CORVINUS UNIVERSITY of BUDAPEST

**DOCTORAL SCHOOL OF ECONOMICS**

# RÉSUMÉ

*for*


## Anita Lovas


## Financing of Innovation under Asymmetric Information

## The Effect of Government Intervention

Ph. D. dissertation

**Supervisor:**

**Edina Berlinger, Ph.D.**
associate professor

Budapest, 2015

**Department of Finance**

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# 1. PRELIMINARIES

## 1.1. Motivations

From theoretical and empirical viewpoint it is justified and widely documented that innovation plays a central role in driving economic growth. This statement is especially true during a crisis, when the old behavior patterns and procedures work less effectively and in many cases there is a need for innovation for survival. Although the Great Depression caused a considerable decline in the financial sector and the real economy, the 1930's can be considered as the most innovative period in the 20th century based on the aggregated data.

International practice shows that governments try to support the innovation process by various means. Parallel to the indirect tools (improving the educational system, creating a legal environment, etc.), a number of direct supportive schemes are operating at national and European levels in order to reduce the funding constraints to micro, small and medium-sized companies which are the "breeding ground" for innovation. It is striking, however, that support systems are based on fairly different mechanisms. There are non-repayable grants, preferential loans, equity-type investments, state guarantees etc. The state or other supporting organizations can directly contract with the inventor or entrepreneur or the providers of the funds. The state (or other funding organization) can perform screening or prescribe other conditions (e.g. project performance).

It is natural to ask what justifies the state participation in innovation financing, that is, why the capital markets themselves are unable to perform this task effectively. Moreover, if the actual state intervention is needed, which support system is best suited to the particular situation and socio-economic environment.

There are a number of arguments for (removing the financial barriers, boosting the economy etc.) and against (the crowding-out effect, the possibility of misuse of the state funds, the application of inappropriate investment criteria etc.) state intervention. The empirical literature of the state support systems show mixed results, but most authors recognize the legitimacy of the various forms of assistance.

Innovation differs from average business investment mostly that, while it has more positive spillover effect, it has smaller probability of success and has greater uncertainty. In fact, the problem is not only that little information is available for decision-making, but also the distribution of information can be very asymmetric (for example, the inventor typically knows

more about the product's physical attributes than the investor, but knows almost nothing about market opportunities). Funding is complicated also by the fact that the inventor usually has no adequate managerial skills and has no or little start-up capital. Thus, a number of factors impede the financing of innovation, which ultimately results in poorer implementation of innovation.

In my thesis, I basically focus on the consequences of asymmetric information. Despite of the extensive international literature, very few Hungarian researchers (e.g. Becskyné [2006] and Glavanits [2012]) dealt with the difficulties that arise due to asymmetric information situation and the tools to handle them.

## 1.2. Adverse Selection

***Problem:*** One of the problems of information asymmetry comes from the fact that financiers and venture capitalists are less familiar with the characteristics of the innovation and the entrepreneurial abilities than the entrepreneur/inventor himself. Therefore, if the financiers offer a contract suitable to the average project, the better entrepreneurs are less willing to accept the contract than the others. This problem gets more serious (i.e. the adverse selection rate grows higher) if the quality of innovations varies in a very wide range and the proportion of weak innovations is higher (Alam – Walton [1995] Hubbard [1998]). In certain market conditions, not only the problem of cross-subsidization, but also market breakdown may occur, that is, even good projects will not be funded, which leads to a significant deadweight loss at individual and social levels.

***Treatment:*** The treatment of adverse selection consists of (1) information disclosure and gathering, (2) signaling the innovator's characteristics and (3) screening the actors (Stiglitz [2000]). The entrepreneur (a well-informed party) can reduce the information asymmetry by information disclosure and signaling. The investors (the uninformed party) take steps to reduce information "handicap" by information gathering and screening. However, these control techniques have direct and indirect costs, as well. Examples of the latter are due to revealing information to other market participants who can take advantage of this opportunity. Therefore, the original owner of the innovation can realize less revenue than originally (Bhattacharya – Ritter [1983] Chen [1994], Jansen [2010]).

In practice, the emphasis is on information disclosure and gathering (Tyebjee – Bruno [1984] Zacharakis – Shepherd [2001] Petti – Gruber [2011]). After the first meeting it takes months the venture capital investment is made, and only a few percent of the requests will get

financing at the end (Cumming – Johan [2009]). The investors examine thoroughly the investment opportunities and the team of the entrepreneur.

