101[a]	0.113[a]
ΔL(government consumption)	−0.285[a]	−0.288[a]	−0.287[a]	−0.254[a]	−0.287[a]
ΔL(government consumption)$_{t-1}$	0.085[b]	0.085[a]	0.084[a]	0.086[a]	0.099[a]
ΔL(openness)$_{t-1}$	0.059[a]	0.049[b]	0.051[a]		0.064[b]
ΔL(openness)$_{t-2}$	−0.092[a]	−0.079[b]	−0.079[b]	−0.093[a]	−0.080[b]
ΔL(human capital)	0.022[a]	0.023[a]	0.022[a]		0.021[a]
L(real GDP)$_{t-1}$	−0.1634[a]	−0.173[a]	−0.172[a]	−0.190[a]	−0.179[a]
L(financial dev.)$_{t-1}$	0.192[a]	0.199[a]	0.197[a]	0.218[a]	0.204[a]
L(government consumption)$_{t-1}$	−0.469[a]	−0.477[a]	−0.474[a]	−0.421[a]	−0.488[a]
L(openness)$_{t-1}$	0.133[a]	0.138[a]	0.138[a]	0.133[a]	0.131[a]

TABLE 2 *(continuum)*

	Consumption tax	Stamp duty	with VAT	with Import duty	Hotel and restaurant tax
ΔL(inflation)	-0.228^a	-0.219^a	-0.221^a	-0.225^a	-0.234^a
ΔL(inflation)$_{t-1}$	0.428^a	0.426^a	0.424^a	0.441^a	0.424^a
L(inflation)$_{t-1}$	-0.750^a	-0.760^a	0.759^a	-0.696^a	-0.756^a
L(human capital)$_{t-1}$	0.034^a	0.034^a	0.035^a	0.026^a	0.036^a
Δ(consumption tax)	-0.007^a				
Δ(consumption tax)$_{t-1}$	-0.006^a				
Δ(stamp duties)$_{t-1}$		-0.017^a			
Δ(VAT)$_{t-1}$			0.018^a		
(import duties)$_{t-1}$				-0.045^a	
Δ(hotel & rest tax)					-0.013^b
Δ(hotel & rest tax)$_{t-1}$					-0.014^b
R^2	0.977	0.971	0.971	0.968	0.974
$F-statistic$	37.17^a	33.14^a	33.13^a	38.49^a	33.37^a
DW	2.35	2.26	2.27	2.19	2.22
AR	3.683	0.925	1.104	1.946	1.466
	[0.052]	[0.418]	[0.386]	[0.173]	[0.264]
RESET	0.317	0.115	0.115	2.606	1.833
	[0.582]	[0.739]	[0.739]		[0.196]
Norm	0.984	1.774	1.895	1.278	0.817
	[0.611]	[0.412]	[0.388]	[0.528]	[0.665]
ARCH	0.085	0.087	0.101	0.914	0.016
	[0.775]	[0.773]	[0.755]	[0.352]	[0.900]

NOTES: [a], [b] and [c] indicates significance at the 1%, 5% and 10% level, respectively.

consumption expenditure, trade openness and inflation are significant determinants of growth.

As shown in the Appendix, estimation of the standard growth model (without a tax index) revealed significant explanatory variables as investment, financial development, government consumption, trade openness, human capital, real GDP and inflation.

The positive effect of human capital on steady-state output is one of the fundamental predictions of the endogenous growth models and is of no surprise here given Barbados' impressive education track record. The coefficient on this combined of educational attainment suggests that a 1 percentage point increase in the percentage of the adult population entering the work force having successfully completed education training at the secondary level or higher, leads to approximately one-fifth (computed as $-0.0349/-0.1566$) of a percentage expansion in economic growth. This finding augurs

well for the significant amount of investment and attention that successive governments have placed on developing the stock of human capital in Barbados. For example, in 1960/61, the government's current expenditure on education was BBD 4 million or 18.3% of total expenditure and this has risen over the years to reach BBD 446.3 million or 21.9% in 2006/07. Indeed, it is at the tertiary level that much of the investment has taken place with the three largest tertiary institutions on the island opening within the sample period of this study: the Cave Hill Campus of the University of the West Indies in 1962; the Barbados community College in 1969; and, the Samuel Jackman Prescod Polytechnic in 1970. Furthermore, this investment has also been accompanied by policies to ensure that each member of the population gets access to at least a basic level of education. Such policies included the abolition of fees at secondary schools and a compulsory school-leaving age of 16 years. The figures on educational attainment indicate that the percentage of the population whose highest level of education is at the secondary or tertiary levels have risen significantly over the sample period. Thus, the quality of its human capital has been increasing over time and as such there is no surprise of the finding of a positive and significant effect on growth.

In addition, the positive coefficient on changes in the human capital variable indicates that improvements in the stock of human capital have a short-run contributory effect to growth. Here, the evidence suggests that a 10% rise in the percentage of the adult population attaining some form of training at the secondary level or further will lead to roughly a 0.2 percentage rise in economic growth.

The positive coefficient on the lagged openness variable can be taken as suggesting that greater openness to international trade has allowed the economy to raise its output levels over the years. Admittedly, this is an outcome indicator and as such may be capturing other policy actions that encourage trade but are unrelated to openness. More so, exports of services are mainly tourism and have little to do with actual openness to trade in the traditional sense. It is possible to have trade controls in place but invest heavily in tourism product development and marketing. It is more likely that the proxy is capturing such effects. Openness also has a positive

short-run impact on growth, as indicated by the combined effects of lags 1 and 2 changes in openness.

The finding of a positive impact of financial development on growth is consistent with the growth literature and suggests that the financial system has developed in a manner which has facilitated growth. Moreover, it is supported by the demand-following of the relationship between financial development and growth, which views the former as a consequence of the demand for financial services (see for example, Robinson, 1952; and Lucas, 1988). Specifically, it would suggest that in the development process, as the Barbadian economy evolved from traditional agricultural production to a more complex, and monetised economy, certain demands were generated for the services of financial institutions. Such demands were created by the growing needs of firms for external finance, as their retained profits fall short of their investment expansion needs. The financial system development was in accordance to meeting such demands.

The evidence also indicates that government consumption expenditure has reduced growth in short-run and also lowered the long-run level of output. Lewis and Craigwell (1998) suggest that it is likely that government spending occurred at the expense of private investment and to the extent that this spending is not productive, fiscal policy will have a negative impact on growth. It does not necessarily mean that all categories of government spending reduce output but that in the aggregate it does.

Finally, gross domestic investment is found to be a significant determinant of economic growth only in the short-run. Its coefficient indicates that a 10% rise in physical capital accumulation leads to approximately 1.1 percentage point increase in output. However, this effect dissipates over time.

When the index of overall taxation is included in the growth model, it is found to have a contractionary effect in the short-run but no long-run impact. The same short-run result holds for indirect taxation. Direct taxation, on the other hand, has negative growth effects in both the short and long run.

While personal taxation and economic growth are not related in the long-term (perhaps indicative of individuals' ability to adjust to increases in personal taxation), they are

positively related in the short-run. This short-run relationship, which can be interpreted as a fall in the personal tax burden resulting in lower economic growth, perhaps highlights the need for the breakdown of personal taxation into the various income categories. It is possible that although the aggregate personal tax burden has been declining, the burden on the higher-income group has been rising. As noted by Goode (1984), progressive taxation curbs savings and therefore capital formation, and also creates disincentives to work and invest.

Similar to personal taxation, corporate and property taxation are unexpectedly positively related to growth in the short-run. On the other hand, in the long run, these forms of taxation are both found to have a negative effect on growth. In other words, increasing (reducing) the burden in these categories of taxes reduces (increases) growth over time. Since the levels of corporate and property taxation have been falling over the sample period, it means that tax polices in these areas have served to raise the rate of economic growth. One inference that can be drawn is that these categories of taxation increased the amount of funds firms and property-holders have at their disposal for investment and consumption purposes, which have positive growth implications. With regards to the stabilisation tax policies of the early 1990s, these are found to have been growth-reducing. Therefore, although these taxes may have been effective in buffering government revenue during the economic downturn of that period, they are likely to have also further suppressed economic activity.

The majority of the categories of indirect taxation policies have had no long-run impact on economic growth; only import duties were found to have negatively impact growth in the long-run, most likely by raising the cost of inputs and thereby discouraging production. While there is no short-run relation between import duties and economic growth, an increase in the burdens from consumption taxes, stamp duties and hotel and restaurant taxes have constrained economic growth, in the short run, as expected. Finally, it appears that the introduction of the VAT, which at the time replaced eleven other taxes, spurred economic growth in the short-run but that effect has since dissipated.

5. CONCLUSION

Given several drawbacks of commonly used, outcome-based, tax measures, we find rule-based measures, such as the Greenidge and Drakes (2009) index of taxation, to be preferable in our determination of the growth effects of taxation in Barbados. To conduct this investigation, literature specific to the Caribbean is surveyed to identify variables for a standard growth regression. This growth equation is then estimated using the UECM approach, the results of which show that investment, financial development, the stock of human capital, government consumption expenditure, trade openness and inflation are significant determinants of growth of the Barbados economy. The Greenidge and Drakes (2009) indexes of overall, direct, indirect and of specific taxation are then individually added to the standard growth regression. Our findings indicate that direct taxation had negative growth effects in both the short and long run. However, indirect, as well as overall, taxation had negative growth effects only in the short run but none in the long run.

These results imply that the gradual reduction of direct taxation undertaken by the government of Barbados has been growth-enhancing, and would suggest that the use of greater indirect taxation (and lower direct taxation) is preferable in the case of Barbados. Indeed, indirect taxation has some advantages over direct taxation. Indirect taxation is said to present less of a disincentive to work, as it is not deducted from workers' wages. With indirect taxation, the consumer can decide the extent to which he will tax himself, or whether he would avoid the tax. Therefore indirect taxes can encourage savings, as persons restrict consumption so as to avoid taxation.

