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Role of Capital Expenditure in the Economic Evaluation of National R&D Investment Project for Cooperative Research of University-industry-research Institute: Cases of Woodchip Power Plant Construction†

국가 R&D 산학연협동연구 투자계획안의 경제성 평가에서 자본적 지출의 역할: 목재칩을 이용한 발전소 건설의 경우를 중심으로

여희정(Heejung YEO)*

목 차

국 문 요 약

본 연구는 투자계획의 경제성분석 계산과정의 변화가 어떻게 R&D 투자결정에 영향을 미치는지를 분석하고자 한다. 이를 위해 본 논문에서는 목재칩 발전소 건설의 국가 R&D 산학연협동연구의 투자계획안 경제성 평가를 위해 자본적 지출의 역할을 탐색한다. 연구 결과 자본적 지출항목을 수익성분석에 포함시키는 것만으로도 건설계획의 투자전망에 영향을 미치는 것으로 나타났다. 본 연구결과는 국가 R&D 과제의 예비타당성 평가에 여러 산업의 특성을 고려한 계산의 표준화가 필요하다는 것을 시사한다.

핵심어 : R&D 투자 계획, 예비 타당성 분석, R&D 가치평가, 경제성 평가

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* Assistant Professor, College of Social Science, Keimyung University, heejungyeo@kmu.ac.kr, 053-580-5581

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ABSTRACT

The aim of this study is to provide evidence of how a change in the process of calculating the economic valuation of a project can affect the decision regarding national R&D investment. The paper examines a R&D project of cooperative research program of university-industry-research institute for the construction of a woodchip power plant to explore the role of capital expenditure in the economic evaluation of an investment project. The paper finds that the simple introduction of capital expenditure in the profitability analysis affects the perspectives on the construction plan. The results of this study indicate that standardization of the calculation process that takes different characteristics of industries into account is needed in the preliminary feasibility study of national R&D projects.

Key Words : R&D Investment Project, Preliminary feasibility study, R&D valuation, Economic evaluation

I. Introduction

R&D is a driving force to increase national competitive advantage. Governments in many countries have increased the level of R&D investment projects. Since 1990s, the Korean government has significantly increased the national investment in R&D and spent the highest amount on R&D relative to GDP of any country. However, the collection of royalties and the commercialization level are decreasing. Moreover, more and more large-scaled projects have been planned even if these did not generate expected performance. Issues receiving much social attention in relation to R&D investments are among others whether investments in certain projects have been indeed made in appropriate scales and whether the outcomes of the investments satisfy demand for items socially required (Lee, 2004).

Most projects on R&D investment insist that the project is highly optimistic about the feasibility and commercialization. Cho et al. (2005) indicated that the efficiency of R&D investments in South Korea was not so high. They argued that although R&D activities in South Korea contributed to the creation of new knowledge, the productivity of R&D work forces was low and the degree to which R&D results were connected to economic outcomes was also low.

Ha (2014) insists that the selection process of research projects is not neutral and rational, but is fractional and political. A decision making to allocate public resources is a political activity. Decisions regarding scientific R&D projects are likely to be concentrated in a closed circle of corporate, banking, and military leaders. Scientists as political actors have their own interests, such as economic interests, individual honor as a scientist, professional clout in the science area, etc. Various coalitions of scientists compete for getting more funding for their own science field. The accountability of decision making can be enhanced not only by eliminating information asymmetry, but also by arranging institutional apparatus.

However, clear ex ante case surveys or ex post facto analysis of risk factors that may be faced by R&D projects have not yet been actively conducted and empirical studies for effective management of risk factors have not yet been accumulated either for Korean cases (Lee and Yoon, 2014). In line with the trend for R&D budgets to be enlarged, the necessity of total periodic systems for effective management of national R&D projects is increasing. The aim of this study is to provide evidence how a change in the calculation process in the valuation of a project can modify the decision of R&D investment.

The paper is organized as follows. Following this introduction, the second section presents evaluation of national R&D investment projects. Section III identifies the factors of private investment decisions. Section IV shows the process of R&D evaluation of a plant construction project. Finally, some concluding remarks are provided in Section V.

