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Risk Efficiency in Indian Commercial Banks

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Abstract: *This study proposes data envelopment analysis models to identify and asses risk in Indian commercial banks. Risk is believed to surface due to external and internal factors, where the former cannot be controlled and the later can be controlled by the bank management. We assume that non performing assets (NPA) arise due to endogenous and exogenous risk. 63 commercial banks comprising public, private and foreign sectors exposed to common frontier production function are considered for performance evaluation. Due to exogenous risk inefficiency more inputs are lost in public sector than private and foreign sectors. More inputs are freely disposed off in private sector than public and foreign sector due to endogenous risk inefficiency. Private sector banks operate more distantly from optimal scale than the public and foreign sector banks.*

Keywords: *Data Envelopment Analysis, Endogenous Risk, Exogenous Risk, Technical Efficiency, Scale Efficiency, Commercial Bank.*

I. Introduction

Due to globalization several foreign banks started to operate on Indian soil. The changes that are taking place world wide continued to give shocks to the banking system which resulted in an expansion of banking services both in range, volume and non-performing assets.

Measuring Commercial banks' efficiency is an important task to bank management and the policy maker. Before we contemplate to measure efficiency 'commercial bank' has to be modeled suitably to meet the objectives of the analyst.

A commercial can be modeled following two approaches, the intermediation and production approach. Under the intermediation approach financial institutions are viewed to intermediate funds between depositors and borrowers (Piyu, Y., 1992). In production approach a commercial bank's resources produce services to the customers (Berg et.al, 1991; Berg et.al. 1993; Parson et.al, 1993; Shaffnit et.al, 1997). The basic difference between the two approaches is that in production approach deposits are treated as output, where as they are viewed as an input in intermediation approach.

Variables similar to Non-Performing Assets (NPAs) were used in commercial bank efficiency measurement by Brocket et.al (1997), Pastor J.M (1999) and Sueyoshi (2001). In the context of Indian Commercial Banks' performance measurement adequate representation is not given to risk as measured by NPAs (Bhattacharya et.al, 1996; Asish Saha, T.S.Ravisankar 2000).

II. Data

Performance of banks and bank branches was studied by a number of analysts, but unfortunately there is no general agreement of choice of technology in terms of inputs and outputs.(Bhattacharya et.al, 1996; Parson et.al, 1993; Hevary Tulkers 1993; Berger et.al, 1993; English et.al,1993; Chaffai 1997; Brocket et.al 1997; De Yong Reber 1997; Mester Loreta 1997; Humphrey David 1993; Berg et.al, 1991; Kumbhakar et.al, 1998). The present study models a commercial bank in production approach perspective. The study accommodates non-performing assets as an input.

For the inputs we use (1) Number of employees (2) Fixed Assets and (3) Non-Performing Assets. Outputs are (1) Deposits (2) Loans and Advances (3) Investments and (4) Non- interest income. The data are secondary arise from the balance sheets submitted to the Reserve Bank of India for the period 2006- 2007 by the commercial banks. To assess efficiency of Indian comeercial banks Data Envelopment Analysis (DEA) models are used as chief tools. Adding too many inputs and outputs to DEA list of variables in the presence of too small a number of Decision Making Units (DMUs) leads to loss of discriminatory power of DEA, since in this case a large proportion of DMUs will surface with 100% efficiency score (Hughs and Yaisawarng, 2004). Thus, an analyst shall be objective oriented and parsimonious while inputs and outputs are listed to confront with DEA. The present study considers 63 Public, Private and Foreign sector banks.

III. Data Envelopment Analysis (Dea) Models:

Four linear programming problems are used to decompose overall technical efficiency multiplicatively into its sources, viz., Exogenous Risk, Endogenous Risk, Scale and Pure Technical Efficiency.

