

# Does Monetary Policy Transparency Aid Technological Knowledge?

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CRETE - Milos, July 10-14, 2024

# Motivation

Technological knowledge is the major driver of economic growth (Romer, 1986, 1990; Grossman and Helpman, 1991).

- An important input in the creation of technological knowledge is Research and Development (R&D).
  - R&D investment is highly idiosyncratic, sensitive to cash flow shocks; financial market volatility and economic instability could be detrimental for a firm's (country's) knowledge capital
- Central bank, as a shaper of markets expectations, plays an important role of economic outcomes
  - via charting the future path of important fundamentals - transparency is vital in this respect
- Ongoing debate about the effect of transparency on economic and financial variables (interest rate, inflation, money markets).

Yet, there is no evidence of the role of transparency on innovation.

# What is Central Bank (or Monetary) Transparency?

There is no precise definition of central bank transparency.

- "[...] A central bank is transparent if its actions are "easily detected", its policies are "easily understood" and its pronouncements are "free from deceit".  
In brief, the central bank should be open, intelligent and honest" (Blinder, 2002, p.3) [▶ here](#)
- Dincer et al. (2022) CBT index: information about central bank's intentions, targets, policies and future actions [▶ here](#)

## Central Bank Transparency: Pros & Cons

The role of central bank (or monetary) transparency has been debatable in the literature. In principle:

- Transparency improves the predictability and credibility of monetary policy (Faust and Svensson, 2001, Dincer and Eichengreen, 2014).
  - more information reduces asymmetric information and mitigates agents' uncertainty
- The provision of costless public information distracts market participants from their private information and possibly away from fundamentals (Morris and Shin, 2005; Demertzis and Hallett, 2007; Kool et al., 2011)
  - markets invest less in private info placing great weight on public information (crowding out of private information) & tend to overreact to the public signal

# Purpose

We examine the effect of central bank transparency on a country's innovation input (proxied by R&D) and output (proxied by patents)

We address three key questions:

- How important is central bank transparency in shaping innovation activity? Is there any optimality issue?
- Is there any (dis)similarity of behaviors between developed and developing economies?
- What type of central bank transparency is more conducive to innovation?

## Methodological Framework: Production of Innovation

New technological knowledge, ideas, are generated in the R&D sector (Romer, 1990). Then,  $\dot{A}$  represents the flow of new technological knowledge generated in the economy at a point in time. New knowledge is produced by researchers,  $L_A$ , according to the following production function:

$$\dot{A} = \tilde{\delta} L_A \quad (1)$$

where  $\tilde{\delta}$  denotes (average) research productivity and is modeled as a function of the existing stock of knowledge ( $A$ ) and the number of researchers ( $L_A$ ) according to:

$$\tilde{\delta} = \delta A^\phi L_A^{\lambda-1} \quad (2)$$

where,

- $\delta > 0$ ,  $\phi$  is the returns to scale in knowledge,
- $\lambda$  is duplication parameter.

## Production of Innovation (cond.)

Taken together, equations (1) and (2) suggest the following technological knowledge production function:

$$\dot{A} = \delta A^\phi L_A^\lambda \quad (3)$$

Dividing by the stock of knowledge,  $A$ , and by taking logs, equation (3) yields:

$$\ln\left(\frac{\dot{A}}{A}\right) = (\phi - 1)\ln(A) + \lambda\ln(L_A) \quad (4)$$

The growth rate of a country's innovation output,  $\ln\left(\frac{\dot{A}}{A}\right)$ , could be proxied by the annual change of the (log) number of patent applications in the country.

## Patents Specification

Taking these into consideration, the resulting final estimating model adopts the following form:

$$\Delta \ln \text{Patents}_{i,t} = \theta \ln \text{Patents}_{i,t-1} + \lambda \ln(\text{R\&D}/\text{Q})_{i,t} + \zeta_i + \phi_t + \epsilon_{i,t} \quad (5)$$

where,

- $\Delta \ln \text{Patents}_{i,t}$  is the logarithmic transformation of the annual growth of patent applications;
- $\text{R\&D}/\text{Q}$  represents private sector R&D expenditure over product variety (Q), which is proxied by the size of the economy's output (GDP) and also captures the capacity of firms to 'absorb' innovation generated elsewhere;
- $\zeta_i$ ,  $\phi_t$ , and  $\epsilon_{i,t}$ , are country fixed effects, time fixed effects, and the white noise error term, respectively.