II. National R&D investment projects

Accountability for the transparency of budget execution and whether outcomes were efficiently (productively) yielded should be the most important criteria of evaluation in national R&D investments. The government has both responsibility and authority for R&D investment related budget planning and the outcomes of budget execution. Because of the nature of R&D investments, however, although the principal manager for budget planning and execution is superficially the government, the agents that actually use the budgets are the scientific researchers or research groups composed of universities, firms, and institutions in many cases. On security of expertise, they also participate in government level R&D planning. The possibility of the principal-agent problem and moral hazard always exists (Park and Lee, 2009). Therefore, controversies over whether budget execution is essentially for the country per se or for research groups occur unceasingly and in particular, when the purposes or directions of the two cases are different from each other. In addition, opportunity costs should be incurred by choices inevitably.

Furthermore, in cases where R&D activities are centered on publicness or originality, the analysis or verification of the R&D activities' economic and social inductive effects may be relatively difficult because of economic gestation periods, high risk, and high level of competition (Park and Lee, 2009). Therefore, assessment of the relationships among policy establishment, budget planning, and outcome creation following budget execution is very important and should be carried out without fail.

Ha (2014) emphasized the necessity of public control in the selection of government R&D projects. He argues that the government and the public should engage in and control the selection process of government R&D projects. Priority setting instead of the first-best choice can ultimately cause primary inefficiency and in the case of governmental investments, even crowding-out effects can be caused to push out private investments.

1. R&D projects evaluation

The government R&D projects are characterized by the large scale of funding, the complexity of technology, and the heterogeneity of objectives. The heterogeneity of the objectives of national R&D programs makes it difficult to compare the relative performance of various projects. Jung and Seo (2010) argue that a multiple criteria should be considered to evaluate the projects.

An evaluation of the impact of research is linked to the innovative process model (Sirilli and Tuzi, F., 2009). A traditional linear-type model assumes that innovation proceeds sequentially through phases involving basic research, applied research, development, production and marketing (Sirilli and Tuzi, F., 2009). Although more investment in R&D is desirable, there is no automatic mechanism by which the technology created leads to increased productivity and product or process innovation.

Sirilli and Tuzi (2009) interviewed 36 project managers who have participated in national R&D research projects. The interviewees indicated that use of the new knowledge or new infrastructures requires medium-long periods of time. The authors argue that in socio-economic terms, making evaluations one or two years after the project has ended may lead to inaccurate conclusions simply because some of the effects may not yet be apparent. Sometimes it is impossible to evaluate the development of socio-economic effects regardless of the time factor.

The Court of Auditors in Italy proposed indicators for research and innovation to evaluate research projects (Sirilli and Tuzi, 2009). These are number of scientific publications, number of patents, number of prototype, number of transfer actions, grants, contracts for researchers, employment created and maintained, research centers and universities involved as partners, and the duration of company involvement. Indicators illustrate a specific aspect of a complex, heterogeneous reality.

The order of importance of the individual indicators varies according to the type of project: research projects give more importance to scientific publications and patents whereas technology transfer and infrastructure development projects, by their very nature, give more importance to impact indicators such as turnover linked to innovation, exports, new companies created (spin-offs) and the activation of new services. It provides benchmarks that are suitable for area of intervention. Even though a series of parameters have been identified to evaluate the socio-economic impact of their projects, serious problems persist when defining indicators and collecting and standardizing data.

Sirilli and Tuzi (2009) argue that research projects have a higher scientific impact and a lower socio-economic impact, whereas for transfer and infrastructure projects, the opposite is true, with a lower impact on the scientific community and a higher socio-economic effect. The most appropriate methodology would be to evaluate each plan by appointing a suitable number of experts chosen from those who were involved in its implementation and external experts capable of independently evaluating the 'value' of the results and their impact. In this way, a reasonable 'balanced' evaluation could be made based on various points of view.