Notwithstanding these benefits, total or extremely heavy reliance on indirect taxation is not advisable and the right mix between this and direct taxation must be found. This is especially so since a higher level of indirect taxation can have inflationary consequences and can lead to a less equitable income distribution, as indirect taxes are more regressive. Moreover, the flow of receipts from indirect taxes is highly likely to be interrupted by periods of recession when consumer expenditure is low. Finding the optimal mix between

direct and indirect taxation, which is one of the oldest issues in public finance, is an area for future research.

REFERENCES

Angelopoulos, K., G. Economides and P. Kammas (2007), "Tax-Spending Policies and Economic Growth: Theoretical Predictions and Evidence from the OECD", *European Journal of Political Economy,* vol. 23, pp. 885-902.

Barro, R. J. (1974), "Are Government Bonds Net Wealth?", *Journal of Political Economy,* vol. 82, pp. 1095-1117.

Barro, R. J. (1997), *Determinants of Economic Growth,* MIT Press, Cambridge.

Barro, R. J., and X. Sala-i-Martin (1995), *Economic Growth,* McGraw-Hill, New York.

Barro, R. J., and X. Martin (1999), *Economic growth,* The MIT Press, London; Cambridge, Mass.

Barro, R. J., and X. Sala-i-Martin (2004), *Economic Growth,* MIT Press, London.

Blanchard, O. J., and S. Fischer (1989), *Lectures on Macroeconomics,* Massachusetts Institute of Technology, USA.

Blanchard, O., and R. Perotti (2002), "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output", *Quarterly Journal of Economics,* vol. 117, pp. 1329-1368.

Boamah, D. (1997), *The Effect of Human Capital on Economic Growth in the Caribbean,* Central Bank of Barbados (Working Papers, vol. I, pp. 55-70).

Bollerslev, T. (1986), "Generalized Autoregressive Conditional Heteroskedasticity", *Journal of Econometrics,* vol. 31, pp. 307-327.

Bretschger, L., and F. Hettich (2002), "Globalisation, Capital Mobility and Tax Competition: Theory and Evidence for OECD Countries", *European Journal of Political Economy,* vol. 18, pp. 695-716.

Cavanagh, C. L., G. Elliott, and J. H. Stock (1995), "Inference in Models with Nearly Integrated Regressors", *Econometric Theory,* vol. 11, pp. 1131-1147.

Craigwell, R., D. Downes, K. Greenidge, and K. Steadman

(2008), "Sectoral Output, Growth and Economic Linkages in the Barbados Economy over the Past Five Decades", *Applied Econometrics and International Development,* vol. 8, pp. 123-136.

De Castro, F., and P. Hernandez De Cos (2008), "The Economic Effects of Fiscal Policy: The Case of Spain", *Journal of Macroeconomics,* vol. 30, pp. 1005-1028.

Devereux, M. P., R. Griffith, and A. Klemm (2004), "Why Has the UK Corporation Tax Raised So Much Revenue?", *Fiscal Studies,* vol. 25, pp. 367-388.

Dollar, D. (1992), "Outward-oriented Developing Economies Really Do Grow More Rapidly: Evidence from Ninety-five LDCs, 1976-1985", *Economic Development and Cultural Change,* vol. 40, p. 523.

Dollar, D., and A. Kraay (2001), "Trade, Growth, and Poverty", *Finance and Development,* vol. 38, pp. 16-19.

Durlauf, S. N., P. A. Johnson, and J. R. W. Temple (2004), *Growth Econometrics,* Wisconsin Madison Social Systems (Working Paper).

Easterly, W., and R. Levine (1997), "Africa's Growth Tragedy: Policies and Ethnic Divisions", *Quarterly Journal of Economics,* vo. 112, pp. 1203-1250.

Forni, L., L. Monteforte, and L. Sessa (2009), "The General Equilibrium Effects of Fiscal Policy: Estimates for the Euro Area", *Journal of Public Economics,* vol. 93, pp. 559-585.

Giordano, R., S. Momigliano, S. Neri, and R. Perotti (2007), "The Effects of Fiscal Policy in Italy: Evidence from a VAR Model", *European Journal of Political Economy,* vol. 23, pp. 707-733.

Goode, R. (1984), *Government Finance in Developing Countries,* The Brookings Institution, Ma., Washington, D. C.

Greenidge, K. (2006), *Essays on the Nature and Impact of Financial Liberalisation,* Thesis/Dissertation, University of Nottingham, UK.

Greenidge, K. C. D., and L. M. E. Drakes (2009), *A New Measure of Taxation: An Application to Barbados,* Mimeo, Thesis/Dissertation, Central Bank of Barbados.

Harberger, A. (1964), "The Measurement of Waste", *American Economic Review,* vol. 54, pp. 58-76.

Hatemi, J. (2002), "Fiscal Policy in Sweden: Effects of EMU Criteria Convergence", *Economic Modelling,* vol. 19, pp. 121-136.

Haug, A. A. (2002), "Temporal Aggregation and the Power of Cointegration Tests: A Monte Carlo Study", *Oxford Bulletin of Economics and Statistics,* vol. 64, pp. 399-412.

Hemming, R., M. S. Kell, and S. Mahfouz (2002), *The Effectiveness of Fiscal Policy in Stimulating Economic Activity–A Review of the Literature,* International Monetary Fund (WP02208).

Kalaitzidakis, P., T. P. Mamuneas, and T. Stengos (2000), "A Non-linear Sensitivity Analysis of Cross-Country Growth Regressions", *Canadian Journal of Economics,* vol. 33, pp. 604-617.

Krugman, P. R., and M. Obstfeld (1997), *International Economics: Theory and Policy,* Addison-Wesley, Ma., USA.

Levine, R., and D. Renelt (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions", *American Economic Review,* vol. 82, pp. 942-963.

Loayza, N. V., and R. Ranciere (2006), "Financial Development, Financial Fragility, and Growth", *Journal of Money,* vol. 38, pp. 1051-1076.

Lucas, R. E. (1975), "An Equilibrium Model of The Business Cycle", *Journal of Political Economy,* vol. 83, pp. 1113-1144.

Mankiw, N. G., D. Romer, and D. N. Weil (1992), "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics,* vol. 107, pp. 407-437.

Mendoza, E. G., G. M. Milesi-Ferretti, and P. Asea (1997), "On the Ineffectiveness of Tax Policy in Altering Long-Run Growth: Harberger's Superneutrality Conjecture", *Journal of Public Economics,* vol. 66, pp. 99-126.

Mendoza, E. G., A. Razin, and L. L. Tesar (1994), "Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Rates on Factor Incomes and Consumption", *Journal of Monetary Economics,* vol. 34, pp. 297-323.

Pesaran, M. H., Y. Shin, and R. J. Smith (1996), *Testing for the 'Existence of a Long-run Relationship,* Department of Applied Economics.

Pesaran, M. H., and Y. Shin (1998), "An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis", in S. Strom (ed.), *Econometrics and Economic Theory in the the 20th Century: The Ragnar Frisch Centennial Symposium,* Cambridge University Press, Cambridge, pp. 371-413.

Pesaran, M. H., Y. Shin, and R. J. Smith (2001), "Bounds Testing Approaches to the Analysis of Level Relationships", *Journal of Applied Econometrics,* vol. 16, pp. 289-326.

Romer, C. D., and D. H. Romer (2007), *The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks,* National Bureau of Economic Research.

Sala-i-Martin, X. (1997a), *I Just Ran Four Million Regressions,* National Bureau of Economic Research.

Sala-i-Martin, X. (1997b), "I Just Ran Two Million Regressions", *American Economic Review,* vol. 87, pp. 178-183.

Sargent, T. J., and N. Wallace (1975), "Rational Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule", *Journal of Political Economy,* vol. 83, pp. 241-254.

Stock, J. H., and M. W. Watson (1993), "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems", *Econometrica,* vol. 61, pp. 783-820.

Tagkalakis, A. (2008), "The Effects of Fiscal Policy on Consumption in Recessions and Expansions", *Journal of Public Economics,* vol. 92, pp. 1486-1508.

Van Hoa, T. (1986), "Effects of Monetary and Fiscal Policy on Inflation: Some Evidence from the J-test", *Economic Letters,* vol. 22, pp. 187-190.

Williams, M., and C. Daniel (1991), "Government Activity and Economic Performance in a Small Developing Economy", *Economia Internazionale,* vol. 44, pp. 269-281.

World Bank (1994), *Jamaica: A Strategy for Growth and Poverty Reduction,* World Bank (Country Economic Memorandum).

Miguel Sarmiento

Central bank economic research: output, demand, productivity, and relevance

1. INTRODUCTION

The research by central banks is intended fundamentally to provide a well-timed theoretical and empirical basis for policy-making to help them fulfill their functions. Research also must become an essential tool for divulging and better communicating policies to the market and the general public. From a broader perspective, Berk (2007) noted that research

must help the central bank to perform its primary functions (e.g. price and financial system stability). Therefore, it must concentrate on topics that are relevant to policy makers, adhere to the highest standards of academic quality, and contribute to specialized knowledge of economics and financial literature.

Several studies have been done in recent years to evaluate the economic research performance of central banks. In the case of Europe the studies focus on the quality of the articles published by researchers, with various rankings of indexed journals used to evaluate the articles as a way to compare the performance of central banks (Eiffinger et al., 2002; Gaspar and Vega, 2002; Jordeau and Pagès, 2003). In a more extensive study, St-Amant et al. (2005) employed different indexes to evaluate the quantity, quality and relevance of the research produced by 34 central banks in the OECD from 1990 to 2003. Results suggest that central banks with a research agenda concentrated on topics that are extremely relevant to decisions by policymakers produce publications of higher academic quality.