## R&D Specification

We model R&D investment as a function of central bank transparency (CBT) and a vector of controls,  $Z$ , (Rodriguez-Pose, 1999) as follows:

$$(\text{R\&D}/\text{Q})_{i,t} = \beta_i + \beta_1 \text{CBT}_{i,t-1} + \beta_2 \text{CBT}_{i,t-1}^2 + \beta_3 Z_{i,t-1} + \alpha_i + \delta_t + \eta_{i,t} \quad (6)$$

where,

- CBT is index of central bank transparency;
- $Z$  is a set of socio-economic variables that describe the conditions which determine the rhythm at which a society adopts innovation and transforms it into real economic activity;
- $\alpha_i$ ,  $\delta_t$ , and  $\eta_{i,t}$ , are country fixed effects, time fixed effects, and the white noise error term, respectively.

## Moderators

To reveal potentially differential responses of R&D to greater central bank transparency, we introduce moderator variables.

- Degree of financial sophistication, proxied by the level of financial development (Ma and Lin, 2016).
- Trust in Institutions (Zak and Knack, 2001), proxied by the control of corruption, as corruption is the ultimate betrayal of public trust (Hakhverdian and Mayne, 2012)

Both, moderators enter into the equation (6) as controls and are also interacted with  $CBT_{t-1}$  and  $CBT_{t-1}^2$ .

## Estimation Strategy

There are two challenges that we need to confront:

- First, the cross sectional dependence in panel regressions caused by the presence of common factors, spacial and spillover effects, which are unobserved, resulting in inefficient estimates (De Hoyos and Sarafidis, 2006).
  - We correct for cross sectional dependence using Driscoll and Kraay (1998) robust standard errors.
- Second, to address the causal effects of central bank transparency on innovation we use:
  - country and time fixed effects, as several unobserved country characteristics might be correlated with both central bank transparency and innovation performance.
  - A two-step instrumental variable (IV) (for R&D equation 6) and GMM estimation (for patent equation 5) using appropriate instruments.

# Descriptive Statistics

Table: Sample of 44 countries, 1999-2019

[▶ here](#) [▶ here](#)

variables	Observations	Mean	St. Dev.	Min	Max
Patents	946	43,666	141,914	3	1,542,002
R&D/GDP	942	1.57	1.03	0.04	5.14
CBT	968	8.95	2.88	1.5	14.5
CBTpolitical	968	2.62	0.60	1	3
CBTeconomic	968	1.65	0.92	0	3
CBTprocedural	968	1.32	0.70	0	3
CBTpolicy	968	1.62	0.96	0	3
CBToperational	968	1.75	0.58	0	3
Unemployment	952	7.78	4.99	1.87	33.29
AgricultureShare	968	8.97	9.53	0.03	51.03
HDI	968	0.83	0.09	0.57	0.96
FD	968	0.58	0.21	0.11	1.00
Institutions	968	0.87	1.05	-1.27	2.47
FDInflows	968	6.32	18.58	-40.33	280.13
Trade	968	91.54	68.29	16.44	442.62

Source: World Bank, World Development Indicators (WDI) & Worldwide Governance Indicators; Dincer et al. (2022); IMF.

# 1. Does Monetary Policy Transparency Matter for Innovation?

**Table:** Monetary Policy Transparency and Innovation Estimates

PANEL A	Estimates of eq. (6): Innovation Input (dep. var.: R&D <sub>t</sub> )							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CBT <sub>t-1</sub>	-0.024*** [0.008]	-0.088*	-0.288***	-0.175***				
CBT <sub>t-1</sub> <sup>2</sup>		0.004	0.013***	0.010***				
FD <sub>t-1</sub>	-0.003 [0.246]	-0.021 [0.244]	-2.255*** [0.635]	-0.152 [0.230]				
Institutions <sub>t-1</sub>	0.225*** [0.055]	0.230*** [0.053]	0.219*** [0.055]	-0.241** [0.109]				
CBT <sub>t-1</sub> * FD <sub>t-1</sub>			0.477*** [0.134]					
CBT <sub>t-1</sub> <sup>2</sup> * FD <sub>t-1</sub>			-0.023*** [0.007]					
CBT <sub>t-1</sub> * Institutions <sub>t-1</sub>							0.141*** [0.020]	
CBT <sub>t-1</sub> <sup>2</sup> * Institutions <sub>t-1</sub>							-0.009*** [0.001]	