2. Preliminary feasibility analysis

The national R&D project management system in South Korea consists of a preliminary feasibility evaluation and an ex post facto evaluation. The Korean government has inaugurated a system for prefeasibility studies on large-scale publicly financed projects such as road, harbor, or airport construction (Lee and Park, 2011). Preliminary feasibility surveys have been conducted in earnest from 2008. These surveys included policy feasibility and technical feasibility in addition to economic feasibility items that are basic items of feasibility surveys (Lee and Yoon, 2014). Among the three sectors of feasibility evaluation, in the case of the technical feasibility sector, planning and technical risks were as indicators to consider risk factors.

To evaluate a project ex ante holds many difficulties. The difficulties contain high uncertainties including private uncertainty and market uncertainty (Lee and Yoon, 2014).

In the case of the economic feasibility, a sort of market risks is considered under the concept of benefits and in the case of the policy feasibility sector, political risks, legal risks, financial risks, and stakeholder risks are set as variables to analyze feasibility. The feasibility study as a tool of deliberation is based on the way of peer-review. The peer-review system has its own limits which could not function properly to stop any exaggerated proposal.

Except for preliminary feasibility surveys, investment funds of individual projects are not examined in advance or managed separately by stage or year in the national R&D project management system. The current management of national R&D projects places emphasis on selecting projects within the range of project budgets and settling research funds rather than examining project costs in advance. In addition, evaluation of national R&D projects does not evaluate whether implemented or not by individual project or calculate appropriate investment cost amounts in advance (Ahn et al., 2014).

Currently, budget planning and adjustment and evaluation of the outcomes of budget execution are quite insufficient in South Korea and evaluation is concentrated on outcomes by project (Park and Lee, 2009). Concrete R&D project evaluation methods have been continuously supplemented and developed through yearly outcome evaluation implementation plans and self-evaluation (Kim, and Ha, 2013). However, in the sophisticatedly subdivided processes of project evaluation implemented after completion of projects, only less than one third of the total amount is evaluated in many cases (Park and Lee, 2009).

In such evaluation systems, the results are likely to show subjective tendencies (Ahn et al., 2014). Furthermore, in the current management systems, the linkage between information on preliminary feasibility surveys and information on survey, analysis, and evaluation which are ex post facto evaluation is not close. It makes difficult to effectively manage the processes ranging from project planning to completion. The content and direction targeted in project plans may be quite different from those in the results in all cases.

III. Private sector investment decision factors

Government investments in R&D seek to influence the private sector to make investments in technological fields important to the country. Capital investment decision or capital budgeting is one of the most important financial decisions for firms (Egbide et al., 2013). This decision determines the future and growth of the firm. Capital investment decision in technology is a process of identifying, analyzing and selecting projects whose returns are expected to increase in the future. It involves the allocation of capital or the commitment of funds to long term assets or capital assets. The R&D project participant firms should make decisions with regard to the type of projects to invest in based on its associated value, risk and return, and how such investments have to be financed.

Feasibility analysis aims to find the strengths and weaknesses of a proposed project, opportunities and the resources required to carry through the prospects for success. Financial feasibility analysis looks at the key metrics to assess the project's final outcomes. The most common metrics include NPV, IRR, ROE, ROI. What should be included in the key metrics depends on the type of project, funding strategies and legal structure.

Many financial models have been built to help determine growth and expansion plans that require expenditure on equipment and other assets. Understanding the relationship between capital expenditure, depreciation, and the financial statement is a very important aspect of financial modeling. Capital expenditure (CapEx) is the spending of money to buy or fix assets. CapEx is typically related to buildings, property, and equipment. CapEx has implications for all financial statements. With respect to the income statement, depreciation expense will increase due to the inclusion of additional assets to depreciate. On the balance sheet Long Term Assets and related line items will increase because of the purchase of assets. Cash flow from investing will change to accounts for the cash used to purchase the assets. Increased depreciation expense will affect net income. The cash will be decreased because cash out the door to purchase with CapEx.