The investors apply a screening prior the investment by offering syndicate contract which contains all the conditions of the investment. These conditions are constructed in order to be acceptable only for the really good entrepreneurs. As in the labor market certificates of qualification, in the innovation financing the patents and patent applications may serve as a signal. The feasibility of prototypes can also be considered as a signal (Audretsch *et al.* [2012]). Those entrepreneurs are more likely to receive funding who already have a patent or a submitted patent application (Hellman – Puri [2000]).

***State intervention***: Kleer [2010] and Takalo – Tanayama [2010] evaluated the effects of government subsidies in case of adverse selection.

According to Kleer [2010] state should subsidize the early stage research projects, but particularly basic research (and not applied ones), because they have little private but high social benefits. Banks (and other private investors) consider only the private benefits hence they give priority to investments with high personal returns (and according to their assumption these have typically smaller positive external effect). Therefore, the state can create value by funding projects with large positive externalities.

Takalo and Tanayama [2010] drew attention to another important aspect of the government's role. Research shows that in certain situations the state has technological advantage in the selection of good projects (e.g. the state has a research capacity that can be used for this purpose).This provides also an informative (though not perfect) signal to the competitive investor.

Under the conditions of this model, the state can reduce the under-funding of innovative projects through two channels. On the one hand the information position of the investors is improved, on the other hand the external financing needs of the projects are reduced. The overall welfare effect of state subsidy depends on the number and the composition of the funded projects (because the state subsidizes projects some wrong projects too).

## 1.3. Moral Hazard

***Single moral hazard:*** Another problem of information asymmetry occurs when a principal entrusts an agent with a task, but can observe the result of the activity and not the activity itself (Gömöri [2001]). In the financing of innovations this means for example, that the

investors provide capital to the entrepreneur to realize a project. However, there is a chance that the entrepreneur does not use the capital properly, for example he focuses on his own private benefits thereby damaging the investor (Gompers [1995] Hellman [1994]).

***Treatment:*** A complex system of tools should be applied to handle the moral hazard, serving the interests of both the investor and the entrepreneur. There are basically two ways (Hart – Moore [1988], Grossman – Hart [1983]: (1) a properly designed contract with good incentives; and (2) monitoring. The project financing – especially in case of early stage innovations – involves a number of uncertainties, for example the costs and the revenues cannot be foreseen exactly, therefore the contract cannot contain measures for all possible events, so the specification and the distribution of the control rights plays a very important role, as well (Hart [2001]).

***Basic incentive model:*** In my theoretical research I analyzed the contractual incentives based on the model of Holmstrom and Tirole [1997] with two players and continuous investment. In this model two private participants contract: an entrepreneur (the owner of the idea and the project manager is the same person), and the investor who is passive in the sense that he only provides the necessary outside financing but otherwise do not contribute to the success of the project.

The design of the optimal financing contract is concentrating on two questions: (1) How much capital can the entrepreneur get from outside, and what is the optimal size of the total investment? (2) How should the project return be shared between the investor and the entrepreneur?

The answer of the model of Holmstrom and Tirole [1997] to question 1 is that the project will be financed only if the sum of the entrepreneur's initial capital and the net present value of the project exceed the agency costs. The answer to question 2 is that the total surplus of the project should be given to the entrepreneur in order to motivate him to behave well and to maximize his efforts for the success of the project.

***Monitoring:*** The conflicts of interest between the parties, thus the agency cost can be reduced if the principal monitors the agent. However, monitoring has a double effect. On the one hand it has the positive effect of reducing the agency costs hence improving the financing, as well as with monitoring the entrepreneur can achieve only smaller private benefit (for example, he will be able to make less inappropriate use of resources). On the other hand, monitoring is costly which decreases the financing capacity. These "benefits" and costs can vary within a

wide range across transactions and companies. If the investor insisted on monitoring, but the benefits are lower than cost, it would reduce the actual size of the project. For an entrepreneur it is favorable if he finds an investor who is able to monitor the project at low cost.

***Double moral hazard:*** In case of innovation financing investors participate actively in the project management, therefore we face a double sided moral hazard problem. Venture capitalists (as active investors) do not only provide financial means to the entrepreneur, but they also provide consultancy services and take on several control functions in the enterprises financed by them. So both the work of the entrepreneur and the venture capitalist influence the success of the project. As their efforts are not perfectly observable, we can refer to this as a double moral hazard situation (Hellmann – Puri [2002] Sahlman [1990]). Therefore, when contracting between venture capitalists and companies it is a central issue to ensure active engagement of both parties.

