

BNDES, Technological Innovation and Performance of Brazilian Industrial Enterprises

João A. DeNegri¹
(Institute of Applied Economic Research)

Bruno C. Araújo
(Institute of Applied Economic Research)

Luiz A. Esteves
(Federal University of Paraná and Siena University)

Abstract

The goal of this work is to verify the impact of credit policy from the Social and Economic National Bank of Development (BNDES) about the productivity of the Brazilian Industrial Enterprises. The hypothesis tested in this work is that the effect operates on the productivity of the enterprises through two distinct channels of transmission: direct and indirect channels. The indirect effect of credit on the productivity would be practiced by the biggest innovative capability of enterprises, which means the enterprises benefited through that credit would increase their possibilities of knowledge production. This work proposes one structural model based on three equations: (1) credit equation; (2) the role of knowledge production; and (3) equation of enterprise performance. The empiric tests developed in this work make use of microdata information from PINTEC, PIA and BNDES. The tests are developed for two distinct periods of time: 2000 and 2003. All the results obtained in this work corroborate with the tested hypothesis.

Key-words: Development Banks; Enterprise Performance; Knowledge Production; Innovation.

Codes JEL: C31; C24; L60; O31; O32

¹ Correspondent author. E-mail: joao.denegri@ipea.gov.br. Web: <http://www.ipea.gov.br>. Address: Institute of Applied Economic Research, SBS – quadra 1- bloco J – ed. BNDES, Brasília/DF.

Introduction

The goal of this work is to verify the effect of credit policy from the Social and Economic National Bank of Development (BNDES) about the productivity of Brazilian Industrial Enterprises. BNDES is a bank of promotion that has as the main characteristic to be the main agent of industrial policy in the Brazilian government.

The hypothesis to be tested in this work refers to the effect of credit operations from the bank on the productivity of benefited enterprises. The hypothesis is that the credit obtained from BNDES affects positively the productivity of firms through the two distinct channels of transmission: direct channel and indirect channel.

The indirect effect of the credit about the productivity would be performed by the biggest innovative capability of firms, which means that the benefited enterprises that were given the credit would foster their possibilities of knowledge production increased. It is relevant to observe that the theoretic literature about the role of promotion institutions in relation to the knowledge production of enterprises is very scarce (Cimoli et al. (2006)).

Even the study on the role of the bank development about the innovative process of enterprises is very incipient (Benfratello et al. (2005)). This work brings a very important contribution to the literature once it is not well known by the up-to-date authors any empiric work that might develop one link among the development banks and the process of knowledge generation among enterprises.

This work still proposes one structural model composed of three equations. The first equation (first stage) is nominated credit equation because through this equation the conditional probabilities in one non-linear model (probit) are obtained. They are the conditional probabilities of access from enterprises to the given credits by BNDES.

The second equation (second stage) is nominated the role of knowledge production. Through one second non-linear model (probit), it is possible to infer the conditional probability of technological innovation generation for each enterprise based on the control of input vectors including their probabilities estimated in the first stage (conditional probabilities of access from enterprises through the given credit by BNDES).

The third and last equation of the system (third stage) is the equation of enterprise performance. Through this work it is possible to infer the direct impacts (probabilities of access to the estimated credit in the first stage) and indirect impacts

(probabilities of innovation estimated in the second stage) from BNDES about the productivity of enterprises.

The empiric tests developed in this kind of work utilize information on microdata from the Industrial Researches per year (PIA) and from the Technological Innovation Researches (PINTEC) from 2000 and 2003². This work still uses information of the records of credit operations from BNDES for the years from 1996 to 2003. All the results obtained in this work corroborate with the tested hypothesis.

This article is structured on the following way: the second section presents the theoretic arguments about the role of promotion institutions on the knowledge production of enterprises. The third section is dedicated to the presentation of used data and descriptive statistics. The third section also presents the econometric specificities and the obtained results. The fourth and last section is dedicated to the conclusions and final considerations.