Investment projects can be evaluated using either discounted cash flow criteria such as the Internal Rate of Return (IRR), Net Present Value (NPV), profitability index, or non-discounted cash flow techniques such as Pay Back Period (PBP) or accounting rate of return.

The discounted cash flow drives the value of a company (Bosch et al., 2007). The key value drivers of discounted cash flow are growth and the return on invested capital relative to the cost of capital. Both value drivers are implicit in the net present value.

The payback period method is the most popular and most widely recognized traditional method of evaluating investment projects. It is defined as the period in which an investment is recovered by the cash inflows it produces. While this method measures the speed of recovery of the capital expenditure, it ignores the time value of money principles. For this reason the payback method is often used to supplement information. The payback method calculates the number of years required for cash inflows simply to equal cash outflows.

Pae and Yoon (2012) examine cash flow forecast report accuracy. They find that forecasting cash flows is different from forecasting earnings. Cash flow information should prove useful in understanding the quality of reported earnings, as well as in determining the true financial conditions and operating performance of firms, because cash flows are less susceptible to manipulation due to their greater visibility and scrutiny.

The future benefits from every project should be expressed in terms of cash flows and not income flows. Cash flows should be determined on an after-tax basis (Egbide et al., 2013). This means that the appropriate discount rate as well as all forecasted flows must be stated in after tax values.

Dutta and Reichelstein (2012) examine the profitability of an investment project by introducing a multi-period principal-agent model in which a manager has superior information on the project. They find that the principal can delegate the investment decision to the better informed manager and reward the manager in proportion to the achieved residual income. The principal creates robust investment incentives by adopting a depreciation method that matches periodic project cash flows with an appropriate share of the initial investment expenditure.

1. Cash flow

Cost accounting is particularly important in engineering economic analysis (Sullivan et al., 2012). It serves to determine the actual cost of products or services, to provide a rational basis for pricing goods, and to provide a means for allocating and controlling expenditures. The exact determination of costs is not simple. As a result, some of the procedures applied are arbitrary devices that may contain a considerable percentage error particularly with respect to the actual cash flows. The traditional approach uses the following variables to evaluate a plant construction investment plan regarding economic viability.

Cash flow in any operations year, *i*, normally calculated from the usual relation:

$$CF_i = R_i - T + D_i - CapEx$$

where R is the revenue (EBIT), T is the annual tax rate in corporate income, D_i is the annual Depreciation and CapEx is the capital expenditure.

Depreciation is an accounting concept that establishes an annual deduction against before-tax income such that the effect of time and use on an asset's value can be reflected in a firm's financial statements (Sullivan et al., 2012).

2. NPV

The debate in the finance literature on the net present value (NPV) and the internal rate of return (IRR) as capital budgeting criteria concluded that the NPV is the best measure of the value created by a project under analysis (Bosch et al., 2007). However, the IRR is widely used among decision makers because it allows analysts to know the margin between the return of the project and the required return. Managers making capital budgeting decisions prefer percentage measures to monetary unit measures. However, the net present value incorporates the complete set of value drivers of the investment project, with the internal rate of return being just one of them (Bosch et al., 2007).

The Net Present Value (NPV) measures a potential increase in the assets or book value above an expected return that would result from constructing and operating the proposed plant over the entire construction and operations period (Mellichamp, 2013). The initial investment expenditure is allocated across the subsequent periods so as to annuitize the project's net present value (Dutta and Reichelstein, 2012). This ensures the project is profitable relative to the hurdle rate making a positive contribution to the income performance of the firm.

$$NPV = -C_o + \sum_{t=1}^{n} \frac{CF_t}{(1+i)^t}$$

C_0=investment, CF_t=cash flows of the investment project under analysis, i=the opportunity cost of capital at which we discount future cash flows.

A positive NPV denotes a potential investment that benefits the organization. The more the value of NPV is increased, the more attractive the project. However, it is possible that two similar profitable projects will generate equal values of NPV but may require different levels of capitalization.