***Treatment:*** Within the framework of the Holmstrom and Tirole [1997] model I examined the double moral hazard problem, as well. I demonstrated how incentives should be designed under double moral hazard and what its impact is on the investment. If the investor plays an active role (e.g. giving management and marketing advices), hence contributes to the success of the project, it is more likely to become successful, which has a positive effect on the project. However, at the same time the agency cost will also be increased, because the venture capitalist' activities have costs. Hence, during the contract design it is important to set proper incentives to ensure the motivation of both parties (the entrepreneur and the active investor). From the point of view of the project size it is critical, how (and how much) the investor contributes (in addition to the financing) to the success of the project and how much it costs. If the cost of the professional help outweighs the expected profit growth, the overall impact would be negative on the project (Schindele [2006]).

***Convertible securities:*** In discrete models where there are only two possible outputs (success or failure), there is no difference between debt (concave) and equity (convex) financing. Hence, investors can be considered as shareholders or creditors as well. The optimal form of financing was discussed in a number of academic articles (e.g. Innes [1990], Hermalin – Katz [1991], Dewatriport *et al.* [2003]). In this literature it is typically assumed that the output of the project is continuous. According to their results, in case of a single moral hazard, the optimal financing form is the debt, while in case of a double moral hazard it is the convertible bond (Schmidt [2003]).

Convertibles are a major instrument in venture capital financing (e.g. Bienz – Hirsch [2012], Gompers [1997], Hellmann – Puri [2002], Kaplan – Strömberg [2003]). The convertible securities make the allocation of cash flow and control rights to be endogen, what can provide incentives to behave optimally for the two parties (double moral hazard).

If active investors would provide debt financing, their profit would have an upper limit, so they would not be motivated to do everything possible to achieve great success, they would content themselves with their fix income (Schmidt [2003]). In case of equity financing, the entrepreneur and the investor would receive a part of the return in line with their ownership. However, this can be only a small proportion of the venture capitalist' return, especially if the project' outside financing need was relatively low, so the venture capitalist's share is small. Therefore venture capitalists should be granted an excess revenue for great success for example with the help of equity options, which encourages them to do high efforts (Casamatta [2003] Repullo – Suarez [2004]). This can be achieved both by convertible securities and by equity complemented with equity options.

***Control rights:*** In the practice of venture capitalists, we can find several instruments to manage the asymmetric information situation. It is common for example that they provide the necessary capital not in a lump sum at the beginning of the project, but in several phases, depending on the performance at the predetermined milestones, which is called as stage financing (Kaplan – Strömberg [2003], Cuny – Talmor [2005]). Vesting clauses and anti-competitive conditions are also employed to handle the hold-up problem, i.e. to prevent the entrepreneur to leave the business (Zsembery [2014]).

The contracts of venture capital financing include several exit rights, like drag-along and tag-along clauses. We define a drag-along right as one that gives its holder the right to force all other shareholders in the firm to sell their shares to an (outside) buyer at the same price at which the right holder sells his shares (Bienz – Walz [2008]). We define a tag-along right as one that allows the holder to include his shares in a sale for the same price as all other shareholders (Antonczyk *et al.* [2007]).

Depending on the investment, some special voting rights can also be reserved for the investors, for example they can have the right to replace the CEO in case of bad business trends (Kaplan – Strömberg [2003]).

***State intervention:*** Schertler [2000, 2002a, 2002b] and Schmidt [2006] evaluated the effects of state intervention under double moral hazard (in venture capital financing).

Schertler [2000, 2002a, 2002b] examined the role of the state subsidy in the cases of debt-like and equity-like financing in a continuous effort and continuous output model. In his model she showed that under both schemes, due to the state support entrepreneurs and investors reduced their efforts, but the number of funded projects increased. Under debt financing, the government covers a share of the venture capitalists' realized losses by refinancing and partly guaranteeing the venture capitalists' participations. Under equity financing, a publicly supported co-investor invests in enterprises if the same investment amount is invested by a private venture capitalist. Inexperienced venture capitalists choose public equity financing under which they have higher incentives to enter the market. Experienced venture capitalists choose public debt financing under which they have lower incentives and can save on their management support.