Another approach used to evaluate the function of research is proposed by Ochoa and Schmidt-Hebbel (2006). They define the quantity of working papers (WPs) published by central banks as a measure of research output, and the number of WPs file downloads from *LogEc*, which is the leading electronic system for tracing economic studies throughout the world, as a proxy of demand. The results of the study show the central banks of Chile and Colombia occupy important positions, both at the Latin American level and compared to the central banks of the developed economies.

Unlike most of the studies mentioned, in which the benchmark focus on research quality –measured by publication of the WPs in an indexed journal–, the approach used in this study assumes that ultimate publication of the article in a recognized economic journal is an added value for the researcher who wants to position his or her work at the intellectual and academic level, but does not constitute the main purpose of research for a central bank. Therefore, what a central bank needs is research focused on topics of particular relevance to well-timed and effective decision-making by the

monetary authority, in addition to being consistently first-rate from a technical and theoretical perspective.

According with this approach, Skreb (2005) suggests that central bank research should be directed towards providing policy makers with technical support on internal and external economic performance, market development, and the short and medium-term effects of adopted policies, using the most modern economic theories and the latest techniques available to solve the problems central banks face. Similarly, Mester (2007) argues that the mission of research in a central bank is to furnish a strong scientific basis – both theoretical and empirical – to support the design of the central bank's policies in its areas of assigned responsibility. Recent external evaluations of research activities in Finland and ECB also suggest emphasize on the relevance of the topics covered by researchers (Goodfriend et al., 2004; Kashyap et al., 2009)

A methodology for a comprehensive evaluation of research performance in a central bank is proposed in this study. The measures of research output and demand suggested by Ochoa and Schmidt-Hebbel are formalized and the analysis is expanded with two additional indexes designed to measure research productivity and relevance. An index of the relevance of research for a central bank is constructed based on the classification of central bank WPs done regularly by the Bank for International Settlements (BIS). It is a more inclusive relevance measure than the one suggested by St-Amant et al., which is based on the number of times central bank WPs are cited in BIS publications and those of the USA Federal Reserve System.

According to empirical evidence, 30 central banks in the OECD and Latin America are evaluated during the period (2000-2007). Three aspects of research are examined in depth: focus of the research agenda, the way it is organized and the strategies used to develop it, as employed by six central banks that are shown in the study to be research leaders, including the Central Bank of Colombia.

This paper is organized into five sections, including this introduction. The methodology used to calculate the indexes and the fundamentals for its application in assessing the central banks in the sample are described in section 2. The results of the international comparison are presented in section

3. Section 4 is focused on the main aspects of research for the group of reference central banks. Some final thoughts are provided in section 5.

2. METHODOLOGY

The four measures described below are proposed to evaluate research performance in the central banks.

Output: Equation (1) offers a measure of research output that measures the quantity of WPs produced by each central bank i, with $i = 1..., I$, where the total number of central banks considered I is 30, and published during the period (2000-2007), with $t = 2000..., T$, where T is 2007:

$$(1) \qquad\qquad S_i = \sum_{t=2000}^{T} q_{i,t}$$

Demand: Equation (2) represents the demand for research measured by the number of WPs file downloads through *LogEc*[1] for each central bank i in period t:

$$(2) \qquad\qquad D_i = \sum_{t=2000}^{T} d_{i,t}$$

Productivity: In economic literature the term productivity is associated with the concept of total factor productivity (TFP); that is, the number of units of output produced by each unit of the factor or input employed (Farrell, 1957).[2] In this case, two indexes were used following the approach proposed by Lubrano et al. (2003), where production is measured by the

---

[1] LogEc is an electronic system that compiles access statistics on the different services that use the *Research Papers in Economics* (RePEc) database, which is the largest collection of economic WPs and journal articles on the Internet. The WPs file downloads through this system do not include those done from each central banks' website.

[2] More structured indexes have been developed to measure productivity in different sectors, due to recent efficiency frontiers developments (Kocher et al., 2006). One of the most used indexes is the Malmquist Index, which identifies whether changes in a company's productivity are due to efficiency gains and/or a technological change. See Galán and Sarmiento (2008) for one application of this index to central banks.

central bank's quantity of WPs and input is measured by the number of authors who took part in producing the research paper.[3] Equation (3) shows the productivity index (PI) that relates each central bank's quantity of WPs ($q_{i,t}$) to the number of authors who were involved in each paper ($n_{i,t}$), for each year t, as follows:

$$(3) \qquad PI_i = \sum_{t=2000}^{T} \frac{q_{i,t}}{n_{i,t}}$$

Relevance: The relevance measure is based on the BIS ranking of central bank WPs, according to the categories established by the *Journal of Economic Literature* (JEL). The ranking of WPs published by central banks between 2000 and 2007, pursuant to the JEL classification, is shown in table 1. Under this approach, macroeconomics and monetary economics constitute the area that accounts for the largest proportion (32.7%), followed by financial economics (18.1%), mathematical and quantitative methods (13%), and international economics (12%). According to this ranking, the WPs in the aforementioned categories are more relevant to the central bank than, for example, WPs in category P (economic systems), which accounts for 0.21%.[4] To make the ranking operative, each proportion was transformed on a scale of one to five points, which indicates the value attributed to each published WP.

The productivity and relevance index (PRI) is shown in equation (4), where each central bank WPs is evaluated with a relevance measure (w_i) and then corrected by the number of authors for each publication:[5]

---

[3] In some studies more weight is assigned to the central bank's authors than to the authors of any other institution taking part in the WP (See Neary, et al. 2003). In this case, the assumption is that all authors took part equally in the WP and, therefore, each is given equal weight.

[4] Gaspar and Vega (2002) suggest the relative importance of the topics measured according to the JEL categories can be considered a good indicator of the policy orientation of central bank research.

[5] In the four measures described above, the result for the best performing central bank was transformed on a relative basis to generate comparative indexes for each aspect evaluated; namely: $I_i^* = (I_{i,t} \times 100) / I_{i,t}^{max}$, where $I_{i,t}$ is the value obtained for each evaluated central bank and ($I_{i,t}^{max}$) is the maximum value obtained by a central bank for the evaluated aspect.

$$(4) \qquad IPR_i = \sum_{t=2000}^{T} \frac{q_i \times w_i}{n_i}; \qquad 1 \leq w_i \leq 5.$$

TABLE 1. WORKING PAPERS RELEVANCE SCALE ACCORDING TO BIS

JEL category	Topics	Share %[a]	Ranking[b]
E	Macroeconomics and monetary economics	32.68	5.00
G	Financial economics	18.14	3.78
C	Mathematical and quantitative methods	12.98	2.99
F	International economics	12.03	2.84
D	Microeconomics	6.39	1.98
J	Labor and demographic economics	3.67	1.56
O	Economic development, technological change, and growth	3.10	1.47
L	Industrial organization	2.74	1.42
R	Urban, rural, and regional economics	2.65	1.41
H	Public economics	2.61	1.40
N	Economic history	1.05	1.16
I	Health, education, and welfare	0.38	1.06
K	Law and economics	0.38	1.06
M	Business administration and business economics; marketing; accounting	0.32	1.05
B	History of economic thought, methodology, and heterodox approaches	0.21	1.03
P	Economic systems	0.21	1.03
Q	Agricultural and natural resource economics; environmental and ecological and economics	0.19	1.03
Z	Other special topics	0.15	1.02
A	General economics and teaching	0.12	1.02
	Total	100	

SOURCES: BIS Research Hub and the author's calculations.
[a] The JEL category as a share of all central bank WPs ranked by BIS during the period 2000–2007. [b] Scale of one to five points, denoting the proportion of the WPs selected by BIS.

As mentioned earlier, this relevance measure is more inclusive than the one used by St-Amant et al., which is based on the number of citations of central bank WPs in BIS publications and those of the Federal Reserve System. The assumption, in this case, is that publication of the article in a recognized journal is added value for the researcher who hopes to position his or her work at the academic level, but is not the main purpose of central bank research.

Several ways of ranking journals to measure the quality of the articles are proposed in the literature (Combes and Linnemer, 2003).[6] However, recent evidence shows these rankings

[6] Kodrzycki and Yu (2006) proposed a recent approach, where journals

can have important methodological differences that affect the way journals are ranked and, consequently, the ultimate assessment of the articles (Wall, 2009).[7] Most of the central banks evaluated try to keep a minimum level of academic quality in their publications, which is guaranteed by using anonymous referees to evaluate the WPs. It is another reason for not evaluating the quality of publications and for focusing on the relevance of the topic.

In fact, most central banks use a *light* arbitration procedure that consists of a rather quick look at the article to make sure it says nothing that might compromise or adversely affect the central bank and contains no analytical or conceptual errors or statistical fallacies.[8] In this respect, the differences among central banks reside in the fact that this arbitration may be done internally by other researchers (e.g. Chile and Colombia), with an outside consultant (e.g. England, Spain and Brazil) or using a combination of internal and outside arbitration (e.g. Canada, the ECB and the Fed-BG). Yet, regardless of the type of arbitration, research quality will always be an aspect of prime importance to central banks.

3. RESULTS OF THE INTERNATIONAL COMPARISON

The indexes described earlier were calculated for 30 central banks with information on WPs published from 2000 to 2007.[9] As for research output, a steady increase in WPs production by the central banks in the sample was observed (85% during the period). When arranged according to all published WPs, the European Central Bank (ECB) and the United States Federal

_____

are ranked on the basis of the weighted average of the citations of articles in other journals, with the idea to measure the influence of the article in the area of economics, social sciences and policy. See also García-Castrillo et al. (2002).