2. Theory

The hypothesis to be tested in this work establishes that the loans given by BNDES operate on the productivity of beneficiated enterprises through two distinct channels of transmittion. The goal of this section is to clarify each one those mechanisms based on the economic theory.

The restriction in the offer of credit lines of long term by commercial banks (public or private) and the still incipient market of Brazilian capitals make BNDES the main source and provider of resources for financing in the long term³. In that sense, the effects of BNDES actions are practically mixed with the benefits of expansion and replacement of capital equipment in a great extension from the enterprises that compose the Brazilian industrial sector.

² Both from the Brazilian Institute of Geography and Statistics (IBGE).

³ Topics as the efficiency (or inefficiency) of bank policies, incentivation and distortions of interest taxes used in the loans, “financial repression” and incomplete markets do not constitute the target of this work. Discussions about “financial repression” commercial liberalization and efficiency (or inefficiency) of the role of governments in the market of capitals are found in McKinnon (1973), Shaw (1973), Cho (1986) and Cho and Hellman (1993). Matters as institutions and markets that provide financial operations on innovation and development are found in Studart (2003) and Block (2002).

2.1. Direct Channel

The direct channel is related to the efficiency gain obtained by the enterprise after the acquisition of new machinery and equipment. One additional peculiarity of this channel is that those gains don't have to be related to innovative processes (of product or process) arising out of the introduction and use of new machinery.

Examples of direct gains of productivity arising out of the acquisition of new machinery are: scale gains, reduction of maintenance costs in equipments wasted by time; increase of capital stock in enterprises operating on one inefficient scale; reduction of use, costs of maintenance and increase of useful life of equipments which are over used.

The replacement or broadening of capital stock still promotes that the enterprises are able to establish competitive and sustainable strategies of long term. In some situations it is desirable that the enterprises operate based on one deliberated indolent capability (and strategic) in a sense of deceiving new competitors⁴, when there is an increase of demand for their products. The replacement of machinery is able to promote the cost reduction related to pollution, environmental improvement, disease reduction and labor accidents, reduction of costs related to unhealthful activities and cost reduction with labor reimbursement⁵.

The last point to be considered is about the possibility of cost reduction with wages arising out of the replacement of the capital stock. It was mentioned in the paragraph above that the replacement of the machinery might imply in the reduction of insalubrity. The cost reduction with wages arising out of the improvement of the work environment is advocated by the theory of wage compensatory differentials⁶. The basic argument is the enterprises that expose their workers to higher work accident risks, or in the development of a disease caused by work, should compensate those workers with higher wages⁷.

⁴ See Steindl (1952) and Cowling (1982).

⁵ See Borooah (1998).

⁶ The idea that the wage differences for one homogeneous work originates based on the heterogeneity of enterprises to be able to provide a safe work environment. This idea was developed originally by Adam Smith, in "The Nation Richness".

⁷ The interested reader can find different formal models of wage compensatory differentials in Rosen (1986), Ehrenberg (1975) and Fernandes (2002).

2.2. Indirect channel

The opposite of direct channel, the indirect channel, is related to the gain of efficiency obtained by the enterprise through innovative processes resulting from the introduction and use of the new machinery. The innovations arising out of the new machinery can be classified as innovation of product or process innovation.

The process innovations, in this specific case, are accomplished through the replacement of capital equipment by the enterprise. The way the production is made with the new equipment differs meaningfully on how the production was organized with the substituted equipment. The term meaningful differences is here used as a change in the enterprise production, that is, the substitution of capital equipment also implied in one change on the functional way of production.

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The product innovations, in this specific case, are also accomplished through the replacement of the capital equipment. The hypothesis here follows the argument from Lach & Rob (1996), where the expenses on research and development imply, in stochastic terms, in technological innovations in a form of prototypes of new products. The implementation of the new knowledge in the form of product is executed only when the acquisition and use of the new capital equipment happen – it means that the capital investments answer the technological innovations of the firm. The authors refer to this idea as implementation hypothesis⁸. In this case there is also a change in the role of enterprise production. However, such a change is noticed in the vector of products that is broadened in dimension through the number of new products.