With the help of an effort continuous model Hirsch [2006]) analyzed five support schemes: (1) state guarantee to the venture capitalist, (2) ex ante grant to the entrepreneur, (3) debt-like financing to the venture capitalist (4) ex post grant to the entrepreneur in case of success, and (5) publicly supported education and training which decreases the costs of the efforts of both parties. . Hirsch also showed in her framework that only ex post grants are a robust instrument for implementing the first-best situation, whereas the success of guarantee programs, ex ante grants and some types of investment grants depends strongly on the characteristics of the project: in certain cases they not only give no further incentives but even destroy contract mechanisms and so worsen the outcome.

## 2. APPLIED METHODOLOGY

The dissertation consists of three major parts. Relying on the economic and financial literature of the recent years, the first section – including chapter 1, 2 and 3 – summarizes how the participants design their contract in order to solve the situation when the type and the action of the parties cannot be fully observed and verified (hidden type and hidden action respectively). In the first case it is the moral hazard, while in the second case it is the adverse selection which aggravates the financing. After this, I introduce several state support forms and examine the effect of the support form on the optimal contracts. To do this, based on the theoretical and empirical literature I set up an analytical framework for the further research, described the inner logic of contract design and presented the corresponding solutions applied in the business practice.

In chapter 4 I show my research findings related to the Hungarian experiences with innovation financing. I conducted two series of interviews. The first one was performed alone, principally focusing on adverse selection issues of the process before the investment. In the second one, I worked with my Master student, Sejla Aman in the autumn of 2013. We concentrated on the moral hazard and the corresponding contract design. The interview was semi-structures as we also asked some open-ended questions in connection with the prepared question form.

In chapter 5, I discuss the impact of state support and derive the optimal scheme. In this research I worked with my supervisor, Edina Berlinger and with my colleague, Peter Juhász. We formulated and solved the problem within the framework of a multivariate optimization model. We relied on Holmstrom and Tirole [1997] continuous-investment model where there were only two players: the entrepreneur and the private investor (i.e. bank or venture capitalist). We complemented this model with the introduction of the state providing support. State support was justified on the ground of positive externalities. In our three-player model, we analyzed the impact of different forms of state support.

Our research is the developed version of our previous work published in Economic Review (Berlinger – Juhász – Lovas [2015]). The main difference is that previously we presented a one-stage optimization model where the state offered a tree-sided contract to the entrepreneurs and private investors and they could take it or leave it. However, in my dissertation a two-stage optimization model is introduced where the state propose a contract to the entrepreneur in the first step, then in the second step the entrepreneur propose a contract tothe investor similarly to Holmstrom and Tirole [1997].

## 3. MAIN RESULTS

In chapters 4 and 5 of the dissertation I present the results of my research. The empirical research in chapter 4 served as the foundation of the research questions and the context of the theoretical model investigated in chapter 5 by helping to select the relevant factors and practical considerations.

### 3.1. Hungarian experience - An Empirical Survey

*(1) To what extent are asymmetric information problems are relevant in case of the characteristics of projects and entrepreneurs?*

Venture capitalists are of the opinion that project risks can be divided into two parts: technological and market risks. An entrepreneur may have informational advantage about the physical feasibility, but in most of the cases it can be easily "equilibrated" by the investors due to previous industry experiences and the experts employed by the investors.

Moreover, an investor who has experience in the given area could be better informed in terms of market opportunities than the entrepreneur. While entrepreneurs have usually more information about the invention itself, it is possible that they have less knowledge about its business feasibility and marketing opportunities. However, it is important to note that venture capitalist do not like this type of information asymmetry either as they are not willing to invest in those businesses where the entrepreneurs have weak market competences. Someone in the entrepreneurial team has to have significant market knowledge and market experience, otherwise they have little chance to get financing.

The interview series revealed that for a venture capitalist in most of the cases the product itself is not less important than the personality of the entrepreneur and his team members. This human capital risk is the main reason why venture capitalists may find themselves in an asymmetric information situation.

*(2) How do investors handle the information asymmetry due the hidden type of the project and the entrepreneur?*

One method is to overstep a significant part of the technological risks, so the investor is only willing to finance the business, if the product already met a specific market demand and is already traded in the market. However, the technology risk cannot be completely eliminated,

because a number of problems may arise during the industrial mass production which have not yet occurred at the small-series level.