# Does Monetary Policy Transparency Matter for Innovation? (cond.)

PANEL B		Estimates of eq. (5): Innovation Output (dep. var.: $\Delta \ln \text{Patents}_t$ )							
$\ln \text{Patents}_{t-1}$		-0.121***		-0.112***		-0.104***		-0.103***	
		[0.037]		[0.037]		[0.036]		[0.036]	
$\ln(\text{R\&D}/\text{GDP})_t$		0.531***		0.330**		0.074		0.113	
		[0.135]		[0.154]		[0.076]		[0.149]	
Observations	892	878	892	878	892	878	892	878	
Number of countries	44	44	44	44	44	44	44	44	
Within R-squared	0.31	0.09	0.31	0.08	0.33	0.08	0.35	0.08	
Year effects	Y	Y	Y	Y	Y	Y	Y	Y	
Country effects	Y	Y	Y	Y	Y	Y	Y	Y	
Summary Effects of CBT									
CBT (local) max					8.39		6.57		
CBT (local) min					12.38		8.70		

Note: Dependent variable in columns (1), (3), (5) and (7) is R&D/GDP, while in columns (2), (4), (6) and (8) is  $\Delta \ln \text{Patents}$ ; Controls (Z), omitted for brevity, include Unemployment is a ratio (unemployed to labor force); AgricultureShare, HDI, FD; Institutions refer to control of corruption; FDIinflows and Trade; (\*), (\*\*), (\*\*\*) are significance levels at the 10%, 5% and 1%, respectively. We use the CD test of Pesaran (2021) for cross sectional dependence, for which we reject the  $H_0$  (no cross sectional dependence) and correct the standard errors by following Driscoll et al.(1998) in all specifications.

## The impact of Moderators

$$(R\&D/Q)_{i,t} = \beta_i + \beta_1 CBT_{i,t-1} * M_{t-1} + \beta_2 CBT_{i,t-1}^2 * M_{t-1} + \beta_3 Z_{i,t-1} + \alpha_i + \delta_t + \eta_{i,t}$$

The effect of moderator, M on the transparency - innovation relation equals to R&D first-order derivative w.r.t. CBT, which set to zero.

$$CBT^* = \frac{\gamma_2 * M + \gamma_1}{-2 * (\gamma_4 * M + \gamma_3)}$$

When moderator (M) is Financial Development:

- $FD > 0.6$  (out of 1), the effect is positive till transparency score becomes 8.39 (max); for any higher value the effect turns negative. For  $FD < 0.6$  the effect is negative till transparency score becomes 12.38 (min); beyond is has positive effects on innovation.

When moderator (M) is Trust:

- $trust > 1.24$  (out of 2.45), the effect is positive till transparency score becomes 6.57 (max); above that value, effect turns negative. For  $trust < 1.24$  the effect is negative till transparency score becomes 8.70 (min); beyond is has positive effects on innovation.

## In Words....

We find that central bank transparency has an effect on R&D (and not on Patents) which varies depending on a country's level of financial development and trust in institutions.

- In high financially sophisticated and trust environments: there is no need for abundant information for investors to react timely in spotting investment opportunities and undertaking risky projects. In contrast, if too much public information is released, uncertainty dissipates as well as investment opportunities as monopoly rents are lower.
- In low financial sophistication and trust environments: takes a significant amount of disclosure to ease financial concerns and incompetencies and clear the air of mistrust for firms to take the risk and invest in R&D.

# Robustness

- 1 Keep only the 12 Euro area countries (with common central bank) of our sample and make use of 'Trust in the European Central Bank' by Eurobarometer. [▶ here](#).
- 2 Exclude the 12 Euro area countries (with common central bank) of our sample. [▶ here](#)
- 3 Use variants of financial sophistication: Financial institutions (FI), Financial Markets (FM) by IMF as well as public's Financial Literacy
- 4 Include an IMF-index of financial stress
- 5 Account for R&D credits - tax benefits on innovative firms, either SMEs or large firms (OECD data)

Results remain unaltered.