The NPV depends on the distribution of cash flows, their size, and the life of the project. Thus, selecting from a set of mutually exclusive projects the project with the highest net return on capital does not mean selecting the project with the highest NPV (Bosch et al., 2007).

3. IRR

The Internal Rate of Return is the rate of return embedded in the cash flow sequence of the investment project that makes the NPV equal to zero.

$$-c_o + \sum_{t=1}^{CF_t} \frac{CF_t}{(1+IRR)^t} = 0$$

The IRR is used to measure the overall rate of return for a proposed project. IRR is defined as the value of the discount rate that sets NPV as equals to zero. The fixed discount rate is allowed to vary in a trial - and - error search.

The IRR method solves for the interest rate that equates the equivalent value of an alternative's cash inflows to the equivalent value of outflows. The IRR is referred to as the breakeven interest rate (Sullivan et al., 2012). For a single alternative, the IRR is not positive unless both receipts and expenses are present in the cash flow pattern, and the sum of receipts exceeds the sum of all cash outflows.

4. Capital cost

As for the CEO of a firm considering a new investment, it is hard for him to approve the project if he ignores the external financing costs. A firm engaged in investment in a stock market can withdraw the investment by selling the stocks if the price of stocks plunges and the firm records a significant loss. In contrast, if the firm decides to construct a plant, and the plant has been built, there is no way to recover the invested capital, even if market prospects for the product change negatively.

Some implicit assumptions are made whenever the NPV and the IRR have been calculated. When firms calculate a NPV, they have two options. One is that they can use their own internal funds to finance the project during each year of construction, thereby effectively using internal funds that could be earning dividends not distributed to the shareholders. The other is that they can borrow funds from an external source. Both interpretations are equivalent, as the firm is paying an opportunity cost, which is the average year-over-year increase in value of company assets on the costs of construction over the lifetime of the project.

The opportunity cost can be viewed as a minimum rate of return of an investment. The minimum rate required is a policy issue resolved by the top management of a firm. However, most papers on the economic analysis of a project assume that the explicit financing costs of the plant project are null; that is, the enterprise concerned finances the construction using their own capital. This hypothesis is unrealistic. The cost of financing of a project influences annual cash flows and the ultimate profitability of a project.

Dutta and Reichelstein (2012) argue that the capital charge rate must be set at a hurdle rate which exceeds the firm's cost of capital. The hurdle rate is the firm's internal rate of return. The project cash flows must yield a non-negative NPV when discounted at the hurdle rate.

When the project is risky, the optimal investment policy leads to an under-investment in comparison to risk free projects, and the principal will apply a higher risk-adjustment hurdle rate. According to Dutta and Reichelstein, (2012), this increase in the hurdle rate does not induce a higher capital charge rate when the investment decision is delegated to the manager. The firm should provide a subsidy in the form of a lower capital charge rate, below the hurdle rate for risk free project to motivate the risk-averse manager to accept the incremental risk.

Mellichamp (2013) proposes criteria on annual per cent increase in NPV to compensate for the generic risks of each project. He summarizes three levels of compensation in terms of the nature of new chemical projects and investment risk. As 〈Table 1〉 shows, when the project is very risky, the annual return required should be more than 20%.

〈Table 1〉 Return requirements

Nature of plant	Level of investment risk	Annual return required, %
-	Negligible	0-5
-	Low	5-10
Commodity chemical	Moderate	10-15
Specialty chemical	High	15-20
High value	Very high	〉20

Source: Mellichamp (2013)

IV. Evaluation of power plant profitability

1. Description of plant construction project

This paper examines an example of a R&D investment project in woodchip power plant to analyze the profitability of capital investment by using discounted cash flow methods. Three electricity gasification power plants to generate energy have been evaluated: 1) gas engine, 2) gas turbine, and 3) gas & turbines, as well as different plant sizes. Various costs, profits and sales data of the woodchip power plants were obtained using the Aspen Plus simulator. 〈Table 2〉 shows a summary of the economic data for gasification systems and plant sizes.

