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Effectiveness of the Global Banking System in 2010: A Data Envelopment Analysis Approach*

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The current crisis has revealed the weaknesses of the global financial in general and its banking system in particular, and puts forward a requirement for assessing the effectiveness and stability of the banking sectors across countries. Based on available data from 64 countries over the world, the author tried to evaluate the effectiveness of the banking sectors in those countries through the view point of the data envelopment analysis approach to define how the global banking systems is under the effect of the current crisis. Findings from the research showed that banking systems in advanced economies are still more effective than in developing countries. Moreover, it explained the effect of the current financial crisis, the role of public finance (and the government), and the development of the (privately) commercial banks to the effectiveness of the banking sectors. The research also explained some determinants that can affect the effectiveness of the banking system, including inflation, bank concentration, and level of economic development.

Keywords: data envelopment analysis, effectiveness, efficiency, banking, cross countries

Introduction

Because of the important role of the banking and financial system in the rapid development of new industrial economies (NIEs) in the 1960s-1970s, there were renewed interests in the relationship between financial and economic growth. Schumpeter (1911) argued that the role of financial intermediaries in savings mobilization, projects evaluation and selection, risk management, entrepreneurs monitor, and facilitating transactions is important to technological innovation and economic growth. Following this argument, many other leading economists continuing emphasized the positively essential role of the financial sector in economic development, including Goldsmith (1969), Shaw (1973), McKinnon (1973), King and Levine (1993a, 1993b).

Banks are the core of the financial system. They accept deposits from savers and lend them to borrowers.

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They hold liquid reserves which allowing predictable withdrawal demand. They issue liabilities which are more liquid than the deposits. They also reduce (or some times eliminate) the need of self-finance (Bencivenga & Smith, 1991, p. 195). Banks hold an important role within the financial system, and to some certain level, researching the banking system therefore means researching the financial system.

Started from the bankruptcy of the Northern Rock Bank in the UK (2008, February), however, the global financial crisis and its heavily impacts have put researchers and policy makers under the requirement of re-assessment and re-evaluation the stability and performance of the global financial and banking system[1].

A firm is effective when it reaches its target outputs. Similarly, a banking system is defined as effectiveness if it can fulfill its missions of providing banking services and monitoring the stability of the system. Meanwhile, if banking systems are set under similar conditions of macro- and micro-economic, the level of outcomes that a banking system can provide (in term of services and stability) is indeed its efficiency. In this sense, the problem of calculating effectiveness of banking systems all over the world becomes the problem of evaluating its efficiency with a (dummy) similar and equal input. This research is trying to define the effectiveness of the global banking system in 2010 through analysing cross-country data observed from 64 countries, using the data envelopment analysis (DEA) approach. The remainder of this paper is organized as follows. Section 2 gives some reviews on efficiency and effectiveness evaluation in the banking sector using DEA approach. Section 3 explains the methodologies and technical will be applied in the research. Section 4 shows empirical results and section 5 concludes.

Literature Review

To evaluate the efficiency of a set of firms (or banks), the most popular approaches are ratio analysis, parametric analysis and nonparametric analysis (the latter two methods belongs to the X-efficiency approach). While ratio analysis focuses on ratios between two variables (of inputs or outputs) to define the productivity and efficiency, X-efficiency analysis evaluates the efficiency of a bank through a multi-variables aspect.

DEA is a popular nonparametric method applied in evaluating efficiency in finance and banking area. After Farrell (1957) laid the foundation for a new approach in evaluating efficiency and productivity at micro-level, Charnes, Cooper and Rhodes (1978) and then Banker, Charnes and Cooper (1984) developed the CCR and BCC-DEA model, respectively, to evaluate the (relative) efficiencies of the researched decision making units (DMUs). Since then, DEA was increasingly applied in efficiency evaluation, especially in social sciences[2].

There are a limited number of researches using DEA to examine banking performance at cross-country level. A study in 1997 showed that out of 130 studies on banking performance and efficiency, only six were focused on comparing the efficiency level of banking systems across countries (Berger & Humphrey, 1997, pp. 182-184). As shown in Table 1, all three DEA studies were using small sample data at institutional (bank) level to define the benchmark frontier, hence, the global banking system was left untouched.