## 2. Is there any (Dis)Similarity of Behaviors Between Developed and Developing Countries?

Table: Monetary Transparency and Innovation: Developed vs. Developing

	Developed		Developing	
	(dep. var.: $R\&D_t$ ; eq.(6))			
$CBT_{t-1}$	0.161**		-0.199***	
	[0.076]		[0.046]	
$CBT_{t-1}^2$	-0.008**		0.011***	
	[0.003]		[0.003]	
PANEL B	(dep. var.: $\Delta \ln Patents_t$ ; eq.(5))			
$\ln Patents_{t-1}$		-0.101**		-0.104**
		[0.039]		[0.048]
$\ln(R\&D/GDP)_t$		0.300		0.018
		[0.234]		[0.026]
Observations	587	564	305	310
Number of countries	28	28	16	16
Within R-squared	0.34	0.08	0.44	0.13
Country effect	Y	Y	Y	Y
Year effects	Y	Y	Y	Y
	Summary Effects of CBT			
	(max)		(min)	
CBT optimum	9.76		9.09	
ex-ante (average effect)	0.03		-0.08	
ex-post (average effect)	-0.02		0.03	

## In Words....

Dissimilar optimality patterns: a robust inverse U-shaped effect of transparency on R&D for developed countries and a U-shaped effect for the developing countries.

- Developed: Increased central bank transparency is welcomed where initially this information is converted into higher R&D investment; yet, the releasing of too much information may distract the market or reduces opportunities
- Developing: change from ‘confidential’ to ‘open’ attempts could be puzzling for the market participants; skepticism gradually decays at the very increased levels of monetary policy transparency, which turns beneficial for innovation.

Note: The roots of dissimilarity could be traced to institutional problems: like loopholes in regulations (Wang and Sun, 2019) supervision deficiencies (Mertzanis, 2020), political interference (Binder, 2021) and corruption (Sami et al., 2020) that ignite a sentiment of distrust in central bank information releasing.

# Robustness: Accounting for Endogeneity

Table: Robustness: IV Estimates (for the R&D eq. (6))

	Developed		Developing	
$CBT_{t-1}$	0.199**		-0.219***	
	[0.085]		[0.059]	
$CBT_{t-1}^2$	-0.012***		0.013***	
	[0.004]		[0.004]	
Observations	519	462	287	266
Number of countries	26	26	16	16
Within R-squared	0.36	0.10	0.42	0.08
Year effects	Y	Y	Y	Y
Country effects	Y	Y	Y	Y
Hansen J-test		0.65		0.42
K-P rk Wald		234.28		212.99
Durbin-Wu-Hausman		0.42		0.30
K-P rk LM F-statistic		0.00		0.00
Arellano-Bond AR-1		0.31		0.19
Arellano-Bond AR-2		0.67		0.27
Arellano-Bond AR-3		0.78		0.27
CBT max	8.00			
CBT min			8.35	

### 3. What Aspect of Monetary Policy Transparency Matters Most for Innovation?

Table: Monetary Policy Transparency and Innovation Estimates

	Estimates of eq. (6): Innovation Input (dep. var.: R&D <sub>t</sub> )									
	Developed					Developing				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CBT <sub>t-1</sub>	0.112 [0.145]	0.367** [0.153]	0.112 [0.075]	0.248 [0.184]	0.941*** [0.135]	-0.756* [0.433]	-0.029 [0.050]	-0.380*** [0.070]	-0.125* [0.060]	-0.160* [0.079]
CBT <sub>t-1</sub> <sup>2</sup>	-0.022 [0.044]	-0.128*** [0.042]	-0.054*** [0.017]	-0.074 [0.055]	-0.212*** [0.030]	0.119 [0.106]	0.021 [0.023]	0.116*** [0.018]	0.034 [0.035]	0.035 [0.030]
CBT optimum	1.45		2.22			1.64				

Note: Columns (1) to (5) report estimates for developed countries while columns (6) to (10) for developing. Dependent variable is R&D/GDP; Central bank transparency index (CBT) is political, economic, procedural, policy and operational aspect in columns (1)- (5) and (6)-(10); (\*), (\*\*), (\*\*\*) are significance levels at the 10%, 5% and 1%, respectively. We use the CD test of Pesaran (2021) for cross sectional dependence, for which we reject the H<sub>0</sub> (no cross sectional dependence) and correct the standard errors by following Driscoll et al.(1998) in all specifications.