〈Table 3〉 presents the key parameters of the conceptual power plant. Working days are set as 8000 hours per year, which is equivalent to 91% of the annual plant capacity. The construction time is assumed to be one year. The startup period is 4 months due to the medium size of the plant. During this period, 50% production is achieved with an expenditure of 100% in both variable and fixed expenses. The operation period is assumed to be 10 years long. The depreciation period was set to be 10 years. A corporate income tax rate of 25% of gross profit was used. It is assumed that the price will increase by 2.5% every year based on the price report published by the Bank of Korea in 2013.

〈Table 2〉 Economic values with respect to plant size and type

Plant size (tons/day)	Gas engine				Gas turbine				Gas & steam turbines			
	50	150	300	500	50	150	300	500	50	150	300	500
Total installed cost (TIC, M$)	12.9	20.9	35.9	58.2	14.2	23.2	36.6	58.0	16.2	27.2	43.5	66.6
Total direct and indirect cost (TDIC, M$)	19.8	32.5	57.1	92.2	21.8	13.4	57.1	90.0	24.7	42.3	68.5	104.0
Project contingency (PC, M$)	4.0	6.5	11.4	18.4	4.4	7.2	11.4	18.0	4.9	8.5	13.7	20.8
Fixed capital investment (FCI, M$)	23.8	39.0	68.5	110.7	26.2	43.1	68.5	108.0	29.7	50.7	82.2	124.8
Working capital (WC, $)	3.6	5.9	10.3	16.6	3.9	6.5	10.3	16.2	4.5	7.6	12.3	18.7
Total Capital Investment (TCI, M$)	**27.4**	**44.9**	**78.8**	**127.3**	**30.1**	**49.6**	**78.7**	**124.2**	**34.1**	**58.4**	**94.6**	**143.5**
Electricity production rate ($EPR \times 10^6$, kWh/yr)	20.6	61.7	123.3	205.6	15.0	55.7	124.7	224.4	25.8	93.4	206.9	369.5
Hot water heat ($\times 10^3$, Gcal/yr)	24.8	74.4	148.7	247.9	29.6	79.5	147.5	231.7	20.3	47.1	76.8	106.7
Specific capital cost (SCC, $/(kWh/yr))	1.3	0.7	0.6	0.6	1.9	0.9	0.6	0.6	1.3	0.6	0.5	0.4
Total woodchips cost (M$/yr)	0.8	2.5	5.0	8.3	0.8	2.5	5.0	8.3	0.8	2.5	5.0	8.3
Total utilities cost (M$/yr)	0.0	0.1	0.2	0.4	0.0	0.1	0.2	0.4	0.0	0.1	0.2	0.4
Fixed cost (M$/year)	1.1	1.4	1.7	2.0	1.5	1.9	2.4	3.0	2.2	2.3	2.9	3.8
Total Production Cost (TPC, M$/yr)	**2.0**	**4.0**	**6.9**	**10.8**	**2.4**	**4.5**	**7.6**	**11.8**	**3.1**	**5.0**	**8.1**	**12.6**
Electricity profit (M$/yr)	2.0	6.0	12.1	20.1	1.5	5.5	12.2	22.0	2.5	9.2	20.3	36.2
Renewable energy cost profit (REC, M$/yr)	0.8	2.5	4.9	8.2	0.6	2.2	5.0	9.0	1.0	3.7	8.3	14.8
Hot water heat profit (M$/yr)	1.4	4.2	8.3	13.9	1.7	4.5	8.3	13.0	1.1	2.6	4.3	6.0
Annual Sale Revenue (ASR, M$/yr)	**4.2**	**12.7**	**25.3**	**42.3**	**3.7**	**12.1**	**25.5**	**43.9**	**4.7**	**15.5**	**32.8**	**57.0**

〈Table 3〉 Economic assumptions

Parameters	Assumption
Plant availability	8000 hr/yr
Plant depreciation period	10 years
Construction period	1 year
Startup time	4 months
Plant lifetime	20 years
Income tax rate	20%
Interest rate	5%
Annual increase of price level	2.5%

2. Role of capital expenditure in the cash flow calculation

Pae and Yoon (2012) state that there are greater concerns over the accuracy of cash flow forecasts than earnings forecasts. They argue that cash flow information is useful to understand the implications of current earnings on future cash flows and to assess the financial viability of companies. A capitalization of after-tax cash flows method has been selected to value a project. One of the differences for the valuation is the assumption of future capital expenditures. By applying the capitalization of earnings method, the firm determines expected future cash flows into perpetuity. It is necessary to estimate the cash flows required to continue funding capital expenditures.