[7] Additionally, some studies show there is an institutional concentration of authors in top economics journals (Kocher and Sutter, 2001).

[8] This process does not include requests for extensions to the model or to the statistical method used, as would be typical in a report subject to *heavy* arbitration, such as one prepared for an academic journal. Nor is it necessary to submit a detailed report on the assessed paper.

[9] The central bank working paper series are showed in the table A.5.

TABLE 2. WORKING PAPERS OF SELECTED CENTRAL BANKS (2000–2007)

Ranking	Central banks	2000	2001	2002	2003	2004	2005	2006	2007	Total	Share %	Average	Var. % (2000–2007)
1	ECB	33	72	93	96	139	166	149	164	912	12.71	114	397
2	Fed-BG	92	84	95	107	103	96	84	96	757	10.55	95	4
3	Chile	30	43	62	59	53	50	54	47	398	5.55	50	57
4	Finland	38	43	45	52	53	47	52	55	385	5.37	48	45
5	Colombia	28	27	32	46	48	40	69	49	339	4.72	42	75
6	Canada	23	27	42	44	49	45	49	58	337	4.70	42	152
7	Germany	10	20	31	20	47	58	60	53	299	4.17	37	430
8	Italy	27	46	28	21	54	28	43	42	289	4.03	36	56
9	St. Louis-Fed	10	6	7	45	32	76	62	54	292	4.07	37	440
10	Atlanta-Fed	28	27	33	43	39	30	30	27	257	3.58	32	−4
11	The Netherlands	18	11	24	29	38	53	41	35	249	3.47	31	94
12	Spain	19	21	29	22	23	42	39	41	236	3.29	30	116
13	San Francisco-Fed	19	23	24	24	35	26	50	33	234	3.26	29	74
14	England	19	27	20	39	35	40	32	19	231	3.22	29	0
15	Chicago-Fed	31	24	31	35	30	24	29	24	228	3.18	29	−23
16	New York-Fed	19	28	15	19	21	39	35	33	209	2.91	26	74

17	Philadelphia-Fed	14	16	22	24	24	28	22	34	184	2.56	23	143
18	Brazil	9	26	26	19	11	9	28	29	157	2.19	20	222
19	Cleveland-Fed	15	19	15	21	16	15	24	25	150	2.09	19	67
20	Minneapolis-Fed	25	13	19	16	22	14	17	18	144	2.01	18	-28
21	France	6	9	11	5	17	18	23	30	119	1.66	15	400
22	Kansas City-Fed	11	15	12	13	12	13	16	13	105	1.46	13	18
23	Austria	3	13	25	6	8	12	28	4	99	1.38	12	33
24	Peru	12	15	9	16	8	8	10	19	97	1.35	12	58
25	Boston-Fed	5	6	8	8	8	18	19	16	88	1.23	11	220
26	Richmond-Fed	12	9	4	19	10	13	13	8	88	1.23	11	-33
27	Mexico	8	8	12	5	7	5	15	15	75	1.05	9	88
28	Ireland	5	6	6	9	10	10	17	10	73	1.02	9	100
29	Dallas-Fed	6	17	7	11	6	11	6	9	73	1.02	9	50
30	Venezuela	6	5	6	14	14	4	8	15	72	1.00	9	150
	Total	581	706	793	887	972	1,038	1,124	1,075	7,176	100	897	85
	Average	19	24	26	30	32	35	37	36	239	3	30	116

SOURCES: BIS Research Hub, the websites of the central banks and the author's calculations.

Reserve-Board of Governors (Fed-BG) led the output with 912
and 757 WPs, and respective annual averages of 114 and 95
(table 2).

The central banks of Chile, Finland, Colombia and Can-
ada, with more than 300 WPs during the period and 40 per
year, exceed the average (239 and 30, respectively). When
comparing WPs output between 2000 and 2007, most of the
central banks increased their WPs output during those years.
The central banks of Germany, France and the St. Louis-Fed

TABLE 3. RESEARCH DEMAND IN CENTRAL BANKS (2007)

Ranking	Central banks	Demand		Var. % 2000–2007	Share %	
		2000	*2007*		*2000*	*2007*
1	Fed–BG	27,020	30,700	13.62	22.08	14.60
2	ECB	3,809	20,629	441.60	3.11	9.81
3	Canada	5,128	14,092	174.82	4.19	6.70
4	St. Louis-Fed	2,043	12,011	487.98	1.67	5.71
5	New York-Fed	6,261	11,841	89.12	5.12	5.63
6	Italy	6,751	11,435	69.38	5.52	5.44
7	Colombia	5,908	11,258	90.55	4.83	5.35
8	Chile	6,595	11,250	70.59	5.39	5.35
9	England	7,906	8,608	8.89	6.46	4.09
10	Atlanta-Fed	8,020	8,428	5.09	6.55	4.01
11	The Netherlands	3,797	8,038	111.72	3.10	3.82
12	Finland	4,594	7,240	57.60	3.75	3.44
13	Philadelphia-Fed	2,685	7,101	164.44	2.19	3.38
14	Germany	1,209	6,984	477.59	0.99	3.32
15	Chicago-Fed	7,570	6,387	−15.63	6.19	3.04
16	Cleveland-Fed	3,134	5,688	81.48	2.56	2.70
17	San Francisco-Fed	2,998	5,669	89.12	2.45	2.70
18	Boston-Fed	1,339	4,670	248.74	1.09	2.22
19	Kansas City-Fed	2,938	3,781	28.68	2.40	1.80
20	Richmond-Fed	4,480	3,252	−27.41	3.66	1.55
21	Minneapolis-Fed	4,012	3,145	−21.60	3.28	1.50
22	Austria	2,007	2,916	45.31	1.64	1.39
23	Brazil	591	2,074	251.16	0.48	0.99
24	Dallas-Fed	1,146	1,872	63.33	0.94	0.89
25	Spain	319	750	134.96	0.26	0.36
26	France	73	400	444.43	0.06	0.19
27	Ireland	46	100	117.77	0.04	0.05
28	Mexico	5	6	20.00	0.00	0.00
29	Peru	3	5	66.67	0.00	0.00
30	Venezuela	2	2	0.00	0.00	0.00
	Total	122,389	210,332	72	100	100
	Average	4,080	7,011	126		

SOURCES: Ideas-LogEc, and the author's calculations.

are prime examples, having increased their WPs output more than four-fold. In the case of the ECB, the important build-up is explained by the institution's consolidation in the European Union since its start in 1999.

The demand for research, calculated with equation (2), shows an important increase during the period due the raise in the number of WPs file downloads for the majority of the central banks in the sample. The number of downloads went from 122,389 in 2000 to 210,332 in 2007 (72% increase), while the increase for the output was 85% (table 3).

In 2007, the Fed-BG occupied first place, with 30,700 downloads, 49% more than those registered in the ECB (20,629), which went to second place. The Bank of Canada was in third place (14,092), followed by the St. Louis Fed (12,011), the New York-Fed (11,841) and the Bank of Italy (11,435). The central banks of Colombia and Chile, with 11,258 and 11,250 downloads, were in seventh and eighth place, respectively.

The relative indexes of output and demand calculated for 2007, where the performance of each central bank is compared to the best in the sample, indicates that demand for ECB WPs and for those of the central banks of Finland, Germany, Brazil, Spain and France is less than the output level during that year. The comparison of the indexes for the ECB and the Fed-BG indicates the latter continues to dominate with respect to the demand for economic literature, even though the ECB produces more WPs (figure 1).

The productivity index (PI) described in equation (3) is presented in figure 2. It shows the central banks with the most production also occupy the top positions with respect to productivity. According to the results for 2007, the ECB, the Fed-BG and the central banks of Finland, Canada and Germany lead the PI. The central banks of Colombia, Chile and Peru occupy prominent positions at the regional level.

The relevance of each WPs, done by calculating the PRI [equation (4)], highlights the progress achieved by the central banks of Peru, Brazil and the Kansas City-Fed, despite having less output. This suggests the topics studied are notably relevant to the central banks. In contrast, when evaluated with this index, the Philadelphia-Fed, the Atlanta-Fed and the Boston-Fed dropped several positions, partly because their