$$Z(CCR,\ u_0) = \text{Min}\left\{\lambda : \sum_{j=1}^{n}\lambda_j x_{ij} \le \lambda x_{i0};\ \sum_{j=1}^{n}\lambda_j u_{rj} \ge u_{r0};\ \lambda_j \ge 0,\ i = 1,2,\ldots,m;\ r = 1,2,\ldots,s\right\}$$

$$Z(BM, CCR, u_0, u_{b0}) = \text{Min}\left\{\begin{array}{r}\lambda : \sum_{j=1}^{n}\lambda_j x_{ij} \le \lambda x_{i0};\ \sum_{j=1}^{n}\lambda_j u_{rj} \ge u_{r0};\ \sum_{j=1}^{n}\lambda_j u_{bj} \le u_{b0};\ \lambda_j \ge 0 \\ i = 1,2,\ldots,m;\ r = 1,2,\ldots,s\end{array}\right\}$$

$$Z(BM, CCR, u_0) = \text{Min}\left\{\begin{array}{r}\lambda : \sum_{j=1}^{n}\lambda_j x_{ij} \le \lambda x_{i0};\ \sum_{j=1}^{n}\lambda_j u_{rj} \ge u_{r0};\ \sum_{j=1}^{n}\lambda_j u_{bj} \le \lambda\, u_{b0};\ \lambda_j \ge 0 \\ i = 1,2,\ldots,m;\ r = 1,2,\ldots,s\end{array}\right\}$$

$$Z(BM, BCC, u_0) = \text{Min}\left\{\begin{array}{r}\lambda : \sum_{j=1}^{n}\lambda_j x_{ij} \le \lambda x_{i0};\ \sum_{j=1}^{n}\lambda_j u_{rj} \ge u_{r0};\ \sum_{j=1}^{n}\lambda_j u_{bj} \le \lambda\, u_{b0};\ \sum\lambda_j = 1 \\ \lambda_j \ge 0;\ i = 1,2,\ldots,m;\ r = 1,2,\ldots,s\end{array}\right\}$$

$Z(CCR,\ u_0)$ is the traditional DEA model of Charnes, Cooper and Rhodes which assumes that outputs are exogenous and inputs are endogenous and it seeks to find potential inputs required to produce u_0, with input mix given no importance, which means that there is no change of technique. This is overall measure of technical efficiency. The constraint of NPAs ($= u_b$) is ignored while it is computed.

Measurement of Risk Efficiency:

The commercial banks are governed by risk environment which vary from one bank to another. This paper refers to credit risk and non-performing assets are assumed to proxy credit risk. $Z(BM, u_0, u_{b0})$ is the Banker and Morey (BM, 1986) model whose solution space is more restricted since we have augmented an extra constraint representing risk environment to the constraints of $Z(CCR,\ u_0)$. We obtain the inequality,

$$Z(CCR,\ u_0) \le Z(BM, u_0, u_{b0})$$

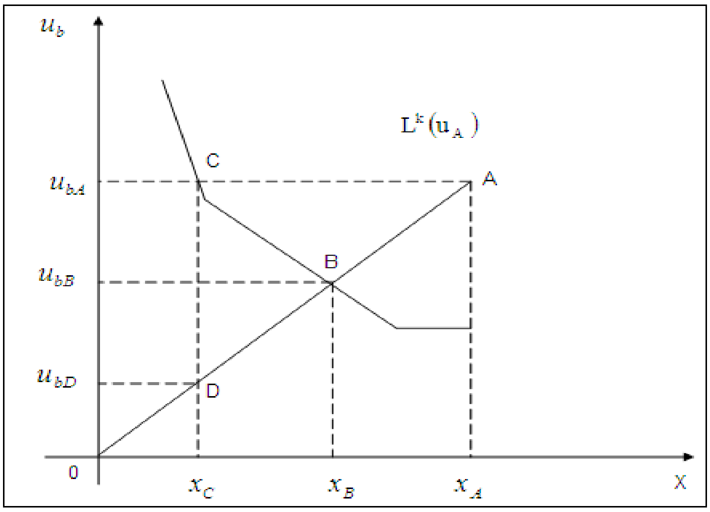

Figure: Exogenous and Endogenous Risk

In the above figure input 'x' and NPAs ($= u_b$) are measured along vertical axis. $L^k(u_0)$ is the input level set consisting of all inputs capable of producing output u_A. If output is exogenous, input and NPAs are endogenous, we have

$$x_B = Z(BM, CCR, u_A)\, x_A$$

However, if output and NPAs are exogenous,

$$x_C = Z(BM, u_A, u_{bA})\, x_B$$

The ratio $\left(OD/OB\right)$ measures endogenous risk efficiency.

$$\frac{OD}{OB} = \frac{Z(BM, u_A, u_{bA})}{Z(BM, CCR, u_A)}$$

Following Fare et.al (2004), the left hand ratio in the following can be recognized as the measure of overall risk efficiency.