The two hypothesis described above are synthetically presented in picture one. The questions about possible simultaneousness in the credit acquisition, capability of innovation and performance of enterprises are going to be discussed in the next sections.

⁸ Implementation or embodiment hypothesis.

3. Results

3.1. Data

The data basis here used is a result of the link of information from the Annual Industrial Research (PIA), Research of Technological Innovation (PINTEC) both from the Brazilian Institute of Geography and Statistics (IBGE) and from the records of credit operations in BNDES.

The Annual Industrial Research constitutes the most complete source of statistic information about the Brazilian industrial sector. It has as a goal to identify the basic structural characteristics from the enterprise segment of the industrial activity in the country and the changes related to the time through annual data. It becomes a basis of industrial enterprises. The research includes the accounting financial information of the enterprises.

As it was mentioned before, the research is annual. It started in 1996 and had available information until the year 2004. For each year, the IBGE collects information of all the enterprises that have more than 30 workers besides some samples related to smaller enterprises. In this work we are going to consider the enterprises that have more than 30 workers.

PINTEC is the research on technological innovation in Brazil and follows exactly the proposals established in Oslo Manual. That is, all the definitions of product innovation, process innovation, and expenses with P & D and other innovative expenditure are identical to the European researches.

The big difference between Brazil PINTEC and the researches of innovation in Europe is the control of the sample made by IBGE. While the European institutes research through Post Office, IBGE makes the information collection of questionnaires through telephone for the smaller enterprises and presence for the big enterprises. There are three editions of this research, from 2000 to 2003, respectively, following every three months of periodicity. The results obtained here refer to the researches from 2000 and 2003. The third data basis is constituted of records of credit operations from BNDES in the period from 1996 to 2003. This way, the final sample used in this work is composed of matching made for enterprises from PIA, PINTEC and BNDES. The linking variable is the Social Security Number for enterprises (CNPJ).

3.2. Descriptive Statistics

The table one presents the descriptive statistics related to the first period of analysis of this study.

The gathering of information derived from different databases in the period described above has generated the total of 8195 enterprise-observations. The descriptive statistics were obtained for five different groups: (1) all the enterprises; (2) innovative enterprises (Inova=1); (3) enterprises that are not innovative (Inova=0); (4) enterprise benefited from BNDES loans (BNDES=1); (5) enterprises that are not benefited from BNDES loans (BNDES=0). The number of observations for each one of those groups is 8195, 4351, 3844, 2966 and 5229 respectively.

The group of enterprises Inova=1 and BNDES=1 present the highest levels of productivity 1 and 2 (the average of 36000 and 9300 respectively), as well as the highest levels of employment (surpassing in both cases the average number of 240 workers), from ICR/1000 (surpassing in both cases the value of 70) and from the percentage of invoicing spent in P&D (surpassing in both cases the percentage of 24%).

As far as the access of enterprises to the different kinds of financing from BNDES in 1996-2000, it was verified that 25% of those enterprises that compose the sample obtained the financing itself. In the case of enterprises that are not innovative (in the period of 1998-2000), this value was 19% while this percentage for innovative enterprises (in the period of 1998-2000) was 34%.

Related to the knowledge production, it was verified that 42% of those sample enterprises innovated in process and/or product in the period of 1998-2000. The enterprises from the group BNDES=1 presented the percentage of 56%, while the enterprises from the group BNDES=0 presented the percentage of 37%.

The table 2 presents the descriptive statistics related to the second period of analysis in this study. In this period the information of the following events is considered: (1) the enterprise obtained access to the financing given by BNDES in the period of 1999 to 2003?; (2) the enterprise developed innovation of product or process in the period of 2001 to 2003 (PINTEC-IBGE)? What is the value of the interest coverage ratio, ICR, in the year when the company obtained the loan from BNDES (PIA-IBGE)? What is the value of the interest coverage ratio, ICR, average, in the period of 1999 to 2003 for those enterprises that were not benefited by the loans from BNDES? All those other pieces of information are related to the year 2003 (PINTEC/PIA-IBGE).