FIGURE 1. INDEXES OF RESEARCH OUTPUT AND DEMAND FOR CENTRAL BANKS, 2007
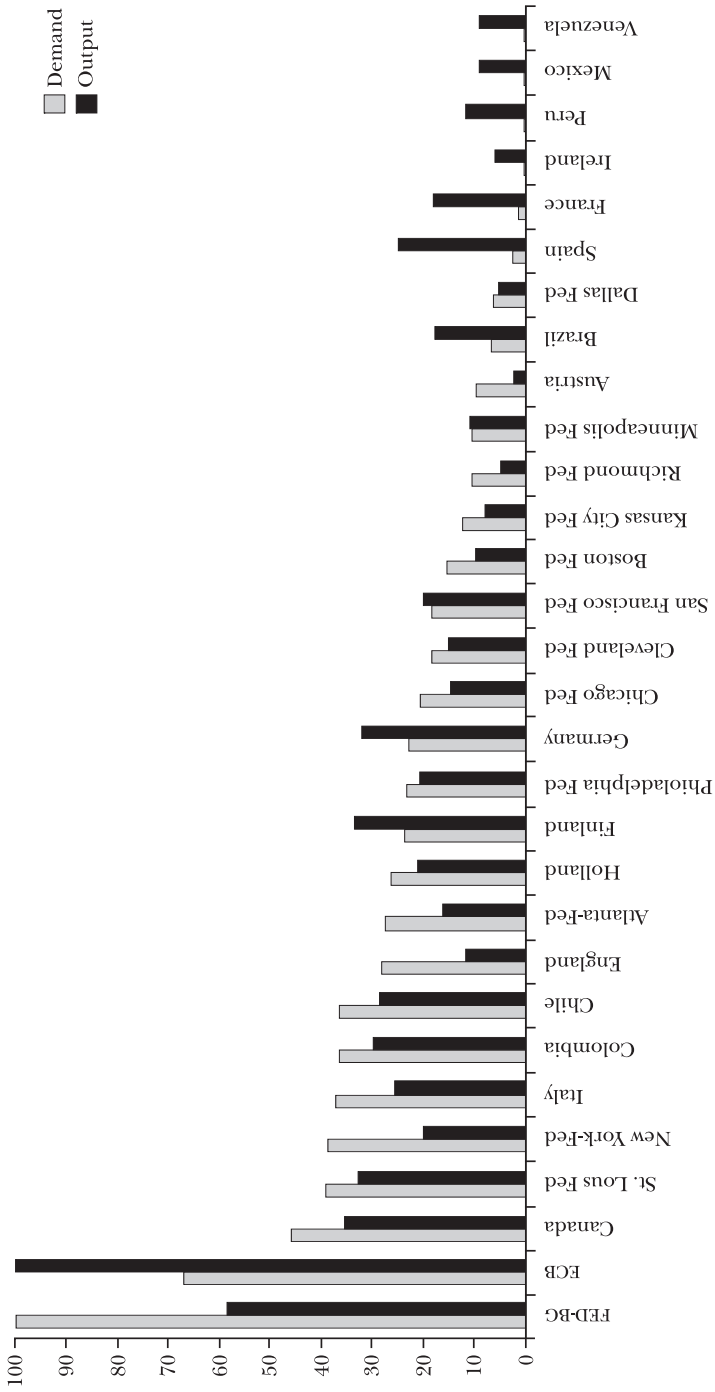
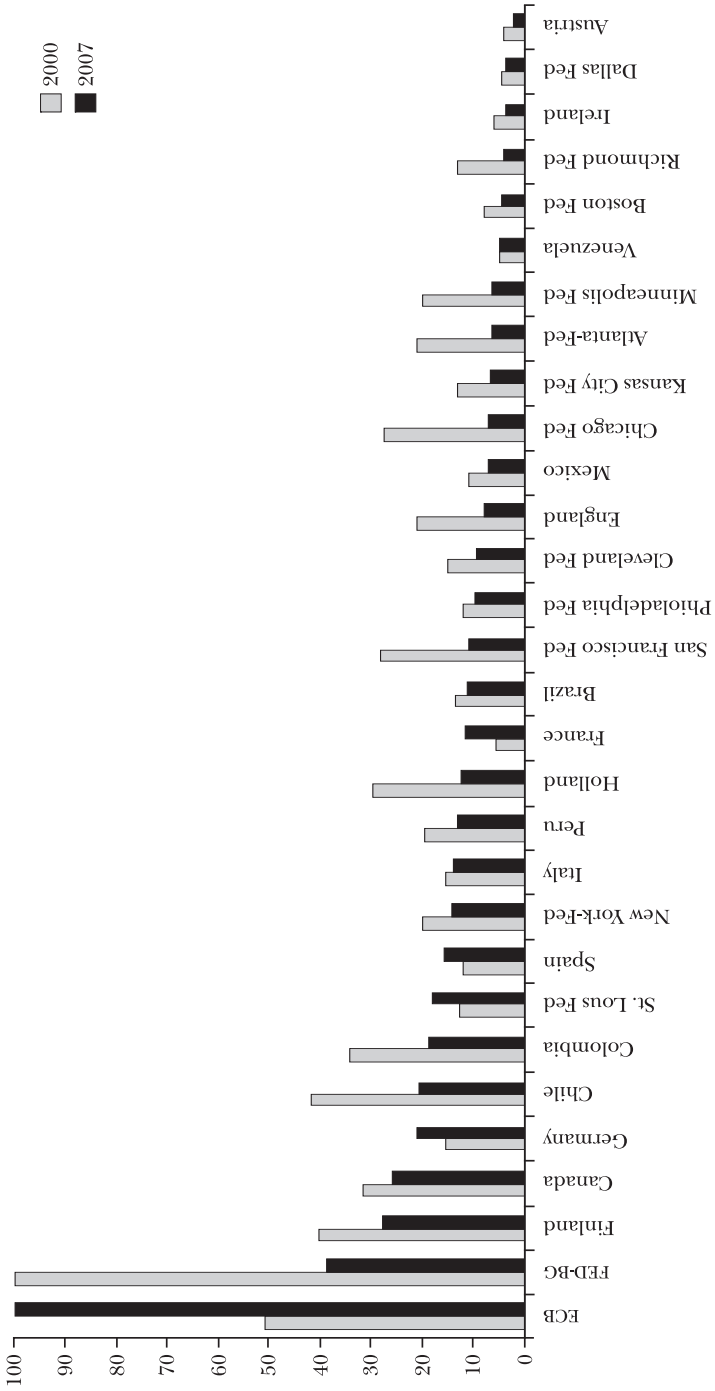SOURCES: Ideas-LogEc; BIS Research Hub, the websites of the central banks and the author's calculations.

FIGURE 2. PRODUCTIVITY INDEX (PI), 2000-2007
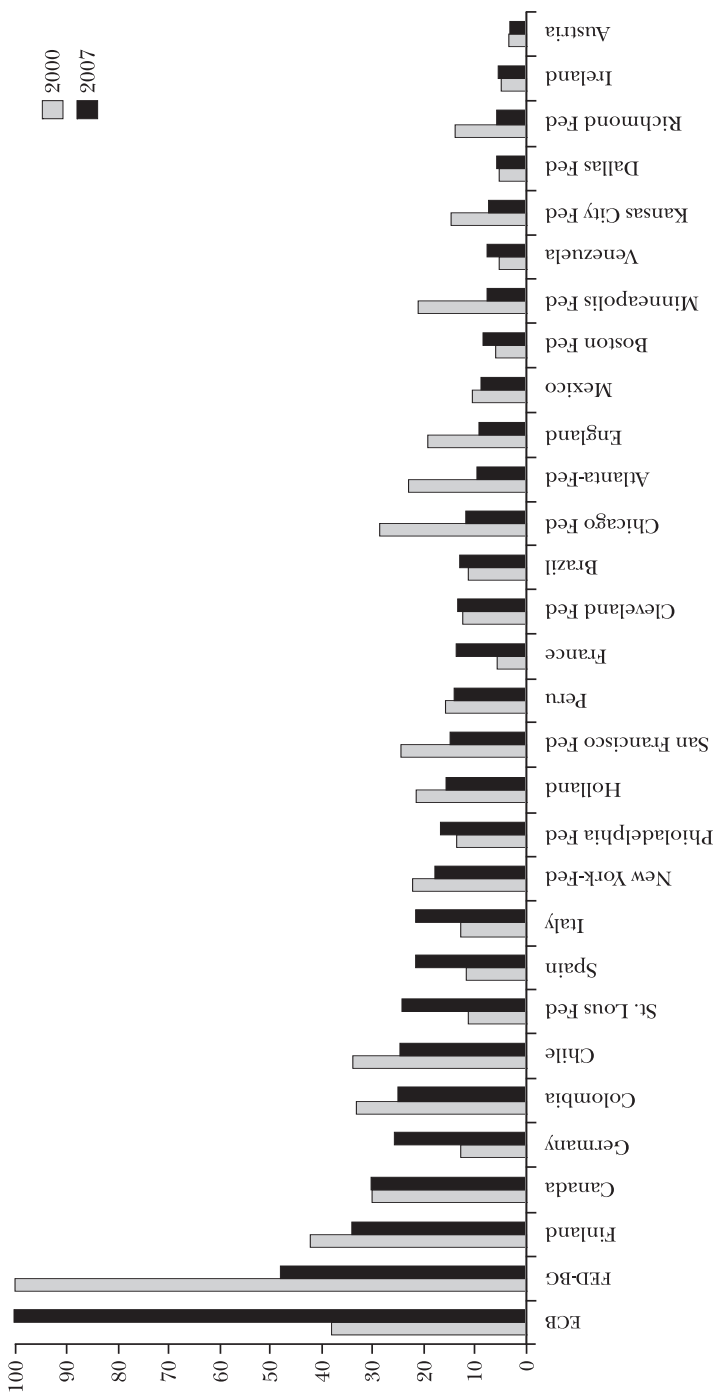
SOURCES: BIS Research Hub, the websites of the central banks and the author's calculations.

FIGURE 3. PRODUCTIVITY AND RELEVANCE INDEX (PRI), 2000-2007

SOURCES: BIS Research Hub, the websites of the central banks and the author's calculations.

research agenda is concentrated on topics that complement the studies done by the Fed-BG and other regional branches (e.g. St. Luis-Fed and the New York-Fed) where the primary focus is on issues related to monetary economics, financial economics and quantitative methods[10] (figure 3).

The increase in the PI averaged 8.6% between 2000 and 2007, due to added productivity on the part of 46% of the central banks evaluated. The PRI declined 22.6%, on average, given the reduction made by the 80% of the central banks. The central bank of France, the ECB, the St. Louis Fed and the central banks of Germany, Spain and Venezuela were the only ones to register an increase in the PRI during those years (See Annex 1).

4. REFERENCE CENTRAL BANKS

Five central banks were selected for comparison with the Central Bank of Colombia. They are the ECB, the Fed-BG and the central banks of Canada, Germany and Chile. These institutions are recognized for their experience in economic research and ranked the best in the indexes calculated earlier. The focus of the research agenda, the way research is organized, and the latest strategies to improve research quality and relevance were examined for this group of institutions.