$$\underbrace{\frac{Z(CCR, u_A)}{Z(BM, CCR, u_A)}}_{\text{Overall Risk Efficiency}} = \underbrace{\left[\frac{Z(CCR, u_A)}{Z(BM, u_A, u_{bA})}\right]}_{\text{Exogenous Risk Efficiency}} \underbrace{\left[\frac{Z(BM, u_A, u_{bA})}{Z(BM, CCR, u_A)}\right]}_{\text{Endogenous Risk Efficiency}}$$

$Z(BM, BCC, u_0)$ measures input pure technical efficiency. It is obtained by augmenting to the constraints of $Z(BM, CCR, u_0)$, the convexity constraint suggested by Banker, Charnes and Cooper (BCC, 1984). Thus, we have the inequality

$$Z(CCR, u_0) \le Z(BM, u_0, u_{b0}) \le Z(BM, CCR, u_0) \le Z(BM, BCC, u_0)$$

consequently, the following multiplicative decomposition:

$$Z(CCR, u_0) = \underbrace{\left[\frac{Z(CCR, u_0)}{Z(BM, u_0, u_{b0})}\right]}_{\text{Exogenous Risk Efficiency}} \underbrace{\left[\frac{Z(BM, u_0, u_{b0})}{Z(BM, CCR, u_0)}\right]}_{\text{Endogenous Risk Efficiency}} \underbrace{\left[\frac{Z(BM, CCR, u_0)}{Z(BM, BCC, u_0)}\right]}_{\text{Sale Efficiency}} \underbrace{\left[Z(BM, BCC, u_0)\right]}_{\text{Pure Technical Efficiency}}$$

IV. Empirical Analysis

We evaluate the performance of 63 commercial banks operating on Indian soil. These constitute public, private and foreign sector banks. Unlike traditional decomposition the overall input technical efficiency is decomposed into endogenous, exogenous, scale and pure technical efficiency, the decomposition being multiplicative. Instead of bank wise, we report sector wise average efficiencies.

Table (1): Mean Efficiency Scores, Standard Deviation

Sectors	$Z(CCR, u_0)$	$Z(CCR, u_0, u_{b0})$	$Z(BM, CCR, u_0)$	$Z(BM, BCC, u_0)$
Public	0.3174 (0.1132)	0.7908 (0.1797)	0.8138 (0.1671)	0.9587 (0.0452)
Private	0.2965 (0.1508)	0.5464 (0.2688)	0.5995 (0.2339)	0.9943 (0.0138)
Foreign	0.6845 (0.2831)	0.8507 (0.2039)	0.8727 (0.1849)	0.9829 (0.0244)

Table (2): Mean Efficiency Scores of Risk and Scale Efficiency

Sectors	Exogenous Risk Efficiency	Endogenous Risk Efficiency	Scale Efficiency
Public	0.4020 (0.0914)	0.9675 (0.0344)	0.8471 (0.1597)
Foreign	0.7920 (0.2534)	0.9716 (0.0678)	0.8774 (0.1834)
Private	0.5909 (0.1916)	0.8608 (0.1732)	0.6103 (0.2381)

In the above table sectoral mean efficiency scores are furnished. The values in the parentheses are standard deviations of efficiency scores. The overall input technical efficiency scores are $Z(CCR,\ u_0)$. These scores assume that implicit in them the influence of risk as measured by NPAs ($= u_b$) and scale efficiency differences. Foreign sector banks' performance is better compared to public and private sector banks. The foreign sector banks experienced 32 percent input losses due to overall technical inefficiency. Low efficiency scores of public and private sector banks reveal that these banks shall adjust their scale of operation towards optimal scale (constant returns to scale), strengthen internal risk control system and adjust their operations suitably to face exogenous risk.