The gathering of information derived from different databases in the periods described above has generated the total of 7898 enterprise-observations. Concerning the example of table 1, the descriptive statistics were obtained for the five different group of analysis. The number of observations for each one of those groups is 7898 (all of them), 3669 (Inova=1), 4229 (Inova=0), 2767 (BNDES=1) and 5131 (BNDES=0).

The comparative analysis of the results from table two does not have a variation meaningfully from the elaborated analysis in the previous paragraphs related to table 1, that is, the enterprises form groups BNDES=1 and Inova=1 present higher levels of productivity, employment and ICR/1000.

In comparative terms to table 1, some points are highlighted: (1) the percentage of innovative enterprises was reduced; (2) the values of ICR/1000 in table 2 are comparative and significantly higher to all groups from enterprises.

3.3. Econometric model

In terms of the specificity econometrics, this work proposes one structural model⁹ composed of three equations. The first equation (first stage) is named credit equation because through it, in one non linear model (probit), the conditional probabilities of access from the enterprises to the credits given by BNDES are obtained.

$$BNDES_j = f(w_j, x_j, \varepsilon_{1j}) \quad (1)$$

The place where f is a probabilistic graph, $BNDES=1$, if the enterprise j obtained credit and $BNDES=0$ in the opposite case, x is one vector of characteristics observed in the enterprise j , while w is one vector of indicator variables from the first equation of the system. The vector w is composed of dummy variables derived from the variable ICR, that is, a set of five dummy variables related to the quintiis of the distribution of this variable and _____ is one aleatory mistake.

The second equation (second stage) is the graph production of knowledge because through this second non linear equation, it is possible to infer about the conditional probability if technological innovation generation for each firm according to what is below:

⁹ In the models CDM [see Crepon et al(1998)].

$$INOVA_j = g(BNDES^*_j, z_j, x_j, \varepsilon_{2j}) \quad (2)$$

The place where g is a probabilistic graph, $Inova=1$ if the enterprise j developed some innovation of production and/process and $Inova=0$ in the opposite case, z is one vector of indicator variables from the second equation of the system. The vector z is composed of the variables Cooperation1-Cooperation 7, $BNDES^*$ is the estimated probability in the first stage of the variable $BNDES$ and ε_{2j} is one aleatory mistake.

The third and last equation of the system (third stage) is the equation of enterprise performance. Through this graph it is possible to infer the direct impacts (probabilities of access to credit, estimated in the first stage) and indirect (probabilities of innovation estimated in the second stage) from $BNDES$ about the enterprise productivity according to the following specification:

$$\ln y_j = \alpha_1 BNDES^*_j + \alpha_2 INOVA^*_j + \beta' x_j + \varepsilon_{3j} \quad (3)$$

The place where y is the productivity of the enterprise j , $BNDES$ and $INOVA$ are the estimated probabilities in first and second stages of the variables $BNDES$ and $INOVA$ respectively.

As it was mentioned before, a problem to be considered in the strategy of identification of direct and indirect effects of financing operations from $BNDES$ is the simultaneousness (or endogeneity) of the access variables to credit (access to $BNDES$), capability to innovate and enterprise performance.

In this work we have tried to deal with this problem in two different ways: (1) in the structure of time in the events: the calculation of productivities (performance measurements) is obtained for the last year of the panel, while the access to $BNDES$ credit precedes or it is related to the period when the enterprise makes the innovation; (2) in the econometric specification: the variables that over identify the non linear equations (1) and (2) were selected and have as a goal to operate as instruments, even considering the fact that our model is one recursive system of equations¹⁰. It is relevant to observe that even considering those measures, the bias arising out of endogeneity is not completely surpassed, affect that demands caution in the interpretation¹¹.

¹⁰ See Amemiya (1978) and Maddala (1983).