The second method is to reduce risk by preliminary analysis of the product, the project and the management. Investors conduct scrutiny and process strict selection system to find the most promising project and to contract with the most reliable entrepreneurs. The steps of the pre-investment process are (1) search, (2) presentation of the information memorandum, (3) the first meeting, (4) preliminary consultations and verifying, (5) the term sheet, (6) the due diligence, and (7) the contracting. The process usually takes 3-6 months. Thus, investors try to deal with the adverse selection prior to contracting, as much time and significant resources are devoted to the selection process.

*(3) Is double moral hazard present in innovation financing and how moral hazard is treated?*

As the success of the project is depending on the effort of both the entrepreneur and the investor, information asymmetry can be two-sided, but the moral hazard is still a greater risk from the venture capitalist's perspective. It is the person of the entrepreneur which is critical from the project's perspective. Therefore, we can say that their moral hazard is dominant, hence the investor can be considered as the principal, and the entrepreneur is the agent, whose activity cannot be fully observed and verified. It is no coincidence that the majority of the syndicate agreements contain elements which seek to provide returns for the investors and to motivate entrepreneurs to do efforts for the success.

The details of the relationship between entrepreneurs and investors are defined in the deed of association and in the syndicate agreement. The two contracts complement each other. The syndicate agreement contains every detail of the financing conditions, the structure, the rules, the rights and the commitments between the entrepreneur and the investor. In Hungary a wide variety of instruments is used to ensure proper monitoring and incentives and the volume of the contract can reach 100-200 pages.

The venture capitalist's contract includes most often the right of the recall the management and the appointment of new executive officers (CEO / CFO) and also the right to nominate the board members.

Stage financing is a common practice in the Hungarian venture capital market as well. Investors expect the agreed business plan to be met.

However, the domestic legal system makes the stage financing complicated. The investor has to buy new business share in Ltd. or new shares in PLC. to raise capital. But this can divert the ownership structure, so not only the investor receives new shares, but the entrepreneur as well (though he did not provide new capital).

An important difference between the domestic market and international trends is that in Hungary convertible securities are used rarely, and shareholder financing is typical. Convertible bonds were used only in two cases during the period of 2009-2014 (MNB [2015]). Convertible loans are more frequent than other convertible securities, but they remain marginal compared to equity financing.

In relation to the exit special sanctions rights (drag-along and tag-along) are always used, but these rights are subject to predetermined conditions. Sanction rights will come into effect if a serious violation of contract occurs; or if the company fails to meet certain criteria (e.g. laid down in the business plan and the related schedule of milestones).

### 3.2. The Evaluation of State Subsidies – Contract Theory Approach

It turned out from the survey carried on the domestic market that adverse selection and moral hazard matters. However, the interviewees considered moral hazard much more important than adverse selection, so investors put emphasis on the decision-making process to reduce risk caused by human factors. The selection processes is thorough and try to get to know all the risks associated with the project and evaluate the investment on this basis.

Therefore in our research we specifically dealt with the moral hazard. The opinion of the investors reflected that the difficulties occur mainly on the part of the entrepreneurs, therefore, in our model we assumed only a single moral hazard. The fact that in Hungary convertible securities are not a popular tool also verifies this assumption.

When building up our model framework, our aim was to examine impact of government subsidy under moral hazard under the most simplified setting, therefore we started from Holmstrom and Tirole [1997] and developed it by introducing the state as the third player.

*(4) What is the impact of the state subsidy on project financing?*

We analyzed the impact of state subsidy on project financing under moral hazard and positive externalities. (Positive externalities justify the need for public intervention.) To do so, first we

examined the non-refundable ex ante subsidy by formalizing the problem and deriving the characteristics of the optimal contract.

When designing the optimal contract we assumed that in the first round the state offer a subsidy by defining its size $(S)$ and the refundable value $(R_S)$. After then, in the second round, based on the conditions of the state subsidy the entrepreneur offers a contract to the private investor in which the invested capital by investor $(F)$ and the return to the investor $(R_F)$ are settled down.

The state decides (1) how much subsidy is given out $(S)$ and (2) under what conditions and how much should be refunded at the end of the project $(R_S)$.

The entrepreneur decides (1) how much capital the private investor gives to the entrepreneur$(F)$, (2) what the size of the project is $(I)$, and how the return is shared in case of success and failure $(R_b, R_F)$.