4.1. Focus of the research agenda

A concentration coefficient of the percentage of WPs located in the most relevant JEL categories (BG, G, F and C), according to the result of the BIS ranking, was established to measure how focused the research agenda is. The calculated indicator shows that 81% of the research done by these banks, on average, is concentrated in the four most relevant categories, with macroeconomics and monetary economics accounting for the largest share (31%), followed by international economics and financial economics (19%). The central banks of Chile and Canada had the highest concentration

---

[10] In fact, Goodfriend (1999) notes the Federal Reserve System had developed a model whereby its regional branches specialize in different types of research. This provides comparative advantages to the system.

TABLE 4. CONCENTRATION OF THE RESEARCH AGENDA IN SELECTED CENTRAL BANKS (2007)

JEL	Topic	ECB		Fed–BG		Canada		Germany		Chile		Colombia		Average	
		WP	%	WP	%	WP	%	WP	%	WP	%	WP	%	WP	%
E	Macroeconomics and monetary economics	71	43	17	18	22	38	15	28	16	34	12	24	26	31
F	International economics	32	20	12	13	10	17	6	11	20	43	5	10	14	19
G	Financial economics	21	13	27	28	11	19	15	28	3	6	9	18	14	19
C	Mathematical and quantitative methods	14	9	25	26	7	12	6	11	3	6	6	12	10	13
O	Economic development, technological change, and growth	7	4	3	3	1	2	2	4	3	6	4	8	3	5
H	Public economics	5	3			2	3	5	9			3	6	3	4
J	Labor and demographic economics	7	4	4	4	1	2	2	4			3	6	3	3
D	Microeconomics	4	2	4	4	1	2	2	4			2	4	2	3
N	Economic history			1	1	2	3					3	6	1	2
L	Industrial organization	2	1							2	4	1	2	1	1
I	Health, education, and welfare			3	3									1	1
K	Law and economics											1	2	0	0
R	Urban, rural, and regional economics					1	2							0	0
Q	Agricultural and natural resource economics; environmental and ecological	1	1											0	0
	Total WP	164		96		58		53		47		49		78	
	Concentration coefficient (E, G, F & C) (%)	84.1		84.4		86.2		79.2		89.4		65.3		81.4	

SOURCES: BIS Research Hub, the websites of the central banks and the author's calculations.

coefficient in the group (89% and 86%, respectively). The area of international economics predominates in Chile (43%) and macroeconomics and monetary economics, in Canada (38%). The coefficient for the ECB and the Fed-BG was 84%, with more of an emphasis on macroeconomics in the ECB (43%) and on financial economics and quantitative methods in the Fed-BG (28% and 26%, respectively) (table 4).

At the Bundesbank (Central Bank of Germany), 79% of the research agenda was concentrated, with macroeconomics and financial economics being the topics that account for the largest proportion. In Colombia, the coefficient was 65%, and was below the average in the four main categories. The largest proportion was in the area of macroeconomics (25%) and financial economics (18%). The proportion of studies dealing with the labor market and economic history was larger compared to the reference central banks. The variety of topics studied in the Central Bank of Colombia stems from the fact that part of the research done by the institution is regarded as a contribution to the economic debate in Colombia and to the academy.

It is important to mention the extensive output of economic research by the academic community in the more developed economies, as it allows the central banks to target their research efforts on topics of concern to their primary functions (e.g. price and financial system stability). Given the absence of specialized research on the part of the academic community, in emerging economies some central banks have assumed a broader and more active role in economic research.

Additionally, longer-term economic research is useful for policymaking, yielding better outcomes. In this respect, Mester suggests that in the monetary policy arena these would include the recent ideas of rational expectations and time inconsistency, the role of central bank independence, and the implementation of a better strategy of price stability. In the financial stability arena, work on capital requirements, risk-modeling, moral hazard, and prompt corrective action are important in formulating better policy.[11]

---

[11] Annex 2 shows the correlation between inflation with the four indexes calculated above, it shows that an increase in WPs generate a reduction in

4.2. Research organization

The bulk of the central banks organize research in three ways. *i)* The centralized approach: research is concentrated in a department that is responsible for pushing the research agenda forward (e.g. Germany). *ii)* The decentralized approach: several departments or branch offices are involved actively in carrying out the research agenda, and studies on the central bank's primary function take precedence (e.g. USA and Canada). *iii)* The intermediate approach: research is led by a department, which receives support from other areas to conduct a portion of the studies contemplated in the agenda (e.g. the ECB, Chile and Colombia).

In the case of Germany, the central bank has a Research Center comprised of eleven research groups: eight dedicated to monetary policy topics and three to financial stability issues. The research teams are comprised of researchers from the central bank and advisers from German universities and European research centers. Outside consultants and visiting researchers from other central banks (the ECB and the Fed) and multilateral organizations (the WB and the IMF) take part in some of the groups.[12]

The Fed-BG uses a decentralized approach in which research is conducted independently by three divisions: Research and Statistics, Monetary Affairs and International Finance. The last division has become particularly relevant, as it is where the major advanced and emerging economies are monitored, and studies are done on financial markets and developments in banking and international trade.

Using a similar approach, the Bank of Canada conducts its research in four divisions: Research, Financial Markets, the International Division, and Monetary and Financial Analysis. In recent years, the Financial Markets Division has developed in-depth studies on topics such as financial infrastructure, risk management and capital market efficiency and stability. Like the Fed-BG, the International Division analyses economies by regions (USA and Mexico, Asia and Europe), develops

―――――

inflation rate near to 13%.

[12] The framework of Central Bank of Germany Research Center is presented in Annex 3.

models to forecast how international markets will perform, and does research on financial stability, exchange rates and global economic growth.

The ECB uses an intermediate approach where two sections interact to produce research. Theoretical and empirical research relevant to monetary-policy implementation is produced under the coordination of the Studies Department, with support from the Economics Department, which does short-term, practical studies (e.g. forecasts on inflation, growth, etc.) to assist decision-making by the Board of Governors. This area also is responsible for monitoring economic performance in the European Union, including financial, monetary and fiscal developments in the euro area.

At the Central Bank of Chile research is done mostly by the Economic Research Division, which keeps an agenda focused on monetary and financial conditions in the Chilean economy, measurement and analysis of external conditions, the development of general equilibrium models, monetary-policy implementation, price dynamics and real fluctuations. For some of the studies it receives support from the Macroeconomic Analysis Division, which develops monetary-aggregate, financial and real forecast models to assist the Board of Directors. The Division for International Analysis is in charge of international reserve management and financial system stability; it carries out studies on topics dealing with international trade and the global financial environment.

The Central Bank of Colombia uses an approach similar to those employed by the ECB and the Central Bank of Chile. The Research Unit pursues the institution's research agenda, conducting studies on long-term topics that contribute to the economic-policy measures adopted by the Board of Directors. The Unit also supports an agenda on topics that contribute to an economic analysis of the country. The researchers in the Unit rely on the Division of Economic Studies for support to develop joint research projects. This Division prepares forecasts on inflation, growth, balance of payments and other economic variables. It also develops models to design and evaluate monetary and exchange policy, produces statistics on monetary aggregates, foreign exchange and credit, and regularly examines the performance of government finances. The Division of Monetary Affairs is responsible for managing

the country's international reserves and implements the monetary-policy and exchange measures adopted by the Board of Directors. It also does studies on monetary economics, financial system stability and international economics.

Annex 4 shows to the extent to which the researchers in the Research Unit and in other departments contribute to the series of working papers published by the Central Bank of Colombia (*Borradores de Economía*). On average, 53% of the working papers are prepared by researchers from the Research Unit (34 WPs in 2008); the other 47% (32 WPs) are done by other Economic Studies and Monetary Affairs part-time researchers .

The Central Bank of Colombia created the Committee on Monitoring Research to coordinate its research agenda. The Committee's primary function is to organize a decision between the researchers and the Board of Directors on the research topics to be pursued. The Committee defines a central topic of study, around which different research projects are developed. Additionally, there is a long-term research agenda in seven areas: monetary, exchange and credit policy; growth and productivity; consumption-savings-investment; government finance; the labor market; foreign trade and international economics; the financial sector, and economic history.

Regional research plays an important role in the research agenda of the Central Bank of Colombia by providing an insight into the development of national economic activity and making it possible to identify how monetary-policy measures affect the country. There are seven Regional Economic Study Centers, which monitor economic performance in the regions and research current issues. Also, there are two specialized research centers in Cartagena and Medellín that study special topics as input for the regional economic debate and to strengthen local research networks.

4.3. Research strategies

The reference central banks use different strategies to target and improve economic research. For example, the Research Center operated by the Bundesbank implements a strategy widely accepted by the European academic community, owing to integration with researchers from other

institutions, mostly central banks and universities. By targeting the topics on the agenda, it has been possible to develop specialized research and to create a synergy with the Board of Directors that contributes to well-timed and efficient decision-making. The agenda is published every two years for the sake of added transparency and to help socialize the research (Deutsche Bundesbank, 2008).

The strategy used by the Fed-BG has been to support internship programs for students doing doctoral dissertations on topics that deal with macroeconomics, international economics, finance, banking and econometrics. It also has a summer internship program for undergraduates who are majoring in economics and finance.[13]

Using a similar approach, the Central Bank of Canada regularly hires undergraduate and graduate students to serve as research assistants and maintains an active alliance with academic institutions for joint research, consultations, courses and seminars. It also has an academic grant program for university professors to promote studies on monetary economics and macroeconomics.

One of the main research strategies at the ECB is based on research networks with European central banks, universities and a number of research centers with which it carries out programs for visiting researchers and/or professors. In an external evaluation of ECB research activities, Goodfriend et al., (2004) suggest that ECB should hiring more research assistants on a temporary basis. Young MSc graduates or PhD students are ideal for these positions because they are familiar with the latest analytical tools and techniques and are highly motivated to spend some time at the ECB.[14]

Additionally, the authors recommend that the ECB must back its commitment to excellence in economic analysis by providing economists with sufficient time and appropriate incentives to do research. Time planned for research should not be sacrificed to other tasks, even in business areas with

---

[13] The internship programs were started at the St. Louis Fed to advance research on monetary economics and eventually were extended to include the entire Federal Reserve System (Bordo and Schwartz, 2008).