In the 2000s, further studies which used common frontier approach were developed by add in the model

[1] According to Science Direct, since 2010, there are more than 2,200 journal articles regarding banking performance after the crisis of 2007-2008 (Retrieved December 20, 2010, from http://www.sciencedirect.com).

[2] Recent study of Avkiran (2010) showed that there are more than 170 articles using DEA as a main methodology to analyse the efficiency of banks and banks branches, including Sherman and Gold (1985), Peristiani (1997), Schaffnit, Rosen and Paradi (1997), and Pastor, Knox Lovell and Tulkens (2006).

some environmental/controllable variables such as banking market conditions or market structure and regulation (Kwan, 2003; Lozano-Vivas, Pastor, & Hasan, 2001; Maudos, Pastor, Perez, & Quesada, 2002; Sathye, 2005). However, as they are also mainly focused on institutional level data while macro-environment is different from country to country, they ignored that banks which are efficient in this country may not performance well if they run as foreign-owned banks in other countries (Berger, 2007, p. 125). Hence, while trying to examine the whole banking systems across countries, this study attempts to overcome the above problem.

Table 1

Studies on Banking Performance at Cross-Country Level (Prior to 1997)

Authors (date)	Method used	Countries included	Institution
Berg, Forsund, Hjalmarsson, & Suominen (1993)	Data envelopment analysis	Norway, Sweden, Finland	Bank
Fecher & Pestieau (1993)	Distribution free approach	11 OECD countries	Financial service
Bergendahl (1995)	Mixed optimal strategy	Norway, Sweden, Finland, Denmark	Bank
Ruthenberg & Elias (1996)	Thick frontier approach	15 developed countries	Bank
Bukh, Berg, & Forsund (1995)	Data envelopment analysis	Norway, Sweden, Finland, Denmark	Bank
J. Pastor, Perez, & Quesada (1997)	Data envelopment analysis	08 developed countries	Bank

Note. Source: Berger and Humphrey (1997).

As DEA evaluates the efficiency of each DMU based on the optimal multipliers (or weights) of inputs and outputs factors, it allows us to examine the effectiveness of a banking system by looking at the achievements of the banking sector, including both quantity (assets, deposits, credits, etc.) and quality (overhead cost, nonperforming loans, frequency of bank crises, etc.) factors of commercial banks in the economy[3]. They are chosen following 122 variables represent the stability of the global financial system (WEF, 2010, Appendix A). However, since DEA treats those factors dynamically (meaning each country can have its own preference on them), to be understandable in evaluating and comparing the effectiveness of the banking systems between countries, a common preference (or common set of weights) for the above analyzed factors is required. Therefore, in this research, the DEA model will be divided into three stages, in which the first stage conducts a dynamic DEA model (DSW model) to define the relatively efficiencies of the banking systems from these 64 countries; the second stage examines the determinants affecting that efficiencies (Tobit model); and the third stage defines the common set of weights for those analyzed factors (CSW model) in order to conduct the final banking effectiveness scores.

Technical Methodologies

In the first step, DSW model is produced to calculate the maximum effectiveness scores that each country can achieve with the observed (achievement) factors. Mahlberg and Obersteiner (2001) and Depotis (2004) developed an input-oriented DEA-like model which treats all factors as outputs, while input is a dummy variable (values equal to 1 for all countries). Therefore, the DSW model in this research is in fact a constant-returns-to-scale (CRS) and input-oriented DEA model. For an evaluated country j_0-th, its efficiency score ($DSWj_0$) can be expressed by the following non-negative linear problem:

[3] It is important to notice that these factors are outcomes that a banking system is aiming for; hence, the DEA model in this paper will use them all as output variables.

$$\mathrm{DSW}_{j_0} = \max \frac{\sum u_m y_{mj_0}}{\sum v_k x_{kj_0}} \quad (1)$$

Subject to:

$$\sum u_m y_{mj} \le \sum v_k x_{kj} \ , \ 1 \le j \le n$$

$$\sum v_k x_{kj} = 1$$

$$\sum u_m = 1$$

$$u_m \ge 0$$

$x_j = 1$ {all original input values are assumed to be equal to 1}

where:

u_m: weight of m-th output factor;

v_k: weight of k-th input factor;

x_{kj}: k-th input of j-th country, $k = 1$;

y_{mj}: m-th output of j-th country;

n: number of countries;

m: number of factors.