The capital expenditures include expenses like building renovations or upgrade of equipment which adds value to the assets of a company. Moreover, the capital expenditures generally depreciate with time and feature a long life. In accounting terms, expenditure is considered as a capital expenditure if the fixed asset is a recently purchased capital (fixed) asset or an investment that is helpful in improving the useful life of an existing capital asset. The cost of asset would be spread out over a specific period of time. This is called capitalization. The balance sheet also shows the asset's depreciation. This may be defined as a decrease in the asset's value over time.

Capital expenditure = purchase of new fixed assets + upgrades to existing fixed assets - sale of any fixed assets

The goal is to determine the level of ongoing capital expenditures required to sustain the existing level of cash flows, and then to adjust depreciation accordingly. The chemical industry is capital intensive. When the subject firm operates in a capital intensive industry, greater emphasis should be placed on forecasted CapEx.

Normalization of capital expenditures requires two steps (Coffey, 2009). First, depreciation is added back to net income, because depreciation is an expense that does not use cash. Second, capital expenditures is subtracted from net income, because CapEx is a use of cash that does not affect income until the assets are depreciated. As Coffey (2009) emphasizes, depreciation should be adjusted to capital expenditures. Depreciation expense will equal the cash needed to purchase capital assets. Fixed assets are used in the production of cash flow, will be replaced when exhausted, and have been depreciated over their estimated lives. It is reasonable to assume that in the absence of growth and inflation, depreciation will equal capital expenditures into perpetuity. Current depreciation is based on past capital expenditures.

It is important to make an appropriate determination of future capital expenditures requirements (Coffey, 2009). This includes an understanding of the business plan, the depreciation policy, the nature of the industry, and the impact of technology. Depreciation is then adjusted based on projected capital expenditures. Finally, it is necessary to determine whether to increase capital expenditures to account for the impact of growth and inflation. In this study, we normalize deprecation and capital expenditures by making them equal.

3. Profitability of power plant construction

Cost-benefit analysis can be used to analyze and strengthen government choices, including whether to undertake an infrastructure project, provide a service, pass a regulation or produce a public good (Harrison, 2010). Most government policies or projects give rise to a stream of costs and benefits over time. A key element of the cost-benefit analysis is the use of a discount rate to compare costs and benefits received at different points in time.

The choice of discount rate can make a significant difference to whether the present value of a project is positive, and to the relative desirability of alternative projects, especially when costs and benefits accrue at different times and over long periods (Harrison, 2010). Yet there is little agreement about the appropriate discount rate. The social discount rate is used to analyze the construction of woodchip power plant.

〈Table 4〉 shows profitability analysis for capital investment by different modes of calculation process in terms of their size and type for 10 years. The impact of CapEx and different social discount rates have been taken into account for the woodchip power plant investment project. The table presents NPV, ROI, payback periods, IRR for each investment plan. It is observed that the difference of cash flows is quite large in each calculation procedure system. As a result, the difference influences the payback periods.

The capital charge rate must be set at a hurdle rate that exceeds the firm's cost of capital. The hurdle rate is effectively the firm's internal rate of return: in order for the project to cover the capital costs, the project cash flows must yield a non-negative NPV when discounted at the hurdle rate (Dutta and Reichelstein, 2012). A profitable project —profitable relative to the hurdle rate—makes a positive contribution to the performance measure for the firm in every period.