[14] It is possible due the budget flexibility and the independence of central banks, especially in developed economies (Galán and Sarmiento, 2007)

current policy or operational responsibilities. For that reason, they suggest to "strengthen incentives to do research and respect the time allocated to it when accommodating the demands for current policy analysis", specifically: *i)* allocate staff sufficient time to do research that is relevant to their area (outside DG Research), *ii)* increase the weight of research activities and especially journal publications in annual appraisal exercises, and *iii)* facilitate and encourage staff to present their research results to the executive Board and senior management.

On the other hand, the strategy of the Central Bank of Chile is visiting other central banks in the developed economies to conduct joint research projects and to participate in forums and seminars.

The Central Bank of Colombia has adopted several strategies to improve and increase its research. One of the most effective has been its involvement in the Centre for Latin American Monetary Studies (CEMLA) research network, where research topics relevant to monetary policy (e.g. nonobservable variables, pass-through mechanisms, DSGE models) are spearheaded and coordinated for the central bank. As a result, it has been possible to work alongside research teams from the most important central banks in Latin America and to provide advice and assistance to smallest central banks.

Another strategy is to develop research with university professors in the United States as a way to delve into specific topics of special interest to the Board of Directors (e.g. bio-fuels, workers' remittances, export markets, etc.). The associate researcher strategy applied at the internal level consists of a researcher from the Unit Research working in association with another department to conduct studies on specific topics, thereby fostering a synergy of knowledge and more decentralization in research.

5. FINAL THOUGHTS

The international comparison shows the research agenda should be aligned with the core functions of the central banks and, in turn, with the economic conditions in each country. Accordingly, at central banks that supervise the financial

system, the area of financial economics occupies an important part of the research agenda (the Fed-BG and Germany). In the case of Chile, for example, the central bank's ongoing study of international economic behavior is consistent, in part, with the country's many Free Trade Agreements, which require steady analysis of the global economy. In Colombia, the Central Bank has an extensive research agenda that includes the most important topics for decision-making and other, less-explored issues, since academic research in Colombia has yet to be consolidated.

According to the results, the Central Bank of Colombia is in a good position when compared to the evaluated central banks, both in terms of output and demand for its WPs. The productivity index also places it in a good position with respect to the reference central banks, underscoring the large output of studies in recent years. When the WPs are evaluated for relevance, using the PRI, the ranking declines slightly, because the research agenda is less concentrated on the relevant topics compared to the reference banks. As to how research is organized, the strategies adopted by the Central Bank of Colombia in recent years have made it possible to provide the Board of Directors with appropriate, well-timed support, and to take advantage of the institution's independence to conduct research in a number of specialized economic areas, which is considered a public good for the country.

In terms of how research is approached, a tendency among the central banks in the sample to develop research and to exchange ideas with academic institutions was identified. The above mentioned gives central banks an outside perspective and helps them to stay abreast of techniques and theories that can be applied to economic analysis and contribute to better policymaking.

Quality of research is not evaluated directly in this study. However, the implementation of a combination of internal and outside arbitration can contribute to increase the quality of research and help to focus on the most relevant topics; it was the practice employed for central banks ranked in the top of this measurement (e.g. Canada, the ECB and the Fed-BG). Additionally, strategies like those suggested by the ECB may increase the incentives for improving research activities and its quality. Specially, facilitate and encourage staff to present

their research results to the executive Board and senior management; likewise, present it in recognized academic seminars.

Finally, it is important to point out that research in a central bank should be carried out in a stimulating environment with a participatory agenda, but focused on the central bank's primary objectives in a way that helps policymakers to do their job. The research must be appropriate and developed with modern theories and the latest techniques, so its quality is reflected in the effectiveness of the adopted policies.

Annex 1

TABLE A.1. INDEX OF PRODUCTIVITY (IP) AND RELEVANCE (IPR) IN CENTRAL BANKS (2000-2007)

	IP		Var. %	IPR		Var. %
Central banks	*2000*	*2007*	*2000–2007*	*2000*	*2007*	*2000–2007*
ECB	38	100	162.80	50.96	100.00	96.23
Fed–BG	100	48	−52.11	100.00	38.92	−61.08
Finland	42	34	−19.66	40.39	27.97	−30.74
Canada	30	30	0.49	31.57	26.14	−17.22
Germany	13	26	102.56	15.27	21.19	38.75
Chile	34	25	−26.57	41.72	20.76	−50.23
Colombia	33	25	−24.31	34.26	18.77	−45.21
St. Louis–Fed	11	24	118.79	12.80	18.03	40.87
Spain	11	22	88.11	12.10	15.92	31.58
New York–Fed	22	18	−20.32	19.79	14.55	−26.47
Italy	13	22	70.13	15.27	14.20	−7.04
Peru	16	14	−12.46	19.46	13.22	−32.08
The Netherlands	21	16	−26.62	29.77	12.46	−58.15
France	6	14	145.79	5.48	11.91	117.55
Brazil	11	13	12.51	13.28	11.28	−15.09
San Francisco–Fed	24	15	−38.40	28.33	11.03	−61.08
Philadelphia–Fed	13	17	23.04	11.77	9.95	−15.49
Cleveland–Fed	12	13	8.79	15.09	9.64	−36.14
England	19	9	−52.13	20.85	7.81	−62.52
México	10	9	−14.94	10.89	7.40	−32.05
Chicago–Fed	29	12	−59.49	27.39	7.32	−73.28
Kansas City–Fed	14	7	−49.74	12.90	6.93	−46.26
Atlanta–Fed	23	9	−58.80	21.13	6.64	−68.60
Minneapolis–Fed	21	8	−63.37	19.72	6.35	−67.78
Venezuela	5	7	49.70	4.72	5.11	8.26
Boston–Fed	6	8	38.22	7.69	4.71	−38.76
Richmond–Fed	14	6	−60.36	13,.07	4.05	−69.01
Ireland	5	5	10.58	5.86	3.94	−32.75
Dallas–Fed	5	6	7.81	4.53	3.71	−17.90

TABLE A.1 *(continuum)*

	IP		Var. %	IPR		Var. %
Central banks	*2000*	*2007*	*2000–2007*	*2000*	*2007*	*2000–2007*
Austria	3	3	–3.24	4.05	2.22	–45.09
Total	606	562	–7	650	462	–29
Average	20	19	9	22	15	–23
Est. dev.	18	18	63	19	18	47

SOURCE: author's calculations.

Annex 2

TABLE A.2. CORRELATION BETWEEN INFLATION, OUTPUT, DEMAND, IP, AND IPR

Weight	*Inflation*	*Output (WP)*	*Demand (WP)*	*PI (WP)*	*PRI (WP)*
Inflation	1.00	–0.13	–0.19	–0.13	–0.12
Output (WP)		1.00	0.78	0.99	0.97
Demand (WP)			1.00	0.72	0.67
PI (WP)				1.00	0.99
PRI (WP)					1.00

SOURCE: author's calculations.

Annex 3

TABLE A.3. CENTRAL BANK OF GERMANY RESEARCH CENTER

Research group	*Issues*	*JEL classification*[a]	*Members*[b]	*Advisors*[c]	*Visiting researches*[c]
1	Money and monetary policy	E4, E5, Gl	15	3	
2	Monetary policy implementation and payment systems	E5, D4	10		
3	Monetary policy and asset prices	E4, E5	9	7	
4	Corporate finance, household and monetary transmission	D1, D2, E2, G3	4	4	5
5	Fiscal policy interaction with monetary policy, capital markets & the real sector	E6, G1	7	2	
6	The role of frictions in goods, labor and financial markets for business cycles and monetary policy	D5, E2, E3	10	5	
7	Short-term forecasting	C1, C3, C5, E3	5	3	
8	International integration	F2, F3, F4	12	1	

TABLE A.3 *(continuum)*

Research group	Issues	JEL classification[a]	Members[b]	Advisors[c]	Visiting researches[c]
9	Financial stability	G2, G3	15		4
10	Risk modeling and financial markets	G1, G2, G3	7		
11	The financial system: structural issues and its changes	E4, E5, G1, G2	17	1	5
	Total		111	26	14

SOURCES: Deutsche Bundesbank (2008), and author's calculations.
[a] Ranked by subject categories, according to the *Journal of Economic Literature* (JEL): C stands for Mathematical and Quantitative Methods; D for Microeconomics; E for Macroeconomics and Monetary Economics; F for International Economics; and, G for Financial Economics. [b] The groups have a team researcher-coordinator. A researcher can belong to several different groups. [c] Researchers from European universities, OECD, and other central banks (the ECB and the Fed), as well as the World Bank and the IMF.

Annex 4

TABLE A.4. BORRADORES DE ECONOMÍA BY THE CENTRAL BANK OF CO-LOMBIA (1994-2008)

Years	Economic studies & monetary affairs divisions		Research unit		Total WP
	WP	Share %	WP	Share %	
1994	9	64.29	5	35.7	14
1995	15	50.00	15	50.0	30
1996	15	68.18	7	31.8	22
1997	7	43.75	9	56.3	16
1998	10	40.00	15	60.0	25
1999	11	39.29	17	60.7	28
2000	14	48.28	15	51.7	29
2001	6	21.43	22	78.6	28
2002	13	40.63	19	59.4	32
2003	20	43.48	26	56.5	46
2004	15	32.61	31	67.4	46
2005	18	45.00	22	55.0	40
2006	33	47.83	36	52.2	69
2007	22	44.90	27	55.1	49
2008	32	48.48	34	51.5	66
Total	240		300		540
Average	16		20		36

SOURCES: Central Bank of Colombia, author's calculations.