Due to the fact that some countries can have the same scores in this DSW model, a super efficiency DEA model (Zhu, 2001) is also ran to determine the ranking order of the researched countries, makes it easier to compare the effectiveness's of the banking systems between countries.

In the next step, a Tobit regression (for more details, see Tobin, 1958) is used to determine the factors affecting the country's banking efficiencies (Tobit model). Since the CSW scores are bounded between 0 to 1, non-censored regression models could be biased (Fethi & Pasiouras, 2010), while Tobit regression is justify as in equation (2). Variables used in this model are ones that mainly related to the financial efficient of a banking system at micro-level and are expressed in Table 2.

$$EF = \alpha + \beta 1*CONC + \beta 2*ROA + \beta 3*ROE + \beta 4*CIR + \beta 5*INF + \beta 6*CTA + \beta 7*NIM + \beta 8*CII + \beta 9*GROUP \quad (2)$$

Table 2

Variables of the Tobit Model

Variables	Definition
EF	CSW-DEA scores.
CONC	Bank concentration (assets of three largest banks as a share of assets of all commercial banks).
ROA	Bank's average return on assets (Net income/Total assets).
ROE	Bank's average return on equity (Net income/Total equity).
CIR	Bank's cost to income ratio (Total costs as a share of total income of all commercial banks).
INF	Inflation, consumer prices (annual %).
CTA	Bank's capital to assets ratio (ratio of bank capital and reserves to total assets).
NIM	Net interest margin of banks (value of bank's net interest revenue as a share of its interest-bearing assets).
CII	Depth of credit information index (measures rules and practices affecting the coverage, scope and accessibility of credit information).
GROUP	Dummy variable of income group (equals to 0 if country belongs to lower income, 1 if middle income, and 2 if high income group).

The last step is to define the optimal common set of weights which should be used for compare and ranking countries based on their banking systems' effectiveness. It is done by applying the CSW model. It is believed that the efficient frontier found in the DSW model in the first step is the "best practice frontier" (Grosskopf & Valdmanis, 1987; Schaffnit, Rosen, & Paradi, 1997); hence, the optimal common weight set will be the one that get every countries' performances closest to that frontier. There are several ways to define that common set of weights is based on this idea. While imposing bounds for factor weights, Roll and Golany (1993) found out that the common set of weights can be defined by maximizing the average efficiency of all DMUs or maximizing the number of efficient DMUs. Kao and Hung (2005) applied a compromise solution approach to minimize the total squared distances between the optimal objective values (found by DEA) and the common weighted values (found by using common set of weights). Jahanshahloo, Memariani, Lotfi and Rezai (2005) applied the multiple objective programming approach to simultaneously maximize the performance scores to get it closes to the "best practice frontier". Liu and Peng (2008) applied the common weights analysis to minimize the vertical and horizontal virtual gaps between the benchmark line (slope equals to 1.0, or performance scores equal to 1.0) and the coordinate of common weighted DMUs. In this paper, we modified the model of Kao and Hung (2005) into a minimum distance efficiencies model, in which the common set of weights can be defined as the one minimizing the total distances between optimal efficiencies (DSW scores) and common weighted scores (CSW scores) of all DMUs, under the condition that each DMU's efficiency cannot exceed its DSW efficiency[4]. To understand the role of each factor in CSW scores, another condition was added where the total sum of weights is equal to 1 (or 100%). The country's banking effectiveness scores will be constructed based on that CSW scores and findings from the super efficiency DEA results in the previous step. This CSW model can be expressed as a non-negatively linear problem as follows:

$$\min \sum \left(e_j^* - e_j \right) \tag{3}$$

Subject to:

$$e_j^* = \mathrm{DSW_j}$$

$$e_j = \frac{\sum u_m y_{mj}}{\sum v_k x_{kj}},\ 1 \le j \le n$$

$$e_j \le e_j^*$$

$$\sum v_k x_{kj} = 1$$

$$\sum u_m = 1$$

$$u_m \ge 0.01^5$$

$x_j = 1$ {all original input values are assumed to be equal to 1}

where:

u_m: weight of m-th factor;

y_{mj}: m-*th* factor of j-th country;

[4] This constrain makes these distances non-negative, hence, they can be used directly rather than the squared distances.