## In Words....

Among the different aspects of central bank transparency, the type that is important for R&D is substantially different between developed and developing countries:

- Developed countries should focus on economic and operational transparency.
- Developing countries should pay attention to procedural transparency, as this seems to be the only type of transparency able to turn the effect of central bank transparency to a positive outcome on R&D innovation.

▶ [here](#)

# Conclusion

- ① Does central bank transparency shape innovation activity?
  - Yes it does.
    - The effects strongly depend on financial market sophistication which act as moderators. Central bank does not need to disclose information for increases in R&D in high financially sophisticated and trusted environments. The opposite holds for low sophistication, low in trust environments.
    - Optimality issue: Inverse U-shape pattern for developed countries and a U-shape for the developing ones
- ② Do particular aspects of transparency matter for innovation?
  - Yes, they do.
    - For developed economies: the economic and mainly the operational aspect of central bank transparency
    - For developing economies: the greater the openness about central bank's procedures the more beneficial for the R&D.

## Policy Relevance

The main takeaway of our research is that rather than developing new metrics of clarity and trust or aiming at providing too much information, it pays off for a central bank to take care of:

- its reputation in terms of trustworthiness (via increasing for example the level of her commitment to deliverables), and
- support the enhancement of the sophistication of the financial sector.

Both attributes make monetary policy more efficient as with little information real outcomes, such as higher innovation, are achieved.

## Standards of Central Bank Transparency

The four transparency standards that a truly modern central bank should meet, according to Blinder (2002) are:

- "Clarity" (or articulating views in explicit and intelligible words and sentences)
- "Substantive content"
- "Open to public scrutiny"
- central bank businesses must be "contacted in the sunshine"

[◀ back to Central Bank Transparency](#)

# Dincer, Eichengreen and Geraats (2022) Index

They construct an index of monetary policy transparency from 1998 to 2019 for 112 central banks and for nearly 150 countries.

An attractive feature of this dataset is that the transparency index can be decomposed into five aspects:

- **Political:** considers openness about monetary policy objectives, including (1) a formal statement and prioritization of the objectives; (2) a quantification of the main objectives; and (3) explicit institutional arrangements, such as instrument independence
- **Economic:** focuses on the economic information used in monetary policymaking, including (1) key macroeconomic and financial variables; (2) the macroeconomic model(s) used by the central bank for its monetary policy analysis; and (3) numerical macroeconomic forecasts by the central bank.
- **Procedural:** concerns the way in which monetary policy decisions are reached, including (1) an explicit monetary policy strategy; (2) a comprehensive, timely account of monetary policy deliberations; and (3) the voting record for monetary policy decisions.
- **Policy:** refers to the prompt disclosure of monetary policy decisions, including (1) prompt announcement of adjustments in the main monetary operating instrument or target; (2) explanation of monetary policy decisions; and (3) explicit policy inclination or forward policy guidance.
- **Operational:** captures the implementation of monetary policy actions, including (1) an evaluation of the achievement of the main monetary policy operating targets; (2) shocks affecting the transmission of monetary policy; and (3) an evaluation of monetary policy outcomes.

# List of Countries

Table: List of Countries

Australia	Finland	Korea	Russian Fed.
Austria	France	Latvia	Saudi Arabia
Belgium	Germany	Malaysia	Singapore
Brazil	Greece	Mexico	South Africa
Bulgaria	Hong Kong	Moldova	Spain
Canada	Hungary	Netherlands	Sweden
China	Iceland	New Zealand	Switzerland
Colombia	Iran	Norway	Tunisia
Cyprus	Israel	Philippines	Ukraine
Czech Rep.	Italy	Poland	United Kingdom
Denmark	Japan	Portugal	United States

Sample of 44 economies: 28 developed and 16 developing [◀ back to Data](#)

