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Is the role of international health aid on adult mortality efficient? Evidence from developing countries using DEA approach

Arshia Amiri[1] and Asim Afridi[2]

[1]*Collage of Economics, Shahid Chamran Ahwaz University, Iran*
E-mail: arshia09@yahoo.com

[2]*Aix-Marseille University, Marseille, France*
E-mail: asim.afridi@gmail.fr

ABSTRACT

This paper uses data envelopment analysis (DEA) method to investigate the efficiency rate of international aid on decreasing adult mortality developing countries over the period of 1995-2006. Result of efficiency rate of Aid on mortality confirms a high efficiency rate for developing countries. We also argue that our finding indicates that a high efficiency rate of international aid and health expenditures on decreasing mortality may be a signal of structural differences between low income, lower middle income and upper middle income countries.

Keywords: Efficiency, Health, DEA, Aid

JEL Classification: C12, C32, I10, I18

1. Introduction

There are many studies investigating the relationship between foreign aid and GDP such as Burnside and Dollar (2000), Easterly (2003), Easterly et al. (2004). Some of them also add "health" in their interpretations and try to relate Development Assistance for Health (henceforth, DAH) and Gross Domestic Product (henceforth GDP) indicators. For instance, Mishra and Newhouse (2010) showed that doubling per capita health aid is associated with a 2% reduction in infant mortality. Sachs (2005) supports a massive

scaling up of aid to help countries to achieve MDGs and implies that DAH improves health outcomes in developing countries by relaxing resource constraints and directly improving health service delivery (see Sachs 2005). Critics argue that aid can adversely affect a country's competitiveness (Rajan and Subramanian 2005) and overwhelm the management capacity of governments (Kanbur, Sandler, and Morrison 1999). While, supporter are of the view that aid leads to improved outcomes in poor countries through better health service delivery and relaxing resource constraints (Levine 2004).

While GDP per capita affects health outcomes, it is also well established that health can have a substantial influence on GDP per capita. This impact takes place through population size, participation and productivity (Bloom and Canning 2000; Arora 2001). Investment in healthcare service benefits significantly for economic growth in Southeast Asian region (Sawatdirakpong and Osathanunkul, 2012). If the effect of such the economic growth caused by the investment in healthcare service might translate into better income distribution, it would be able to reduce poverty in Southeast Asian countries too (Techanan and Suriya, 2012). Health affects participation in a number of ways. Healthier people are more likely to participate in the workforce and less likely to be absent from work due to illness, either personally or within families (Bloom and Canning 2000). The impact of health outcomes on economic growth is also probably a result of the strong relationship between these outcomes, particularly life expectancy, and educational investments (Becker 2007; Grossman 2004).

The aim of this study is to calculate the efficiency rate of international aid on decreasing adult mortality in a health framework for developing countries. It will do so using Data Envelopment Analysis (DEA) method in variable and constant return to scales. Efficiency is one of the most important concepts in an economic analysis. Since the appearance of the seminal work of Charnes et al. (1978), some of the major researches have thrust in DEA over the three decades (Cook and Seiford, 2009). It is essential to know how far a variable can be expected to change its amount by simply increasing its efficiency, without absorbing further resources (see Farrell, 1957). The investigation of efficiency on the relationship between mortality and international aid would be important to economists in making policies in order to improve the effects of aid on mortality by improving the health structure in countries.

2. Data and model

We use database for 90 countries on per capita international health aid, per capita GDP, per capita private and government health expenditure, and adult mortality developed by IHME and National Health Accounts, World Health Organization. All variables are used as growth amounts during the period of 1995 to 2006. We have included 34 low-income (LIC), 38 lower middle-income (LMIC), 18 upper middle-income (UMIC) according to World Bank classification. For the list of countries included in our data, see Table 1. The following health model is estimated for our country group:

$$Mortality = f(GDP + Aid + GHE + PHE)$$

Which mortality (one output) is a function of per capita GDP, international aid, per capita government health expenditure (GHE) and per capita private health expenditure (PHE; four outputs).

