

Cost-benefit Analysis of Open High Performance Computing Platform : Case of KISTI's 4th Supercomputer

Myoung-Ju Koh, Jin Kim, and Kujin Cho

Abstract—Developed countries consider High Performance Computing (HPC) as one of key instruments to boost scientific and industrial competitiveness in the state level. To strengthen HPC technology capability, each country drives various investments and supports such as related R&D, HPC platform services, and professional manpower training. Korea also enacted "National HPC Promotion Act" in 2011. KISTI has endeavored to secure HPC resources and encouraged its utilization as an only provider open HPC platform service since the introduction of first supercomputer in 1988. KISTI's supercomputer is only public HPC resources in Korea therefore its effective uses and efficient resource allocation can have positive impact on national competitiveness. In this context, this study tries to analyze economic benefits of 4th supercomputer empirically based B/C analysis and then explore strategic significance of open HPC platform.

Research Keywords—Cost-benefit Analysis, Supercomputer, B/C Analysis, Open High performance Computing platform

1 INTRODUCTION

High Performance Computing (HPC) capacity is a key factor for the national competitiveness in terms of science and industry. Recent emerging trends such as the 4th industrial revolution and big data analysis are based on the computing capability. In this context, the United States that is the world's best HPC capacity has been actively invest and support the HPC program and policy after an enactment of High Performance Computing Act (1991). China and Japan also drive full investments to HPC related industry focusing on development of a world-class HPC with their own technologies. To strengthen HPC technology capability, each country drives various investments and supports.

Korea also tries to promote HPC technologies and related research. To achieve this, Korean government enacted National Supercomputing Promotion Act in 2011 (It is a second enactment of supercomputing in

the world.) and established the first master plan for the HPC in 2012. KISTI, that is the national supercomputing center by the law has only public HPC resources in Korea and provides open HPC platform services since the introduction of first supercomputer in 1988.

KISTI will launch new 5th supercomputing service in 2018 and the 4th supercomputing service will be terminated at the same time. At this point, empirical analysis of the 4th supercomputing's impact could give us some implications about open HPC platform. In this reason, this study tries to analyze economic benefits of 4th supercomputer empirically based B/C analysis and then explore strategic significance of open HPC platform.

2 RELATED WORK OR LITERATURE REVIEW

2.1 Review Stage

The cost-benefit analysis is one of the most prevalent economic analysis method for the rigorous assessment of public investments, also is a one of technical methods to select the best alternative by comparing and evaluating costs and benefits of various alternatives ([2][4][6]). Basically, the cost-benefit analysis is applied to calculate the future effects and costs of a policy or program, in some cases, it can be used to measure economic effects at the intermediate or final phase of

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policy or program([3], [1]).

Some studies tried to evaluate the supercomputing program even though there are few studies to examine the performance of supercomputer. Jun Koo et al.(2009) study explored economic effects of KISTI's 3rd supercomputer. However, this study's results did not explore socio-economic impact of the supercomputer. Jaesung Kim et al.(2010) analyzed economic impact of small business support using supercomputer. Although it explored meaningful effects of supercomputer, its results are limited to industrial perspective. That is, it focused too much on industrial impacts of open HPC platform.

In these contexts, this study tries to analyze economic effects of 4th supercomputer with broader perspective including scientific and industrial impacts such as support to basic science.

3 CONCEPT, MODEL AND METHODOLOGY

This study analyzes economic benefits of KISTI's 4th supercomputer based on cost-benefit analysis and then explore strategic significance of open HPC platform.

3.1 Methodology

This study uses Net Present Value(NPV) and Benefit/Cost Ratio(BCR) for the analysis. When the NPV is larger than 0 or BCR is greater than 1, it is examined to have economic feasibility. As a investment condition, US Office of Management and Budget suggests 1.25 of BCR standard and Preliminary Feasibility Test of Korea Development Institute applies 1.1~1.5 of BCR standard.

NPV is a measurement of profit that convert net profits that occur over whole period of policy or program to present value. That is, it discounts future cash flows so the calculation reflects the time value of money. The policy or program with positive NPV means that it has economic feasibility. The higher BCR, the more economically feasible. The BCR means the ration of profits to investment.

3.2 Model

The cost-benefit analysis of 4th supercomputer includes following cost and benefit items(Fig. 1). In terms of the cost, it includes system installation costs, operational costs, services and support costs.

The 4th supercomputer is only open HPC platform and service in Korea. The benefits include followings. First, one of benefit is from shared resources effect. It can reduce opportunity costs that occur when each individual or institute build the HPC system individually.

- Open Hardware effect (joint utilization of HPC resources): cost saving effect that reduces hardware construction and operation costs when each

Items		Measurement Variables
Costs		Costs for Introduction and Operation of 4 th Supercomputer
Benefits	Joint Utilization (open platform effect)	Joint Utilization of H/W, S/W, operational manpower
	User support services	Paid Accounts, Consulting for users, optimization/parallelization
	Utilization and Application effect	R&D effects for Basic Science, Benefits from support for small business

Fig. 1. Cost- benefit analysis items

4th supercomputer users individually establish their own hardware systems.

- Open Software effect (joint use of common softwares): cost saving effect that reduces purchase of software (KISTI's open HPC platform provides users common softwares.)