[5] Mahlberg and Obersteiner (2001) found that restriction weights with lower bound of 0.01 steered a middle course between too strong predetermination and too large flexibility.

n: number of countries;

m: number of factors.

The final effectiveness scores will then be calculated following this equation:

$$ES_j = \sum u_m^{CSW} y_{mj} \quad (4)$$

where:

ES_j: Effectiveness score of country *j*-th;

u_m^{CSW}: Common weight of factor *m*-th;

y_{mj}: Value of factor m-th of country *j*-th.

Empirical Results

In the first stage, countries and factors are collected from the database of Beck, Demirgüç-Kunt and Levine (2000), Laeven and Valencia (2010), the World Bank (World Development Indicator, Global Development Financial, and Doing Business databases), the International Monetary Fund (IMF, 2010), the Consultative Group to Assist the Poor (CGAP, 2010) and Annual Reports from Central Banks of such researched countries. Ten factors[6] are included in this research, covering both quantitative (the first 5 factors) and qualitative (the last 5 factors) aspect of the banking sectors (see Table 3). It is important to notice that the last 3 factors are undesirable factors (as they have negative effect to the banking effectiveness), hence, they was transformed into desirable ones through the linear monotone decreasing transformation method[7].

Table 3

Descriptive Statistics of Factors

Factors	Mean	Standard error	Standard deviation	Minimum	Maximum
Commercial banks' assets/GDP	0.74	0.06	0.48	0.09	2.42
Domestic credit provided by banking sector (% of GDP)	80.21	8.74	69.92	-11.17	379.30
Commercial banks' deposits/GDP	0.60	0.04	0.36	0.12	1.80
Number of ATMs per 100,000 people	28.27	4.87	38.96	0.06	236.07
Number of branches per 100,000 people	11.47	1.23	9.86	0.53	45.60
Private credit bureau coverage (% of adults)	36.72	4.38	35.03	0	100
Public credit bureau coverage (% of adults)	8.24	1.60	12.76	0	48.50
Banks' overhead costs/Total assets	0.22	0.01	0.05	0	0.26
Nonperforming loans ratios of commercial banks	17.39	0.78	6.23	0	22.80
Frequency of banking crises	2.92	0.09	0.72	0	4.00

Note. Data of the last three variables are already transformed.

As mentioned in section 3, those factors will be treated as output variables, while a dummy-input (equals to 1) will be set for the whole 64 countries. The DSW model then produces an effective frontier built from 25 countries, while the other 39 are ineffective (see Appendix A Table A2).

Within the ineffective ones, none of them is developed countries, suggesting that the banking systems in

[6] According to Dyson et al. (2001, p. 248) and Avkiran (2001, p. 68), one rule of thumb in using DEA is that the sample size has to be at least 3 times bigger than the number of total inputs and outputs to overcome the discrimination problem. As we have 64 samples over 10 variables, hence, this research is justified.

[7] In this method, the transformed values will be calculated by the difference between a proper translation vector *w* with the original values of those undesirable factors. For more details, see Seiford and Zhu (2002) and Fare and Grosskopf (2004).

advanced economies still run better than in developing countries although they had to bear stronger effect from the current crisis. This can be explained by the difference between projected values and original values of these factors (in percentage of original values), in which the biggest differences are mainly for quantity factors, except for the case of private credit bureau coverage. The results show that, major weaknesses of ineffective countries in banking system development are the ATM network, bank deposits to GDP, private credit coverage, bank assets, and bank's domestic credits. Those are the disadvantage of developing countries as they are still on their way developing their financial and banking systems (see Table 4).

Table 4

Differences Between Projected and Original Values for Inefficient Countries

Factors	Total differences	
	In value	In percentage of original value
Commercial banks' assets/GDP	21.72	45.56
Domestic credit provided by banking sector (% of GDP)	2,338	45.55
Commercial banks' deposits/GDP	21.67	56.44
Number of ATMs per 100,000 people	1,373	75.88
Number of branches per 100,000 people	379.4	51.7
Private credit bureau coverage (% of adults)	1,230	52.34
Public credit bureau coverage (% of adults)	56.46	10.71
Banks' overhead costs/Total assets	0.741	5.376
Nonperforming loans ratios of commercial banks	80.16	7.201
Frequency of banking crises	21.68	11.59
Average	552.3	36.24

In the second stage, the results from Tobit model show the relation between the banking systems' effectiveness and various variables such as inflation level of the economy, income group that the country belongs to, concentration of the banking system, etc., as summarized in Figure 1. It is obvious that higher inflation, banking concentration, and bank's cost-income ratio can reduce the effectiveness of the banking sector (respectively significant at 1, 5 and 10 percent), while the high level of economic development (improving to higher income group) can help increase the effectiveness of the banking system (5% significant level).