# Descriptive Statistics by Group (Developed & Developing)

Table: Descriptive Statistics: Developed & Developing

	Developed Countries (28)			Developing Countries (16)			Differences	
	(Obs)	(Mean)	(Std. Dev.)	(Obs)	(Mean)	(Std. Dev.)	(Mean)	(p-value)
Patents	599	44,947	4,593	347	41,455	9,776	3,492	0.72
R&D	616	2.02	0.98	347	0.72	0.42	1.27	0.00
CBT	616	10.23	1.97	352	6.70	2.85	3.53	0.00
CBT <sub>political</sub>	616	2.76	0.02	352	2.37	0.04	0.39	0.00
CBT <sub>economic</sub>	616	2.08	0.03	352	0.89	0.04	1.19	0.00
CBT <sub>procedural</sub>	616	1.45	0.03	352	1.10	0.04	0.35	0.00
CBT <sub>policy</sub>	616	2.01	0.03	352	0.93	0.05	1.08	0.00
CBT <sub>operational</sub>	616	1.94	0.02	352	1.41	0.03	0.52	0.00
FD	616	0.69	0.16	352	0.39	0.14	0.30	0.00
Institutions	616	1.51	0.69	352	-0.24	0.48	1.75	0.00
Unemployment	615	7.01	3.97	337	9.18	6.22	2.17	0.00
AgricultureShare	616	4.22	3.38	352	17.29	11.01	13.07	0.00
HDI	616	0.89	0.04	352	0.74	0.06	0.15	0.00
FDI <sub>inflows</sub>	616	7.85	22.60	352	3.65	6.68	4.19	0.00
Trade	616	98.33	78.82	352	79.66	41.68	18.67	0.00

## Within Group: Gains and Losses from Higher Transparency

Average CBT score of developed economies is  $10.23 >$  the optimum (max) value (9.76). Increased transparency could result in:

- losses for some countries - especially for Sweden (CBT=13.43) by 0.06%
- gains for some others - asian mainly, e.g., Hong Kong (CBT=7.25) and Singapore (CBT=7.34) by 0.04%

Average CBT score of developing economies is  $6.70 <$  the optimum (min) value of 9.09. Increased transparency could result in:

- losses for some countries - especially for China (CBT=2.2) by 0.15%
- gains for some others - particularly Hungary (CBT=10.45) by 0.03%

# Trust in the European Central Bank (ECB)

**Table:** Monetary Policy Transparency and Innovation Estimates (Eurozone)

Estimates of eq. (6): Innovation Input (dep. var.: R&D <sub>t</sub> )	
CBT <sub>t-1</sub>	0.518** [0.255]
CBT <sub>t-1</sub> <sup>2</sup>	-0.010 [0.010]
CBT <sub>t-1</sub> * Trust <sub>t-1</sub>	0.320*** [0.117]
CBT <sub>t-1</sub> <sup>2</sup> * Trust <sub>t-1</sub>	-0.033 [0.009]
Observations	230
Number of countries	0.54
Year effects	Y
Country effects	Y

[◀ back to Robustness](#)

# Excluding Eurozone Countries

**Table:** Monetary Policy Transparency and Innovation Estimates w/o Eurozone

PANEL A	Estimates of eq. (6): Innovation Input (dep. var.: R&D <sub>t</sub> )							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CBT <sub>t-1</sub>	-0.018** [0.007]		-0.093** [0.043]		-0.350*** [0.068]		-0.175*** [0.042]	
CBT <sub>t-1</sub> <sup>2</sup>			0.004* [0.002]		0.016*** [0.004]		0.010*** [0.002]	
FD <sub>t-1</sub>	0.649** [0.267]		0.600** [0.259]		2.093*** [0.570]		0.476* [0.248]	
Institutions <sub>t-1</sub>	0.312*** [0.064]		0.316*** [0.060]		0.293*** [0.062]		-0.225* [0.111]	
CBT <sub>t-1</sub> * FD <sub>t-1</sub>					0.604*** [0.157]			
CBT <sub>t-1</sub> <sup>2</sup> * FD <sub>t-1</sub>					-0.029*** [0.009]			
CBT <sub>t-1</sub> * Institutions <sub>t-1</sub>							0.155*** [0.023]	
CBT <sub>t-1</sub> <sup>2</sup> * Institutions <sub>t-1</sub>							-0.009***	