Secondly, the benefits can include KISTI's various services through open HPC platform. 4th supercomputer provides not only the HPC Hardware and software resources, but also optimization and parallelization services, consulting services for HPC applications at no charge. We examine the expected cost if the services would be a charge. The willing to pay of users for the services can convert to economic values. It can be benefits of open HPC platform.

Third, the benefits are social benefits that can be produced from broad utilization of HPC. The 4th supercomputer is only open HPC infrastructure so that be used by industry as well as academic field. Even though it is difficult to measure quantitatively, this study explores the effect through R&D effect and industrial effect.

- R&D effect: multiply R&D costs by benefit inducement coefficient applying the Mansfield method that is widely used to estimate social rates of return
- Industrial effect: multiply economic benefits from modeling & simulation support for small business by number of support cases

4. ANALYSES

This analysis calculates the costs and benefits by Korean won and the analysis period ranges from 2007 when the 4th supercomputer is introduced to 2015. In this analysis, 5.5% of Korea Development Institute was applied as social discount rate.

The 4th supercomputer is composed of 4 sub-systems. The Fig 2. shows the establishment and operation costs of the 4th supercomputer.

The benefits can be explored from Fig 3. The joint utilization and user support are based on Jun Koo et al(2009)'s method. The utilization effects are estimated from Mansfield(1991) and Jaesung Kim et al(2010).

Annual Costs (Million won)		2007	2008	2009	2010	2011	2012	2013	2014	2015
4 th supercomputer introduction and installation	GAIA 1 st ('07. Sep)	-	1,840	1,128	416	416	416	-	-	-
	GAIA 2 nd ('09. Jun)	-	-	777	4,056	4,056	4,056	1,014	-	-
	TACHYON 1 st ('08. Jan)	-	3,290	6,580	368	368	368	184	-	-
	TACHYON 2 nd ('08. Sep)	-	3,288	6,576	6,576	11,782	-	-	-	-
Operation and Service		5,956	5,694	7,387	8,094	9,327	11,132	8,434	7,363	7,329
Sum		5,956	14,112	22,448	19,510	25,949	15,972	9,632	7,363	7,329

Fig. 2. cost of the 4th supercomputer

Annual Benefits (Million won)		2007	2008	2009	2010	2011	2012	2013	2014	2015
Joint Utilization effect	HW	38	10,589	14,243	31,628	64,917	42,500	42,278	29,237	30,541
	S/W	1,269	42,993	39,026	45,348	35,281	36,564	38,140	54,474	57,335
	Operational Manpower	1,862	33,519	38,908	39,140	33,355	41,198	40,848	42,049	40,786
	Subtotal	2,969	87,101	92,177	116,116	133,553	120,262	121,267	125,760	128,661
User support services	Paid Account	1,204	1,204	992	1,537	2,033	2,127	1,750	1,684	1,573
	Consulting for Users optimization/parallelization	5	4	5	6	6	2	7	8	9
	Subtotal	8,101	543	21,997	1,762	1,147	9,661	7,929	8,032	8,088
Subtotal		9,310	1,751	22,995	3,325	3,186	11,790	9,686	9,724	9,670
Utilization and Application effect	Use for Science	20,953	49,646	78,972	68,637	91,289	56,189	33,886	25,902	25,785
	Use for Industry	190	174	128	22	183	173	128	172	203
	Subtotal	21,143	49,820	79,100	68,659	91,471	56,362	34,014	26,075	25,988
Total Benefits		33,422	138,673	194,272	188,100	228,210	188,415	164,967	161,558	164,319

Fig. 3. Benefit of the 4th supercomputer

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Costs	5,956	14,112	22,448	19,510	25,949	15,972	9,632	7,363	7,329
Benefits	33,422	138,673	194,272	188,100	228,210	188,415	164,967	161,558	164,319
Costs (present value)	9,141	20,529	30,952	25,499	32,146	18,755	10,721	7,768	7,329
Benefits (present value)	51,293	201,724	267,871	245,839	282,173	221,244	183,612	170,444	164,319
NPV (cumulative)	42,152	223,348	460,266	680,606	931,172	1,133,662	1,306,553	1,469,229	1,626,218
BCR	10.99								
ROI	998.7								

Fig. 4. Cost-Benefit Results of 4th supercomputer

As the analytic results, we can get NPV, BCR, ROI of 4th supercomputer(Fig 4).

5 CONCLUSIONS

The analysis results show that the 4th supercomputer's NPV is 1,626,218million won, BCR is 10.98, and ROI is 998.7%. It means that open HPC platform using supercomputer has more significant economic effects than other public goods or public infrastructures. It can be summed up in the following reasons.

First, the benefits of open HPC platform cannot be limited to only economic profits. Therefore, this analysis tries to include social and national impact of HPC platform because 4th supercomputer is national strategic resource.

Secondly, the effect needs to include not only economic and industrial effects, but also basic science R&D. The 4th supercomputer are used in various field including academies and industries because it is only open HPC platform in Korea.

Lastly, optimal replacement period of HPC is 5 years but the 4th supercomputer has been operated for 9 years. The increase of operational period can cause higher

costs because of obsolescence, however it has more influence on increase of benefit in this case.

As the analytic results, 4th supercomputer's benefits are higher than 3rd supercomputer(BCR: 9.18[3]). It can show the importance of open HPC platform as national strategic resources.

However, this study has some limits that the intangible effects could be over-estimated. It is because that this analysis tries to consider various benefits from macroscopic perspective. This potential problem will be improved at the follow-up study.

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