3. Data Envelopment Analysis method (DEA)

DEA analysis is the non-parametric mathematical programming approach to frontier estimation, proposed by Farrell (1957), was considered by only a handful of authors in the two decades following Farrell paper (Coelli, 1996). Authors such as Afriat (1972) suggested mathematical programming which could achieve the task. Charnes et al. (1978) proposed a model which had an input orientation and assumed constant returns to scale (CRS). Although this study uses DEA with macroeconomic data, DEA can also be used in the measurement of efficiency at microeconomic level such as a work of Singkharat et al (2012). Subsequent papers have considered alternative set of assumption, such as Banker et al. (1984) who proposed a variable returns to scale (VRS) model (Coelli, 1996). One form of their (VRS) model is

$$E_c = \max \sum_{k=1}^{t} u_k y_{rk} \Big/ \left(v_0 + \sum_{j=1}^{s} v_j x_{rj} \right)$$

$$\text{Subject to } 0 \le \sum_{k=1}^{t} u_k y_{rk} \Big/ \left(v_0 + \sum_{j=1}^{s} v_j x_{rj} \right) \le 1, i = 1,\ldots,n$$

u_k ; $v_j \ge \varepsilon > 0$; v_0 unconstrained in sign.

Where X_{ij} and Y_{ik} represent input and output data for the *i*th country with *j* ranging from 1 to s and k from 1 to t, and ε is a small non-Archimedean quantity (Charnes and Cooper, 1984; Charnes et al. 1979). Index r indicates the country to be rated, and there are n countries. When v_0 is set to 0, the assumption of constant returns to scale is imposed, and the model becomes that of Charnes et al. (1979), (Wu, Yang & Liang, 2006).

4. Results

This study uses DEA analysis to measure how far from the frontier different countries are located, i.e. indicating how much mortality may be decreased at the current level of aid, GDP and health expenditures. In other words, static efficiency exists at a point in time and focuses on the maximum potential of adult mortality which can be decreased

with the current economic and health structure of each country in comparison with other countries. According to table 1, we find a high efficiency rate for developing countries. The result of both CRS and VRS models is reported. Although, results based on VRS may be closer to reality and they are also higher than CRS ratios. In the following table we report the result of firm peers analysis for each of the countries. The result may be useful for each country in order to reach lower mortality growth, i.e. country peers analysis shows that if a country wants to have more efficient health system (efficient health expenditure growth, efficient economic growth, and efficient international aid growth) and gains lower mortality growth, and if it has potential, then may follow other countries which have more efficient health systems. Also a country peers weight shows the ratio which an inefficient country has to follow its peers to reach an efficient one at frontier function. For example, Bangladesh (1 code) may follow Sri Lanka (64 code) health system about 44.1%, Rwanda (26 code) health system about 1.2%, Chile (76 code) health system about 18.9% and Cote d`Ivoire (43 code) health system about 35.8%, to reach an efficient health system. According to table 1, the mean of CRS are 0.639, 0.640, 0.684 and 0.649 and the mean of VRS are 0.738, 0.720, 0.787 and 0.740, for LIC, LMIC, UMIC and in total, respectively. Comoros, Haiti, Rwanda, Zimbabwe from LIC, and Dem. Rep. Congo, Cote d`Ivoire, Jordan, Malaysia, Nicaragua and Sri Lanka from LMIC, and Argentina, Chile, Lebanon, Panama, Peru and Turkey from UMIC are at frontier function and gain full efficiency rate. Other countries which have the highest efficiency but not at frontier are: Bangladesh, Central African Republic, Nepal, Solomon Islands, Djibouti and Pakistan. Compared with high efficiency countries, Chad, Ethiopia, Ghana, Laos, Liberia, Mozambique, Gambia, Togo, Zambia, Angola, Bhutan, Cameron, China, Guyana, Mongolia, Nigeria, Senegal, Sudan, Vanuatu, Yemen, Botswana and Dominican Republic have lowest range in efficiency of health system. A large number of high efficiency rates are gained in the countries which have higher income and also a large number of low efficiency rates is obtained in low income countries. In another word, we argue our finding that a higher efficiency rate of international aid and health system on decreasing mortality may be a signal of structural differences between LIC vs. LMIC vs. UMIC. In the country peers and weights analysis, which is the result of DEAP computer software and also is available in tables 1, Zimbabwe, Congo, Democratic Republic and Cote d`Ivoire are the efficient patterns of most developing countries.