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Tobit regression                                  Number of obs   =         51
                                                  LR chi2(9)      =      29.02
                                                  Prob > chi2     =     0.0006
Log likelihood =  36.183029                       Pseudo R2       =    -0.6694

------------------------------------------------------------------------------
          EF |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        CONC |  -.1178702   .0534656    -2.20   0.033    -.2257683   -.0099722
         ROA |   -.000442   .0006043    -0.73   0.469    -.0016614    .0007775
         ROE |   -.029139   .0565369    -0.52   0.609    -.1432352    .0849572
         CIR |  -.0367652   .0217527    -1.69   0.098     -.080664    .0071335
         INF |  -.0071183     .00253    -2.81   0.007     -.012224   -.0020126
         CTA |  -.0072785   .0029542    -2.46   0.018    -.0132402   -.0013167
         NIM |   .3790703   .2781161     1.36   0.180    -.1821907    .9403313
         CII |   -.007743   .0066039    -1.17   0.248    -.0210702    .0055842
       GROUP |   .0465285   .0190049     2.45   0.019     .0081751    .0848819
       _cons |   1.126271   .0879408    12.81   0.000     .9487993    1.303743
-------------+----------------------------------------------------------------
       /sigma |   .062421   .0079119                      .0464541    .0783879
------------------------------------------------------------------------------
  Obs. summary:          0  left-censored observations
                        35     uncensored observations
                        16 right-censored observations at EF>=1
```

Figure 1. Determinants of the global banking effectiveness.

In the last stage, solving the non-linear problem of the CSW model (equation (3)) helped us defining a common set weight for the ten factors of every country in the research (see Table 5). Noticeably, important factors which strongly affect the performance of the banking sector in those countries are non-performing loans ratio (79.49%), public credit bureau coverage (10.47%), and number of branches per 100,000 people (3.03%). The other factors only keep minimum role (1% weight) in the final results. It shows that the effectiveness of the banking sector is mainly affected by the damage of the global crisis, the (financial) public policy of the government, and the development of the commercial bank system of each country respectively. It also suggests that the quality of the banking sector is now becoming more important than the quantity aspect, not only for countries with developed banking systems but for developing countries as well. Thus, country which focuses on improving the quality of its banking sector can have higher effectiveness and is more stable.

Table 5

Common Set of Weights for the Effectiveness Scores

Factors	Weight
Commercial banks' assets/GDP	1.00
Domestic credit provided by banking sector (% of GDP)	1.00
Commercial banks' deposits/GDP	1.00
Number of ATMs per 100,000 people	1.00
Number of branches per 100,000 people	3.03
Private credit bureau coverage (% of adults)	1.00