〈Table 4〉 provides NPVs based on cash flows generated from different calculation processes in terms of CapEx. For this study 3 hurdle rates of return in the investment project were used, specifically, 10%, 7%, and 5%, and the changes of value in NPVs were observed for each rate. Most NPVs and IRR are negative when considering the CapEx. A negative NPV means a loss of potential investment; thus the project is not profitable for the firm.

When CapEx is taken into account in the free cash flow calculation process, the average payback period exceeds 10 years; 10 years for gas engine, 11 years for both gas turbine and gas & steam turbine. In contrast, without considering CapEx the average payback period is 6.9 years; 7 years for gas engine, 7.3 years for gas turbine, 6.3 years for gas & steam turbine. A firm will believe that it needs just 7 years to recover the capital invested. Thus, it is more likely to make an investment decision if CapEx is not considered. However, it is observed that these financial parameters show positive values and higher IRR when CapEx is not taken into account.

〈Table 4〉 Profitability analysis of power plant construction

Plant size, tons/day	with consideration of CapEx						without consideration of CapEx					
	NPV, 10%	NPV, 7%	NPV, 5%	Average ROI, %	Payback period, year	Project IRR, %	NPV, 10%	NPV, 7%	NPV, 5%	Average ROI, %	Payback period, year	Project IRR, %
Gas Engine, 150	-25.26	-23.79	-22.50	18	9	-9	-1.76	3.55	7.89	18	8	9
Gas Engine, 300	-29.95	-24.94	-20.74	31	11	-2	11.31	23.04	32.60	31	7	14
Gas Engine, 500	-39.88	-30.36	-22.42	13	10	1	26.77	47.15	63.75	13	6	15
Gas Turbine, 150	-36.70	-36.55	-36.30	5	11	-19	-10.73	-6.35	-2.73	5	9	4
Gas Turbine, 300	-32.73	-28.21	-24.39	11	12	-3	8.47	19.71	28.89	11	7	13
Gas Turbine, 500	-32.91	-22.62	-14.06	14	10	2	32.12	53.01	70.01	14	6	17
Gas Steam Turbine, 150	-35.85	-34.44	-33.16	7	15+	-11	-5.27	1.12	6.37	7	8	7
Gas Steam Turbine, 300	-23.42	-15.31	-8.57	14	9	3	26.11	42.30	55.47	14	6	17
Gas Steam Turbine, 500	-4.34	13.22	27.63	19	8	9	70.29	100.59	124.77	19	5	22

Calculation of the IRR considering only the project cash flows (excluding the financing cash flows) generates the project IRR.

V. Concluding remarks

The paper examines private capital investment plans induced by a national R&D project for a woodchip power plant construction. This study explores the role of capital expenditure in the valuation of an investment plan. Profitability of three electricity gasification power plants has been evaluated. The paper finds that the selection of discount rates is important to establish whether a particular project has a present value of benefits greater than its costs, and to rank viable alternatives. In an economy with many investment instruments, no single discount rate exists that will measure all possible returns to capital. When applying relatively high discount rates, projects require a significant upfront cost to realize a flow of benefits over long period. The projects may be discouraged. To the contrary, a lower discount rate than currently applied can lead to greater public infrastructure investments, and favor investment in future generation. However, using an artificially low discount rate for project evaluation can make future generations worse off.

The paper also finds that the simple introduction of capital expenditure in the profitability analysis affects the perspectives on the construction plan. The findings of the study suggest that it is more likely that a project will be selected if the capital expenditure is not considered, thus providing an optimistic forecast. To prevent divergence of calculation in the R&D research project, a standardization of the calculation process is needed that takes the different characteristics of industries into account in the preliminary feasibility study of national R&D projects.

To do this, the research team should be composed of experts in different fields. It is rare to find experts came from business administration, accounting, or marketing fields, for example, participating as team members. However, their participation needs to be encouraged for the sake of having expertise with regard to marketing knowledge and commercialization purposes, etc.

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여희정

프랑스 University of Toulouse 1에서 경영학 박사학위를 취득하고 현재 계명대학교 국제통상학과 교수로 재직 중이다. 관심분야는 경제성평가, 기술무역, R&D 투자분석 등이다.