In case of a nonrefundable ex ante subsidy the value of $R_S$ is zero by definition.

The state's objective is to maximize the total social utility, but in a way that takes into account the reaction functions of the private actors. The reaction functions reflect the choices of the entrepreneur and the investor, if the state subsidy is predetermined. The social utility is defined as the sum of the private benefits (the net present value of the project) and the public benefits (externalities minus net state subsidy).

The problem to be solved by the entrepreneur can be expressed as follows:

$$\max p_H RI - p_H R_F - A \tag{1}$$

which is subject to

$IC_b$ $$R_b - \frac{BI}{\Delta p} \geq 0$$

$PC_F$ $$p_H R_F - F \geq 0$$

$BC_0$ $$A + F + S - I \geq 0$$

$BC_1$ $$RI - R_b - R_F \geq 0$$

NNC $$F, I, R_b, R_F \geq 0$$

It is evident from the simple moral hazard model that in the optimum all constraints will bind (except for the non-negativity constraints). After solving the equations we get that the size of investment ($I$) is proportional to the sum of the initial asset of the entrepreneur and the ex-ante state subsidy:

$$I^{(1)} = \frac{A+S}{1-p_H\left(R-\frac{B}{\Delta p}\right)} = \frac{1}{1-\rho_0}(A+S) \tag{2}$$

This is one of the entrepreneur's reaction functions, because it defines the size of the project in the function of the subsidy.

Now consider the optimization program of the state. On the one hand, the state must take into account the budgetary constraint, namely that it cannot finance more than any quantifiable externalities showed up in the budget.

$PC_S$ $$EI - S \geq 0 \tag{3}$$

Let us substitute the reaction function of the entrepreneur to the budgetary constraint of the state. We get:

$PC_S$ $$(E)\frac{A+S}{1-\rho_0} - S \geq 0 \tag{4}$$

The aim of the state is to maximize the sum of private and public benefits. Therefore, the objective of the state:

$$\max p_H RI + EI - I \tag{5}$$

Let us substitute reaction function of the entrepreneur into (5):

$$\max\,(p_H R + E - 1)\frac{A+S}{1-\rho_0} \tag{6}$$

Hence, this is the program to be maximized by the state subject to:

$PC_S$ $$E\frac{A+S}{1-\rho_0} - S \geq 0$$

NNC $$S \geq 0$$

Having determined the optimal subsidy, let us go back to the optimization problem of the entrepreneur. We calculated the optimal size of the project, the necessary private capital and the social utility. Our results can be compared to the base case where public support is not available neither for the entrepreneurs nor for the investors), therefore private parties have to finance the investment on their own and can share the returns between themselves.

The optimum size of the investment in the three-player model with non-refundable subsidy compared to the two-player, original model is as follows:

$$I^{(1)} = \frac{A}{1-\rho_0-E} > \frac{A}{1-\rho_0} = I^{(0)} \tag{7}$$

Social utility with and without state subsidy can also be expressed:

$$U^{(1)} = \frac{p_H R - 1 + E}{1-\rho_0-E} A > \frac{p_H R - 1}{1-\rho_0} A = U^{(0)} \tag{8}$$

Thus, state subsidy has clearly created value within the framework of this model. Thanks to the state subsidy the size of the project increased; and the greater the positive externalities $(E)$ are, the greater the increment is.

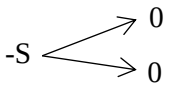
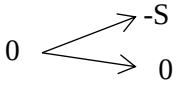
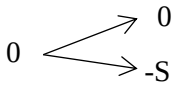
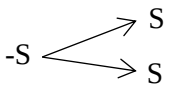
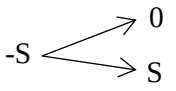
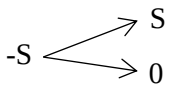
*(5) What is the difference between the effects of the various forms of subsidy?*

The above discussed three-player, two-stage optimization model can be defined and solved for six different forms of state subsidy:

1. nonrefundable prior subsidy,
2. refundable prior subsidy,
3. ex-post grant in case of success,
4. refundable subsidy in case of failure,
5. guarantee,
6. refundable subsidy in case of success.

Four subsidies are due ex-ante (1,2,4,6), and two of the subsidies are due ex-post (3,5). A summary of the subsidies is shown in Table 1, where the cash-flows are presented from the state perspective $(-S)$ is an outflow for the state but an inflow for the private parties).