TABLE A.5. CENTRAL BANK WORKING PAPER SERIES

No.	Central bank	Working paper series
1	Banco Central de Chile	Working Papers
2	Banco Central de Reserva del Perú	Working Papers
3	Banco Central de Venezuela	Working Papers
4	Banco Central do Brasil	Working Papers
5	Banco de España	Working Papers, Economic Studies, Economic History Studies
6	Banco de la República (Colombia)	Borradores de Economía
7	Banco de México	Research Papers
8	Bank of Canada	Working Papers, Technical Reports
9	Bank of England	Working Papers
10	Bank of Finland	Working Papers, Studies in Economics and Finance, BOFIT Discussion Papers
11	Banque de France	Working Papers
12	Banca d'Italia	Temi di Discussione, Historical Research Papers
13	Central Bank of Ireland	Research Technical Papers
14	De Nederlandsche Bank	WO Research Memoranda, MEB Series, Research Series Supervision, DNB Staff Reports, DNB Occasional Studies
15	Deutsche Bundesbank	Diskussionspapiere
16	European Central Bank	Working Papers Series, Occasional Paper Series
17	Federal Reserve Bank Board of Governors	Finance and Economic Discussion Series, International Finance Discussion Papers
18	Federal Reserve Bank of Atlanta	Working Papers, Research Reports
19	Federal Reserve Bank of Boston	Working Papers
20	Federal Reserve Bank of Chicago	Working Papers, Consumer and Community Affairs Policy Studies, Emerging Issues Series, Occasional Papers; Emerging Payments
21	Federal Reserve Bank of Cleveland	Working Papers, Policy Discussion Papers
22	Federal Reserve Bank of Dallas	Working Papers, Centre for Latin American Economics (CLAE) Working Papers
23	Federal Reserve Bank of Kansas City	Research Working Papers, Payments System Research Working Papers
24	Federal Reserve Bank of Minneapolis	Working Papers, Discussion Papers, Staff Reports
25	Federal Reserve Bank of New York	Staff Reports
26	Federal Reserve Bank of Philadelphia	Working Papers, Payment Cards Center Discussion Papers
27	Federal Reserve Bank of Richmond	Working Papers
28	Federal Reserve Bank of San Francisco	Working Papers, Pacific Basin Working Papers
29	Federal Reserve Bank of St. Louis	Working Papers
30	Oesterreichische Nationalbank	Working Papers

SOURCES: BIS Research Hub and the websites of the central banks.

REFERENCES

Berk, J. M. (2007), *What Kinds of Research in Central Banks? The Experience of De Netherlandsche Bank,* Mimeo, Workshop Designing Central Banks, Joint Deutsche Bundesbank and Bank of Finland Conference, Eltville am Rhein, November 8-9.

BIS (2008), *Central Bank Research Hub,* Bank for International Settlements. ⟨http://www.bis.org/cbhub/index.htm⟩.

Bordo, M., and A. Schwartz (2008), "Monetary Economic Research at the St. Louis Fed during Ted Balbach's Tenure as Research Director", *Federal Reserve Bank of St. Louis Review,* September/October 2008, Vol. 90, No. 5, pp. 499-504.

Combes, P., and L. Linnemer (2003), "Where are the Economists who Publish?", *Journal of the European Economic Association,* Vol. 1, No. 6, pp. 1250-1308.

Deutsche Bundesbank (2008), *Research Programme 2008/2009,* Deutsche Bundesbank, January.

Eijffinger, S. C .W., J. de Haan, and K. Koedijk (2002), "Small Is Beautiful: Measuring the Research Input and Output of European Central Banks", *European Journal of Political Economy,* Vol. 18, No. 2, pp. 365-74.

Farrell, M. J. (1957), "The Measurement of Productive Efficiency", *Journal of the Royal Statistics Society,* series A, Vol. 120, No. 3, pp. 253-81.

Galán, J., and M. Sarmiento (2007), "Staff, Functions, and Staff Costs at Central Banks: An International Comparison with a Labor-demand Model", *Money Affairs,* Centre for Latin American Monetary Studies (CEMLA), Vol. 20, No. 2, July-December, pp. 131-180.

Galán, J., and M. Sarmiento (2008) "Banknote Printing at Modern Central Banking: Trends, Costs and Efficiency", *Money Affairs,* CEMLA, Vol. 21, No. 2, July-December, pp. 217-62.

García-Castrillo, P., A. Montanes, and F. Sanz-Gracia (2002), "A Worldwide Assessment of Scientific Production in Economics (1992-1997)", *Applied Economics,* Vol. 34, No. 12, August, pp. 1453-75.

Gaspar, V., and J. L. Vega (2002), "Research at a Policy-Making Institution: Launching Research at the ECB", *Swiss Journal of Economics and Statistics,* Vol. 138, No. 4, pp. 359-76.

Goodfriend, M., R, König, and R. Repullo (2004), *External Evaluation of the Economic Research Activities of the European Central Bank,* Mimeo, European Central Bank, February.

Jordeau, E., and H. Pagés (2003), *Benchmarking Research in European Central Banks,* Mimeo, Workshop on Central Bank Efficiency, Sveriges Riksbank, Stockholm, May 23-24.

Kashyap, A., M. Pohjola, and V. Wieland (2009), *External evaluation of the Bank of Finland's research activity,* Bank of Finland, Helsinki ⟨http://www.bof.fi/en/tutkimus/esittely/evaluaatio/index.htm⟩.

Kocher, M., and M. Sutter (2001), "The Institutional Concentration of Authors in Top Journals of Economics during the Last Two Decades", *Economic Journal,* Royal Economic Society, Vol. 111, No. 472, June, pp. 405-21.

Kocher, M., M. Luptácik, and M. Sutter (2006) "Measuring Productivity of Research in Economics: A Cross-Country Study Using DEA", *Socio-Economic Planning Sciences,* Vol. 40, No. 4, December, pp. 314-32.

Kodrzycki, Y. K., and P. Yu (2006), *New Approaches to Ranking Economics Journals,* Federal Reserve Bank of Boston, June (Working Paper, No. 5-12).

Lubrano M., L. Bawens, A. Kirman, and C. Protopopescu (2003), "Ranking Economics Departments in Europe: A Statistical Approach", *Journal of the European Economic Association,* Vol. 1, No. 6, pp. 1367-401.

Mester, L. (2007), *What Kinds of Research Should Central Banks Do?,* Mimeo, Workshop Designing Central Banks, Joint Deutsche Bundesbank and Bank of Finland Conference, Eltville am Rhein, November 8-9.

Neary, P., J. Mirrlees, and J. Tirole (2003), "Evaluating Economics Research in Europe: AN Introduction", *Journal of the European Economic Association,* Vol. 1, No. 6, December, pp. 1239-49.

Ochoa, M., and K. Schmidt-Hebbel (2006), *El Banco Central de Chile en Comparación con los Bancos Centrales del Mundo,* Banco Central de Chile, June (Working Paper, No. 367).

Skreb, M. (2005), "Do All Central Banks Need a Well-developed Brain?", in Neil Courtis & Peter Nicholl (eds.), *Central Bank Modernisation,* Central Banking Publications Ltd, London.

St-Amant, P., G. Tkacz, A. Guérard-Langlois, and L. Morel
    (2005), *Quantity, Quality and Relevance: Central Bank Re-
    search, 1990-2003,* Bank of Canada (Working Paper, No.
    2005-37).
Wall, H. (2009), *Journal Rankings in Economics: Handle with
    Care,* Federal Reserve Bank of St. Louis, St. Louis (Working
    Paper Series, No. 14).

Index 2010

MEMBERS OF CEMLA

ASSOCIATES

Banco Central de la República Argentina
Centrale Bank van Aruba
Central Bank of the Bahamas
Central Bank of Barbados
Central Bank of Belize
Banco Central de Bolivia
Banco Central do Brasil
Eastern Caribbean Central Bank
Cayman Islands Monetary Authority
Banco Central de Chile
Banco de la República (Colombia)
Banco Central de Costa Rica
Banco Central de Cuba
Centrale Bank van Curaçao en Sint Maarten
Banco Central del Ecuador

Banco Central de Reserva de El Salvador
Banco de Guatemala
Bank of Guyana
Banque de la République d'Haïti
Banco Central de Honduras
Bank of Jamaica
Banco de México
Banco Central de Nicaragua
Banco Central del Paraguay
Banco Central de Reserva del Perú
Banco Central de la República Dominicana
Centrale Bank van Suriname
Central Bank of Trinidad and Tobago
Banco Central del Uruguay
Banco Central de Venezuela

COLLABORATORS

Central Banks

Deutsche Bundesbank (Alemania)
Bank of Canada
Banco de España
Federal Reserve System (Estados Unidos)
Banque de France

Banca d'Italia
De Nederlandsche Bank (Países Bajos)
Bangko Sentral ng Pilipinas
Banco de Portugal
European Central Bank

Other Institutions

Superintendencia de Bancos y Seguros
  (Ecuador)
Superintendencia del Sistema Financiero
  (El Salvador)
Superintendencia de Bancos
  (Guatemala)
Comisión Nacional de Bancos y Seguros
  (Honduras)
Superintendencia de Bancos (Panamá)

Superintendencia de Bancos (República
  Dominicana)
Banco Centroamericano de Integración
  Económica
Deutscher Genossenschafts– und Raiffei-
  senverband e. V. (Confederación Ale-
  mana de Cooperativas)
Fondo Latinoamericano de Reservas
Foreign Trade Bank of Latin America, Inc.

www.cemla.org