In regression to purge the dependent variable from the influence of an explanatory variable, later is regressed on the former. To disentangle the influence of a variable from an efficiency score, the later is expressed as an additional constraint. NPAs are expressed as an additional constraint, $Z(BM, u_0, u_{b0})$ are obtained. Recognition of NPAs as a constraint dramatically increased the mean efficiency scores of public, private and foreign sector banks. Input losses are found more in private sector than public and foreign sector banks. This observation implies that exogenous credit risk is an important source of commercial banks' radial overall efficiency scores. **It also implies that the public sector banks are hurt due to exogenous credit risk more than private and foreign sector banks.**

The efficiency score $Z(BM, u_0, u_{b0})$ still found influenced by endogenous credit and scale efficiency differences. While exogenous risk arises due to non-discretionary factors like lending to priority sectors at below market rate of interest, competition from rival banks, and lack of freedom to adjust, endogenous risk arises due to weakness of the internal risk control system.

$Z(BM, u_0, u_{b0})$ can be purged off the endogenous risk component by recognizing that NPAs can be reduced strengthening internal risk control system administering controls on the size of the loans, careful evaluation of the creditability of the borrower, demanding adequate collateral security, looking for investments leading to better opportunity costs, motivating employees to make them feel their belongedness and spreading risk.

The private sector banks experienced huge input losses compared to public and foreign sector banks as revealed by the efficiency scores $Z(BM, CCR,\ u_0)$. This fact reveals that the internal risk control system is the weakest for private sector banks than public and foreign sector banks.

The commercial banks of India vary significantly in size. We disentangle the scale differences from $Z(BM, CCR,\ u_0)$ by augmenting the convexity constraint suggested by Banker, Charnes and Cooper (BCC, 1984). The resulting efficiency scores $Z(BM, BCC,\ u_0)$ measure input pure technical efficiency. The resulting mean scores are close to one, 96%, 98% and 99% respectively for public, private and foreign sectors.

The ratio $\frac{Z(CCR,\ u_0)}{Z(BM, u_0, u_{b0})}$ measures exogenous risk efficiency. The public sector banks appear to suffer more from exogenous risk than the foreign and private sector banks. This is expected since the public sector banks are to look after government's programs such as granting loans to priority sector at less than market rates of interest, to weaker sections against poor collateral securities and so on. The mean differences of exogenous risk efficiency of any two of the sectors is significantly different from zero at $p < 0.01$.

The ratio $\frac{Z(BM, u_0, u_{b0})}{Z(BM, CCR,\ u_0)}$ measures endogenous risk efficiency. Private sector banks experience input losses more than the public and foreign sector banks. These banks, therefore, possess weaker internal risk control system than the other two sectors of banks on an average. Public and private sectors behave alike when they dealt with endogenous risk. Between public and private; private and foreign the mean differences of endogenous risk efficiency are found significant at $p < 0.01$.

The ratio $\frac{Z(BM, CCR,\ u_0)}{Z(BM, BCC,\ u_0)}$ measures input scale efficiency. The mean scale efficiency scores imply that the departure of private sector from optimal scale is more than the public and foreign sector. In terms of scale efficiency the public and foreign sectors behave alike as their mean difference of scale efficiency does not differ significantly from zero. Between public and private; private and foreign sector banks the mean scale efficiency differences are significant at $p<0.01$.

V. Conclusions

This study decomposes multiplicatively the overall technical efficiency into exogenous risk, endogenous risk, scale and pure technical efficiency. It is assumed that Non-Performing assets capture the risk component involved in commercial bank business. The risk faced by a commercial bank arises from forces operating from outside and within leading to exogenous and endogenous risk respectively.

The study compares 63 commercial banks comprising public, private and foreign sector banks against a common non-parametric production frontier. The empirical results reveal that exogenous risk is menace more to the public sector than foreign and private sector banks. The built in risk control system is equally strong for public and foreign sector banks. The private sector banks experienced significantly more input losses than public and foreign sector banks due to endogenous risk inefficiency. This banking sector should strengthen its internal risk control system.

Private sector banks appear to operate more distantly from optimal scale than public and foreign sector banks. The foreign sector banks are well ahead in their performance compared to public and private sector banks.

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Appendix-I

$$
\begin{aligned}
Z(BM, CCR, u_0) &= \text{Min}\{\lambda : \lambda(x, u_b) \in L^k(u_0)\} \\
&= \text{Min}\{\lambda : \lambda f(u_b) x \in L^k(u)\} \\
&= [f(u_b)]^{-1} \text{Min}\{\lambda f(u_b) : \lambda f(u_b)\, x \in L^k(u)\} \Rightarrow \{\text{NPAs have neutral effect on all the inputs}\} \\
&= [f(u_b)]^{-1} \text{Min}\{\delta : \delta\, x_0 \in L^k(u_0)\} \\
&= [f(u_b)]^{-1} Z(CCR, u_0)
\end{aligned}
$$

$$
f(u_b) = \frac{Z(CCR, u_0)}{Z(BM, CCR, u_0)}
$$

$f(u_b)$ measures overall risk efficiency.