**1. table: State subsidy forms and their cash-flows of the state's perspective**

| | Unconditional | Conditional | |
|---|---|---|---|
| | | Reward in success | Reward in failure |
| **Non refundable** | 1. Nonrefundable ex-ante subsidy (like EU's grants)   | 3. Nonrefundable ex-post subsidy in succes (like award for the success)   | 5. Nonrefundable ex-post subsidy in failure (like guarantee)   |
| **Refundable** | 2. Refundable ex-ante subsidy (like loans with unlimited liablity)   | 4. Refundable subsidy if the project fail (like Hungarian grants)   | 6. Refundable subsidy if the project succeeds (like loans with limited liability)   |

*Source: Berlinger – Juhász – Lovas [2015], 149.p.*

We solved the two-stage optimization program for all of the subsidy forms and we determined the size of the project and the total social utility, as well. Finally, we compared the parameters of the subsidized case to the baseline one.

It can be shown that if the loan is to be repaid in any case (the second scheme), and the interest rate is equal to the market rate, then it is not a real subsidy and the project size is the same size as in the two-player case. The state has no interest in intervening in this form. If it did so, state support would simply crowd out private financing without any growth effect. However, if the interest rate of the loan to be refunded is lower than the market rates, the interest rate subsidy can be expressed in its present value, and the effect is the same as that of a non-refundable subsidy of the similar amount.

The remaining five schemes (1, 3, 4, 5, 6) can be considered as real subsidy, hence hereinafter we only deal with these forms. These forms of subsidy will lead essentially to the same result; the details can be summarized as follows:

- The size of the project is the same in all of the five schemes, and we can see that the optimal project size is larger than in the baseline case, because in the formula externality $(E)$ reduces the denominator. Hence we can conclude that state subsidy has a positive effect on economic growth:

$$I = \frac{A}{1 - E - \rho_0} > \frac{A}{1 - \rho_0} \tag{9}$$

- The present value of the state subsidy ($S'$) strongly depends on the externalities ($E$), but it is also influenced by the moral hazard ($\rho_0$) and the initial asset of the entrepreneur ($A$):

$$S' = \frac{E}{1 - E - \rho_0} A \tag{10}$$

- The total social utility is also higher than in the base case:

$$U = \frac{p_H R + E - 1}{1 - E - \rho_0} A > \frac{p_H R - 1}{1 - \rho_0} A \tag{11}$$

As we can see in (11) externalities ($E$) have two effects: on the one hand they increase the counter, on the other hand reduce the denominator relative to the base case.

- Thus, subsidy forms differ only in their shaping and their internal structure (e.g. the timing of cash flows, share of returns), but their growth and social effects are the same.

- An important result is that the state support, regardless of the specific form, clearly creates value added within the framework of the model. This value creation comes from two sources, firstly due to the additional capital made available by the state, secondly due to the indirect effect of the state capital to mobilize more private capital.

  It is also demonstrated that contrary to the common believes a properly designed support system will not worsen, but will improve the contractual incentives, so effectively reduces the risk of moral hazard. Note that the state subsidies resolved two types of market failure at the same time: the moral hazard and the externalities. Without state subsidy, this potential benefit would be lost for the society.

- It is also true in the three-player model that the total social surplus is given to the entrepreneur in order to motivate him to exert maximum effort. It is also clear that for the entrepreneur it is always worth to participate in the subsidy program, the private investor expectedly gets back his money, so none of the private participants would leave the two bilateral agreements.

On this basis, it can be concluded that negative experiences with public subsidy cannot be explained by the mere fact of state subsidy. If the state subsidy system worked well, moral hazard would be diminished, private funding would be stimulated and social welfare would be increased.

In this model, we have the opportunity to analyze the potential causes of the big gap between the model and reality for example some state supported projects have negative NPV even in case of good behavior; or the state supported project do not have positive external effects at all; or the subsidy contract is not optimal.

But it is also possible that the model shown does not include the important details prevalent in the practice, such as:

- if public money spent on funding is limited, how the projects should be ranked for state support;
- if the administration of state subsidy is costly;
- if decision makers follow other principles than to maximize the overall social utility;
- if the parameters of the projects are not known;
- if supported participants may get a long term competitive advantage by receiving state subsidy.

These issues can be investigated in further research.

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