Public credit bureau coverage (% of adults)	10.47
Banks' overhead costs/Total assets	1.00
Nonperforming loans ratios of commercial banks	79.49
Frequency of banking crises	1.00

By applying this common set of weights, the effectiveness scores of country's banking systems can be calculated and countries can be ranked as in Table 6. Since non-performing loans ratio became the most important factor, countries having problems with NPLs became less efficient and ranked bottom in the list, including even Denmark and New Zealand.

Table 6

The Global Banking Effectiveness in 2010

Rank	Country	Effectiveness score	Rank	Country	Effectiveness score
1	Japan	23.231	33	Kuwait	17.606
2	Canada	23.231	34	Venezuela, RB	17.556
3	Chile	23.231	35	Moldova	17.504
4	Malaysia	22.275	36	Lithuania	17.394
5	Australia	22.177	37	Bolivia	17.333
6	Switzerland	22.079	38	Croatia	17.307
7	United States	22.037	39	Uganda	16.947
8	Bulgaria	21.755	40	Jordan	16.891
9	Argentina	21.671	41	Mozambique	16.853
10	Ecuador	21.461	42	Poland	16.771
11	Costa Rica	21.421	43	Colombia	16.770
12	United Kingdom	21.415	44	Armenia	16.276

(Table 6 continued)

Rank	Country	Effectiveness score	Rank	Country	Effectiveness score
13	Korea, Rep.	21.066	45	Thailand	16.203
14	Sweden	21.060	46	Russian Federation	16.066
15	Brazil	20.968	47	Georgia	15.859
16	El Salvador	20.232	48	Morocco	15.475
17	Dominican Republic	20.070	49	Kazakhstan	15.288
18	Peru	19.907	50	Albania	15.116
19	Israel	19.735	51	Yemen, Rep.	14.566
20	Guatemala	19.626	52	Nigeria	14.202
21	Singapore	19.326	53	Kenya	11.871
22	Estonia	19.276	54	Bangladesh	10.486
23	Panama	19.085	55	Tunisia	9.696
24	Indonesia	18.993	56	Romania	9.442
25	Turkey	18.749	57	Egypt, Arab Rep.	8.051
26	South Africa	18.538	58	Mauritius	7.601
27	Czech Republic	18.302	59	Denmark	6.519
28	Hungary	18.233	60	New Zealand	5.338
29	Saudi Arabia	18.045	61	Vietnam	4.841
30	India	17.921	62	Angola	4.761
31	Macedonia, FYR	17.842	63	Botswana	0.662
32	Slovak Republic	17.750	64	Sierra Leone	0.203

Conclusions

Using data from 64 countries in the world, this research applied the data envelopment analysis (DEA) to evaluate the effectiveness of banking systems in the World in 2010. The research was divided into three steps, in which the first stage applied data envelopment analysis method to build a common frontier for these 64 countries; the second step detected the determinants of the banking sector's effective; and the last step defined a common set of weights for analyzing factors helping in ranking the effectiveness of the global banking system in 2010.

The research evaluated the effectiveness of the global banking systems using a dummy input and ten outputs to create a common frontier for the whole banking systems of 64 countries (while previous studies used institutional level data of smaller sample size); and after that building a common set of weights to calculate the effectiveness scores of the global banking system, applied to the DEA method. This proposes an interesting function for using DEA in examining the effectiveness (and efficiency) in the banking sector.