This can be decomposed into exogenous and endogenous risk efficiencies.

Appendix-II

(1) Public Sector Banks

S.NO	Bank Name	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	State Bank of India	0.2992	1.0000	1.0000	1.0000	0.2992	1.0000	1.0000
2	State Bank Bikaner & Jaipur	0.3408	0.8849	0.9037	0.9958	0.3851	0.9792	0.9075
3	State bank of Hyderabad	0.3439	0.8837	0.9097	0.9543	0.3892	0.9714	0.9533
4	State Bank of Indore	0.3809	0.8469	0.8510	0.9979	0.4498	0.9952	0.8528
5	State Bank of Mysore	0.2946	0.7238	0.7725	0.9666	0.4070	0.9370	0.7992
6	State bank of Patiala	0.4284	1.0000	1.0000	1.0000	0.4284	1.0000	1.0000
7	State bank of Saurashtra	0.2218	0.4773	0.4950	0.9591	0.4647	0.9642	0.5161
8	State Bank of Travancore	0.3679	0.8764	0.8783	1.0000	0.4198	0.9978	0.8783
9	Allahabad Bank	0.2651	0.5593	0.5962	0.9082	0.4740	0.9381	0.6565
10	Andhra Bank	0.3463	1.0000	1.0000	1.0000	0.3463	1.0000	1.0000
11	Bank of Baroda	0.3107	0.9386	0.9488	0.9589	0.3310	0.9892	0.9895
12	Bank of India	0.3201	0.9960	0.9964	1.0000	0.3214	0.9996	0.9964
13	Bank of Maharashtra	0.2689	0.6861	0.7618	0.9763	0.3919	0.9006	0.7803
14	Canara Bank	0.2783	0.6269	0.6612	0.8181	0.4439	0.9481	0.8082
15	Central bank of India	0.2060	0.6772	0.7038	0.9268	0.3042	0.9622	0.7594
16	Corporation Bank	0.3752	0.8978	0.9192	0.9728	0.4179	0.9767	0.9449
17	Dena Bank	0.2430	0.5360	0.5454	0.9760	0.4534	0.9828	0.5588
18	IDBI Ltd.	0.7833	1.0000	1.0000	1.0000	0.7833	1.0000	1.0000
19	Indian Bank	0.2012	0.7119	0.7556	0.8951	0.2826	0.9422	0.8442
20	Indian Overseas Bank	0.3006	0.8673	0.8856	0.9310	0.3466	0.9793	0.9512
21	Oriental Bank of Commerce	0.4353	1.0000	1.0000	1.0000	0.4353	1.0000	1.0000
22	Punjab & Sind Bank	0.1807	0.4520	0.4673	0.9442	0.3998	0.9673	0.4949
23	Punjab national Bank	0.2677	0.8601	0.8707	0.8767	0.3112	0.9878	0.9932
24	Syndicate Bank	0.2912	0.7692	0.8229	0.9313	0.3786	0.9347	0.8836
25	UCO Bank	0.2730	0.6683	0.7266	1.0000	0.4085	0.9198	0.7266
26	Union bank of India	0.3163	0.7941	0.8329	0.9462	0.3983	0.9534	0.8803
27	United Bank of India	0.1880	0.4635	0.5360	0.9257	0.4056	0.8647	0.5790
28	Vijaya Bank	0.3588	0.9446	0.9463	0.9819	0.3798	0.9982	0.9637

(2) Foreign Sector Banks:

S.NO	Bank Name	(1)	(2)	(3)	(4)	(5)	(6)	(7)
29	ABN Amro bank	0.6895	1.0000	1.0000	1.0000	0.6895	1.0000	1.0000
30	Abu Dhabi Commercial Bank	0.9239	0.9239	0.9239	1.0000	1.0000	1.0000	0.9239
31	American Express Bank	0.1208	0.5921	0.7690	0.9905	0.2040	0.7700	0.7764
32	Bank of Bahrain & Kuwait	0.3739	0.3739	0.3739	0.9979	1.0000	1.0000	0.3747
33	Bank of Ceylon	0.8064	0.8064	0.8064	1.0000	1.0000	1.0000	0.8064
34	Bank of Tokyo-Mitsubishi UFJ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
35	Chinatrust Commercial Bank	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
36	Citi Bank	0.7371	1.0000	1.0000	1.0000	0.7371	1.0000	1.0000
37	Deutsche Bank	0.6148	1.0000	1.0000	1.0000	0.6148	1.0000	1.0000
38	Hong Kong & Shanghai Banking Corporation	0.4722	0.8009	0.8266	0.9520	0.5896	0.9689	0.8683
39	JB Morgan Chase bank	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
40	Standard Chartered Bank	0.4755	0.7107	0.7723	0.9909	0.6691	0.9202	0.7794

(3) Private Sector Banks:

S.NO	Bank Name	(1)	(2)	(3)	(4)	(5)	(6)	(7)
41	Axis Bank	0.5112	1.0000	1.0000	1.0000	0.5112	1.0000	1.0000
42	Bank of Rajasthan	0.2238	0.5351	0.5632	0.9680	0.4182	0.9501	0.5818
43	Catholin Syrian Bank	0.1644	0.3254	0.3919	0.9905	0.5052	0.8303	0.3957
44	Centurion Bank of Punjab	0.1159	0.2515	0.3891	0.9303	0.4608	0.6464	0.4183
45	Citi Union Bank	0.2725	0.4994	0.5641	0.9922	0.5457	0.8853	0.5685
46	Development Credit bank	0.2082	0.3646	0.4358	0.9889	0.5710	0.8366	0.4407
47	Dhanalakshmi bank	0.1893	0.3041	0.4082	0.9920	0.6225	0.7450	0.4115
48	Federal Bank	0.3419	0.7654	0.7745	0.9726	0.4467	0.9883	0.7963
49	HDFC Bank	0.2874	0.8221	0.8514	0.9008	0.3496	0.9656	0.9452
50	ICICI Bank	0.6919	1.0000	1.0000	1.0000	0.6919	1.0000	1.0000
51	Induslnd Bank	0.5864	0.9127	0.9164	1.0000	0.6425	0.9960	0.9164
52	Ing Vysys bank	0.2961	0.4889	0.5056	0.9572	0.6056	0.9670	0.5282
53	Jammu & Kashmir Bank	0.3601	0.8196	0.8262	0.9966	0.4394	0.9920	0.8290
54	Karnataka Bank	0.3180	0.7031	0.7200	0.9909	0.4523	0.9765	0.7266
55	Karur Vysya Bank	0.3007	0.5790	0.6086	0.9760	0.5193	0.9514	0.6236
56	Kotak Mahindra bank	0.2920	0.5697	0.7157	1.0000	0.5126	0.7960	0.7157
57	Lakshmi Vilas bank	0.2953	0.5581	0.6160	0.9967	0.5291	0.9060	0.6180
58	Lord krishna Bank	0.1389	0.1666	0.3457	0.9990	0.8337	0.4819	0.3460
59	Ratnakar bank	0.1355	0.1355	0.2449	0.9952	1.0000	0.5533	0.2461
60	Sangli Bank	0.0584	0.0584	0.1326	0.9837	1.0000	0.4404	0.1348
61	SBI Comm.& Intl Bnak	0.4509	0.4509	0.4509	0.9976	1.0000	1.0000	0.4520
62	South Indian Bank	0.3063	0.7056	0.7266	0.9879	0.4341	0.9711	0.7355
63	Tamilnad Mercantile Bank	0.2748	0.5516	0.6003	0.9901	0.4982	0.9189	0.6063

(1) $= Z(CCR, u_0)$,
(2) $= Z(BM, u_0, u_{b0})$,
(3) $= Z(BM, CCR, u_0)$,
(4) $= Z(BM, BCC, u_0)$

(5) $= \dfrac{Z(CCR, u_0)}{Z(BM, u_0, u_{b0})}$,
(6) $= \dfrac{Z(BM, u_0, u_{b0})}{Z(BM, CCR, u_0)}$,
(7) $= \dfrac{Z(BM, CCR, u_0)}{Z(BM, BCC, u_0)}$