¹¹ The econometric approach commonly used in these cases is the utilization of asymptotic least squares, ALS [see Crepon et al (1998)]. Such procedure is contested by some authors [see Loof and Heshmati

Tables

Variables	All	Innovation =1	Innovation =0	BNDES=1	BNDES=0
Productivity 1 (00)	27474 (88692)	36617 (102878)	20685 (66172)	36172 (79561)	24459 (92794)
Productivity 2 (00)	70203 (233911)	92931 (270997)	53329 (176011)	9440 (214828)	61805 (242044)
BNDES (96-00)	0.25 (0.77)	0.34 (0.75)	0.19 (0.77)	1	0
Innovation (98-00)	0.42 (0.87)	1	0	0.56 (0.74)	0.37 (0.92)
Employment	164 (934)	242 (1185)	105 (480)	294 (1298)	118 (619)
ICR/1000	49 (2885)	75 (3876)	28 (812)	72 (2287)	42 (3151)
Cooperation 1	3.91 (0.85)	3.81 (1.11)	3.99 (0.29)	3.84 (0.95)	3.94 (0.78)
Cooperation 2	3.89 (0.93)	3.76 (1.22)	3.99 (0.31)	3.82 (1.00)	3.92 (0.89)
Cooperation 3	3.97 (0.41)	3.94 (0.55)	3.99 (0.15)	3.95 (0.50)	3.98 (0.36)
Cooperation 4	3.94 (0.66)	3.88 (0.89)	3.99 (0.17)	3.92 (0.70)	3.96 (0.65)
Cooperation 5	3.97 (0.44)	3.94 (0.59)	3.99 (0.12)	3.95 (0.50)	3.98 (0.40)
Cooperation 6	3.95 (0.60)	3.89 (0.79)	3.99 (0.23)	3.91 (0.67)	3.96 (0.55)
Cooperation 7	3.97 (0.45)	3.93 (0.60)	3.99 (0.16)	3.94 (0.52)	3.98 (0.40)
% Faturamento gasto em P&D	0.14 (1.88)	0.32 (2.53)	0.07 (0.32)	0.24 (2.49)	0.11 (1.40)
North Region	0.03 (0.28)	0.03 (0.25)	0.03 (0.32)	0.02 (0.23)	0.03 (0.31)
Northeastern Region	0.10 (0.54)	0.09 (0.45)	0.11 (0.61)	0.10 (0.45)	0.10 (0.58)
Southeastern Region	0.58 (0.87)	0.58 (0.78)	0.58 (0.96)	0.58 (0.74)	0.58 (0.93)
South Region	0.25 (0.77)	0.26 (0.70)	0.24 (0.94)	0.27 (0.70)	0.22 (0.79)
Center-Western Region	0.04 (0.35)	0.04 (0.31)	0.04 (0.39)	0.03 (0.26)	0.04 (0.40)
Observations	8195	4351	3844	2966	5229

Note: Standard Deviation between parentheses

(2006) and Loof and Heshmati (2002)]. This study follows the structure of identification according to the suggestion given by the last authors.