Findings from the research showed that banking systems in advanced economies are still more effective than in developing countries. Reasons seem to be related to the development of the banking sector in quantity (number of bank branches) and more importantly in quality aspects (including the NPL ratio, public credit bureau coverage, bank concentration, bank's capital, and cost-income ratio). It is also included the effect of economic development, expresses through level of income (group) and inflation rates. These results partly explained the effect of the current financial crisis to the banking sector, the role of public finance (and the government) in this kind of situation, and the important role of developing commercial banking system to its efficiency and effectiveness.

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Appendix A

Table A1

Countries' Data

Country	*y*1	*y*2	*y*3	*y*4	*y*5	*y*6	*y*7	*y*8	*y*9	*y*10
Albania	0.77	66.88	0.74	2.37	2.11	0.00	9.90	0.24	16.70	3.00
Angola	0.24	9.34	0.24	9.58	0.60	0.00	2.50	0.23	5.34	4.00
Argentina	0.18	24.47	0.20	14.91	10.01	100.00	34.30	0.18	20.60	0.00
Armenia	0.20	16.66	0.12	1.37	7.59	34.50	4.40	0.22	18.90	3.00
Australia	1.29	143.75	1.14	64.18	29.86	100.00	0.00	0.24	22.80	4.00
Bangladesh	0.54	59.38	0.51	0.06	4.47	0.00	0.90	0.24	12.10	3.00
Bolivia	0.32	55.24	0.38	4.80	1.53	33.90	11.60	0.21	19.00	2.00
Botswana	0.19	-11.17	0.58	9.00	3.77	51.90	0.00	0.22	0.00	4.00
Brazil	0.91	117.85	0.66	17.82	14.59	59.20	23.70	0.14	20.20	2.00
Bulgaria	0.85	66.74	0.77	29.79	13.87	6.20	34.80	0.25	20.90	3.00
Canada	1.40	178.07	1.04	135.23	45.60	100.00	0.00	0.24	22.20	4.00
Chile	0.78	115.92	0.55	24.03	9.39	33.90	32.90	0.23	22.30	2.00
Colombia	0.51	43.26	0.22	9.60	8.74	60.50	0.00	0.21	19.30	2.00
Costa Rica	0.49	53.90	0.25	12.83	9.59	56.00	24.30	0.15	21.80	2.00
Croatia	0.90	75.09	0.77	40.10	23.36	77.00	0.00	0.24	18.40	3.00
Czech Republic	0.67	57.98	0.62	19.57	11.15	73.10	4.90	0.24	20.00	3.00
Denmark	2.42	211.45	0.72	52.39	37.63	5.20	0.00	0.23	3.30	3.00

(Table A1 continued)

Country	*y*1	*y*2	*y*3	*y*4	*y*5	*y*6	*y*7	*y*8	*y*9	*y*10
Dominican Republic	0.22	39.06	0.21	15.08	6.00	46.10	29.70	0.13	19.80	3.00
Ecuador	0.28	19.76	0.28	6.32	9.30	46.00	37.20	0.22	20.80	2.00
Egypt, Arab Rep.	0.56	77.70	0.75	1.78	3.62	8.20	2.50	0.22	8.50	3.00
El Salvador	0.42	49.94	0.42	11.07	4.62	94.60	21.00	0.23	20.50	3.00
Estonia	1.18	97.26	0.48	57.70	15.19	20.60	0.00	0.17	21.40	3.00
Georgia	0.40	32.87	0.22	1.17	3.14	12.20	0.00	0.18	19.20	3.00
Guatemala	0.44	40.11	0.37	20.20	10.12	28.40	16.90	0.01	20.90	4.00
Hungary	0.90	80.70	0.50	29.40	28.25	10.30	0.00	0.00	20.30	2.00
India	0.69	68.35	0.70	7.29	10.64	10.20	0.00	0.24	21.00	3.00
Indonesia	0.29	36.75	0.33	4.84	8.44	0.00	22.00	0.23	20.10	3.00
Israel	0.95	82.16	0.87	18.81	14.74	89.80	0.00	0.24	21.80	3.00
Japan	1.48	379.30	1.80	113.75	9.98	76.20	0.00	0.25	21.60	3.00
Jordan	1.29	114.92	1.09	9.38	10.02	0.00	1.00	0.24	19.10	3.00
Kazakhstan	0.89	33.51	0.39	7.01	2.47	29.50	0.00	0.23	18.20	3.00
Kenya	0.29	40.09	0.29	0.99	1.38	2.30	0.00	0.21	14.30	2.00
Korea, Rep.	1.21	112.32	0.59	90.03	13.40	93.80	0.00	0.25	22.20	3.00
Kuwait	0.81	74.92	0.71	19.69	8.27	30.40	0.00	0.23	20.20	3.00
Lithuania	0.73	64.37	0.36	28.78	3.39	18.40	12.10	0.24	18.70	3.00
Macedonia, FYR	0.55	42.70	0.56	49.97	26.79	0.00	28.10	0.22	16.50	3.00
Malaysia	0.99	115.54	1.09	16.44	9.80	82.00	48.50	0.24	18.50	3.00