TABLE 1. Results of efficiency rates during the period of 1995-2006 using DEA

Countries name and code		Efficiency rate		Countries peers and weight									
		CRS	VRS	Code	Weight	Code	Weight	Code	Weight	Code	Weight	Code	Weight
Low income countries													
1	Bangladesh	0.706	0.909	64	0.441	26	0.012	76	0.189	43	0.358		
2	Benin	0.525	0.653	43	0.214	34	0.446	7	0.085	42	0.255		
3	Burkina Faso	0.686	0.758	7	0.253	52	0.712	34	0.035				
4	Burundi	0.715	0.784	43	0.498	42	0.069	34	0.201	7	0.232		
5	Central African Rep.	0.871	0.906	43	0.144	42	0.185	7	0.589	34	0.082		
6	Chad	0.357	0.564	7	0.208	52	0.365	34	0.427				
7	Comoros	1	1	7	1								
8	Congo, Rep.	0.88	0.894	43	0.27	42	0.045	26	0.038	15	0.647		
9	Ethiopia	0.561	0.563	42	0.243	15	0.348	7	0.095	43	0.313		
10	Gabon	0.708	0.834	43	0.04	42	0.247	34	0.332	7	0.381		
11	Ghana	0.445	0.58	42	0.182	43	0.072	34	0.553	15	0.180	7	0.013
12	Guatemala	0.699	0.705	43	0.144	42	0.062	7	0.782	34	0.012		
13	Guinea	0.557	0.737	43	0.024	42	0.047	34	0.532	7	0.397		
14	Guinea-Bissau	0.536	0.704	52	0.429	7	0.536	86	0.035				
15	Haiti	1	1	15	1								
16	Kenya	0.682	0.754	7	0.074	42	0.203	43	0.495	34	0.227		
17	Laos	0.498	0.5	42	0.336	7	0.242	15	0.422				
18	Liberia	0.283	0.35	42	0.293	73	0.235	34	0.472				
19	Madagascar	0.878	0.89	43	0.704	42	0.131	34	0.024	7	0.14		
20	Malawi	0.52	0.71	7	0.314	34	0.58	42	0.106				
21	Mali	0.549	0.623	43	0.215	34	0.266	42	0.012	7	0.507		
22	Mauritania	0.623	0.721	52	0.539	34	0.175	7	0.286				
23	Mozambique	0.103	0.432	52	0.179	34	0.613	7	0.208				
24	Nepal	0.838	0.999	15	0.541	26	0.456	42	0.003				
25	Niger	0.715	0.717	15	0.275	42	0.126	7	0.599				
26	Rwanda	0.751	1	26	1								
27	Sierra Leone	0.857	0.86	73	0.185	42	0.535	43	0.28				
28	Solomon Islands	0.832	0.913	43	0.375	42	0.18	34	0.2	7	0.245		
29	Tanzania	0.645	0.68	52	0.808	34	0.154	73	0.005	43	0.034		
30	Gambia	0.495	0.561	43	0.512	42	0.013	7	0.201	34	0.274		
31	Togo	0.447	0.583	42	0.049	7	0.443	34	0.508				
32	Uganda	0.681	0.707	42	0.114	34	0.098	15	0.324	43	0.465		
33	Zambia	0.473	0.518	7	0.123	43	0.619	34	0.207	42	0.05		
34	Zimbabwe	0.634	1	34	1								
Lower middle income countries													
35	Angola	0.521	0.572	73	0.004	52	0.848	34	0.148				
36	Belize	0.552	0.651	34	0.123	7	0.807	52	0.071				
37	Bhutan	0.454	0.52	26	0.301	42	0.403	15	0.296				
38	Bolivia	0.808	0.855	52	0.414	34	0.165	73	0.087	43	0.334		
39	Cameroon	0.419	0.591	42	0.271	34	0.637	7	0.092				
40	Cape Verde	0.656	0.663	52	0.935	34	0.034	73	0.006	43	0.025		
41	China	0.389	0.394	87	0.019	52	0.119	76	0.021	82	0.205	43	0.636
42	Congo, Dem. Rep.	1	1	42	1								
43	Cote d`Ivoire	1	1	43	1								
44	Djibouti	0.745	0.951	73	0.039	52	0.233	34	0.58	43	0.148		
45	Ecuador	0.785	0.803	43	0.822	52	0.115	7	0.026	34	0.037		