Mauritius	0.88	111.78	0.86	22.04	11.92	0.00	36.80	0.24	2.50	4.00
Moldova	0.49	39.76	0.45	236.07	10.07	0.00	0.00	0.21	18.10	4.00
Morocco	0.91	95.54	0.94	9.68	15.80	14.00	0.00	0.25	17.30	3.00
Mozambique	0.22	14.14	0.29	4.90	2.92	0.00	2.30	0.20	20.50	3.00
New Zealand	1.55	156.45	0.96	50.36	28.04	100.00	0.00	0.25	1.70	4.00
Nigeria	0.45	26.73	0.26	18.63	6.42	0.00	0.00	0.23	17.00	3.00
Panama	0.86	85.41	0.88	16.19	12.87	45.90	0.00	0.19	21.60	3.00
Peru	0.21	18.51	0.26	5.85	4.17	31.80	23.00	0.23	21.10	3.00
Poland	0.55	60.06	0.42	17.31	8.17	68.30	0.00	0.24	18.90	3.00
Romania	0.52	40.91	0.32	12.47	13.76	30.20	5.70	0.18	9.50	3.00
Russian Federation	0.49	26.03	0.36	6.28	2.24	14.30	0.00	0.18	19.50	2.00
Saudi Arabia	0.55	9.42	0.53	14.70	5.36	17.90	0.00	0.25	21.90	4.00
Sierra Leone	0.09	7.35	0.15	1.14	2.76	0.00	0.00	0.16	0.00	3.00
Singapore	1.10	79.17	1.18	37.93	9.13	40.30	0.00	0.26	21.90	4.00
Slovak Republic	0.55	53.80	0.49	29.21	10.28	44.00	1.40	0.24	20.10	3.00
South Africa	0.95	215.47	0.67	17.50	5.99	54.70	0.00	0.22	19.40	4.00
Sweden	1.40	133.43	0.57	29.56	21.80	100.00	0.00	0.25	22.30	2.00
Switzerland	1.89	180.59	1.31	70.60	37.99	22.50	0.00	0.23	22.80	3.00
Thailand	0.84	145.65	0.79	17.05	7.18	32.90	0.00	0.24	17.60	2.00
Tunisia	0.62	72.04	0.52	17.69	15.51	0.00	19.90	0.24	7.80	3.00
Turkey	0.51	52.54	0.42	18.00	8.50	42.90	15.90	0.22	19.70	2.00
Uganda	0.22	11.45	0.20	0.70	0.53	0.00	0.00	0.20	21.10	3.00
United Kingdom	2.08	211.35	1.71	42.45	18.35	100.00	0.00	0.25	21.70	3.00
United States	0.73	271.64	0.83	120.94	30.86	100.00	0.00	0.22	20.30	2.00
Venezuela, RB	0.38	20.49	0.39	16.60	4.41	0.00	0.00	0.21	21.40	3.00
Vietnam	1.24	94.99	0.93	15.36	3.42	0.00	19.00	0.25	2.00	3.00
Yemen, Rep.	0.13	11.29	0.21	2.75	1.97	0.00	0.20	0.25	18.00	3.00

Note. *y*1, *y*2,..., *y*10 are respectively referred to ten factors in Table 3.

Table A2

Dynamic DEA Efficiencies

Rank	Country	DSW score	Rank	Country	DSW score
1	Moldova	1.000	33	Thailand	0.961
2	Malaysia	1.000	34	India	0.957
3	Japan	1.000	35	Dominican Republic	0.955
4	Canada	1.000	36	Croatia	0.951
5	United Kingdom	1.000	37	Panama	0.947
6	Denmark	1.000	38	Czech Republic	0.947
7	Mauritius	1.000	39	Lithuania	0.944
8	Argentina	1.000	40	Estonia	0.939
9	Switzerland	1.000	41	Venezuela, RB	0.939
10	United States	1.000	42	Poland	0.938
11	Chile	1.000	43	Indonesia	0.937
12	Guatemala	1.000	44	Jordan	0.935
13	Singapore	1.000	45	Albania	0.931
14	Macedonia, FYR	1.000	46	Brazil	0.930
15	South Africa	1.000	47	Slovak Republic	0.929
16	New Zealand	1.000	48	Uganda	0.925
17	Australia	1.000	49	Bangladesh	0.920
18	Bulgaria	1.000	50	Kuwait	0.912
19	Vietnam	1.000	51	Turkey	0.904
20	Sweden	1.000	52	Mozambique	0.901
21	Korea, Rep.	1.000	53	Kazakhstan	0.893
22	El Salvador	1.000	54	Nigeria	0.893
23	Botswana	1.000	55	Hungary	0.890
24	Saudi Arabia	1.000	56	Armenia	0.870
25	Angola	1.000	57	Bolivia	0.867
26	Ecuador	0.985	58	Egypt, Arab Rep.	0.863
27	Yemen, Rep.	0.984	59	Russian Federation	0.855
28	Costa Rica	0.980	60	Colombia	0.846
29	Morocco	0.972	61	Georgia	0.842
30	Tunisia	0.970	62	Kenya	0.813
31	Peru	0.969	63	Romania	0.750
32	Israel	0.965	64	Sierra Leone	0.750

Note. First 25 countries are ranked based on super-efficiency DEA results.