Countries name and code		Efficiency rate		Countries peers and weight									
		CRS	VRS	Code	Weight	Code	Weight	Code	Weight	Code	Weight	Code	Weight
46	Egypt	0.595	0.612	7	0.929	42	0.011	34	0.06				
47	El Salvador	0.82	0.856	52	0.819	73	0.022	43	0.031	34	0.127		
48	Guyana	0.454	0.456	42	0.185	7	0.489	15	0.326				
49	Honduras	0.835	0.872	52	0.607	73	0.033	43	0.232	34	0.128		
50	India	0.634	0.752	87	0.445	76	0.022	54	0.016	52	0.518		
51	Indonesia	0.541	0.664	34	0.395	42	0.141	7	0.464				
52	Jordan	1	1	52	1								
53	Lesotho	0.171	0.695	52	0.297	34	0.241	7	0.462				
54	Malaysia	1	1	54	1								
55	Mongolia	0.491	0.545	42	0.01	43	0.186	34	0.222	7	0.583		
56	Morocco	0.612	0.624	15	0.868	82	0.066	7	0.066				
57	Nicaragua	1	1	57	1								
58	Nigeria	0.291	0.447	42	0.403	34	0.597						
59	Pakistan	0.902	0.961	52	0.609	34	0.18	73	0.112	43	0.099		
60	Papua New Guinea	0.72	0.804	42	0.241	43	0.474	34	0.25	7	0.034		
61	Paraguay	0.674	0.786	43	0.487	34	0.372	42	0.141				
62	Philippines	0.618	0.687	73	0.005	52	0.139	34	0.245	43	0.61		
63	Senegal	0.578	0.592	7	0.666	34	0.05	42	0.284				
64	Sri Lanka	0.786	1	64	1								
65	Sudan	0.471	0.516	42	0.288	43	0.479	34	0.233				
66	Swaziland	0.14	0.732	73	0.134	34	0.866						
67	Syria	0.832	0.855	52	0.681	34	0.082	73	0.058	43	0.179		
68	Thailand	0.62	0.628	43	0.344	73	0.107	42	0.519	34	0.029		
69	Tunisia	0.649	0.664	15	0.556	26	0.053	42	0.003	43	0.388		
70	Vanuatu	0.451	0.47	42	0.058	73	0.132	34	0.111	43	0.699		
71	Vietnam	0.54	0.565	42	0.368	26	0.091	15	0.541				
72	Yemen	0.567	0.57	82	0.031	52	0.295	43	0.028	7	0.355	15	0.291
Upper middle income countries													
73	Argentina	1	1	73	1								
74	Botswana	0.097	0.47	52	0.17	34	0.629	7	0.202				
75	Brazil	0.805	0.814	82	0.237	15	0.363	7	0.093	43	0.306		
76	Chile	1	1	76	1								
77	Colombia	0.687	0.799	26	0.387	15	0.602	42	0.011				
78	Costa Rica	0.713	0.791	15	0.187	82	0.727	76	0.086				
79	Dominican Rep.	0.417	0.509	43	0.3	42	0.098	34	0.416	7	0.187		
80	Fiji	0.667	0.682	7	0.625	43	0.174	42	0.158	34	0.043		
81	Jamaica	0.7	0.815	7	0.362	52	0.455	34	0.183				
82	Lebanon	1	1	82	1								
83	Mauritius	0.58	0.592	7	0.382	43	0.541	42	0.044	34	0.032		
84	Mexico	0.492	0.544	43	0.052	26	0.252	42	0.696				
85	Namibia	0.332	0.612	34	0.906	73	0.094						
86	Panama	1	1	86	1								
87	Peru	0.825	1	87	1								
88	Suriname	0.666	0.854	82	0.429	54	0.206	86	0.365				
89	Turkey	0.751	1	89	1								
90	Uruguay	0.584	0.691	26	0.18	42	0.82						

Note: Efficiency rate in hear means that for example in Bangladesh 70.6% (CRS), and 90.9% (VRS): with the current health system in Bangladesh, Bangladesh can decrease the adult mortality as its effective amount. But reach to 70.6% (CRS), and 90.9% (VRS) of its potential decreasing. The 100% (1 amount in

table) efficiency rates mean the points which are at frontier function. In country peers analysis each country face to some codes of other countries. For example, Bangladesh (code 1) is face to 64, 26, 76 and 43 countries codes. It means that if Bangladesh wants to reach an efficient health system and be at frontier function, and then has to follow Sri Lanka, Rwanda, Chile and Cote d`Ivoire. Also, each country code in country peers analysis face to a weight. This weight defines the ratios which each country has to follow of its peers.

5. Conclusions

This study uses the DEA method to calculate the efficiency of international aid on decreasing mortality following a health model framework during 1995-2006. The result of DEA shows that a large number of high efficiency rates are gained in higher income countries and vice versa. We also argue that our finding indicates that a higher efficiency rate of international aid and health expenditures on decreasing mortality may be a signal of structural differences between LIC vs. LMIC vs. UMIC. Our explanation of the source of this result is the structural differences UMIC, LMIC and LIC, such as the share of public in health expenditures and the level of public infrastructure, and also the differences between population growth, share and the level of economic growth (see Erdil and Yetkiner 2010). Also, result of country peers analysis confirms that a large number of countries have to follow the health structure of Zimbabwe, Congo, Democratic Republic and Cote d`Ivoire to reach lower adult mortality growth in their health systems.

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