Table 2. Descriptive Statistics, PINTEC 2003

Variables	All	Innovation =1	Innovation =0	BNDES=1	BNDES=0
Productivity 1 (03)	35777 (162023)	46560 (172602)	28966 (150508)	50948 (140501)	30661 (171353)
Productivity 2 (03)	97236 (469944)	127584 (498690)	78119 (439028)	142464 (386955)	82221 (505348)
BNDES (99-03)	0.25 (0.83)	0.33 (0.82)	0.19 (0.82)	1	0
Innovation (01-03)	0.38 (0.93)	1	0	0.51 (0.81)	0.34 (0.98)
Employment	156 (1143)	238 (1579)	105 (499)	294 (1757)	111 (557)
ICR/1000	92 (6686)	115 (6017)	78 (7218)	187 (10826)	66 (2905)
Cooperation 1	3.96 (0.57)	3.92 (0.81)	3.99 (0.19)	3.92 (0.72)	3.98 (0.47)
Cooperation 2	3.95 (0.65)	3.90 (0.88)	3.99 (0.30)	3.90 (0.81)	3.97 (0.53)
Cooperation 3	3.99 (0.24)	3.98 (0.35)	3.59 (0.07)	3.98 (0.30)	3.99 (0.21)
Cooperation 4	3.97 (0.48)	3.94 (0.70)	3.99 (0.12)	3.95 (0.57)	3.98 (0.43)
Cooperation 5	3.98 (0.34)	3.96 (0.47)	3.99 (0.14)	3.97 (0.40)	3.99 (0.30)
Cooperation 6	3.97 (0.49)	3.93 (0.69)	3.99 (0.16)	3.93 (0.64)	3.98 (0.38)
Cooperation 7	3.98 (0.32)	3.96 (0.46)	3.99 (0.07)	3.97 (0.38)	3.99 (0.27)
North Region	0.03 (0.35)	0.03 (0.33)	0.03 (0.36)	0.04 (0.31)	0.03 (0.36)
Northeastern Region	0.10 (0.58)	0.09 (0.50)	0.11 (0.65)	0.09 (0.46)	0.10 (0.63)
Southeastern Region	0.56 (0.95)	0.56 (0.87)	0.56 (1.01)	0.55 (0.80)	0.57 (1.02)
South Region	0.25 (0.83)	0.28 (0.78)	0.23 (0.87)	0.29 (0.73)	0.24 (0.88)
Center-Western Region	0.04 (0.39)	0.03 (0.31)	0.05 (0.45)	0.03 (0.27)	0.05 (0.44)
Observations	7898	3669	4229	2767	5131

Note: Standard deviation between parentheses

Table 3. First Stage, Probit BNDES		
Variables	Pintec 2000	Pintec 2003
Constant	-2.69 (0.16) ^{***}	-1.99 (0.11) ^{***}
ICR 1	base	base
ICR 2	0.29 (0.05) ^{***}	0.40 (0.04) ^{***}
ICR 3	0.51 (0.05) ^{***}	0.41 (0.04) ^{***}
ICR 4	0.38 (0.05) ^{***}	0.25 (0.04) ^{***}
ICR 5	-0.45 (0.06) ^{***}	-0.15 (0.04) ^{***}
Ln (Employment)	0.07 (0.02) ^{***}	0.07 (0.01) ^{***}
Observations	8195	7898
Notes: (1) P-value 0.01 (***) , 0.05 (**), and 0.10 (*); (2) All regressions include controls for locations and sector; (3) Standard errors between parentheses ; (4) Sample weights are used.		

Table 4. Second Stage, Probit INNOVATION		
Variables	Pintec 2000	Pintec 2003
Constant	4.98 (0.44) ^{***}	4.40 (0.60) ^{***}
BNDES*	0.27 (0.02) ^{***}	0.35 (0.02) ^{***}
% Faturamento gasto em P&D	0.51 (0.03) ^{***}	
Cooperation 1	0.24 (0.03) ^{***}	0.19 (0.05) ^{***}
Cooperation 2	0.36 (0.03) ^{***}	0.17 (0.03) ^{***}
Cooperation 3	0.18 (0.06) ^{***}	0.08 (0.10)
Cooperation 4	0.36 (0.05) ^{***}	0.31 (0.06) ^{***}
Cooperation 5	0.29 (0.06) ^{***}	0.001 (0.07)
Cooperation 6	0.23 (0.04) ^{***}	0.23 (0.05) ^{***}
Cooperation 7	-0.07 (0.07)	0.41 (0.09) ^{***}
Ln (Employment)	0.26 (0.01) ^{***}	0.15 (0.01) ^{***}
Observations	8194	7898
Notes: (1) P-value 0.01 (***) , 0.05 (**), and 0.10 (*); (2) All regressions include controls for locations and sector; (3) Standard errors between parentheses ; (4) Sample weights are used.		

Table 5. Third Stage, FGLS Productivity				
Variables	Productivity 1 2000	Productivity 2 2000	Productivity 1 2003	Productivity 2 2003
Constant	9.17 (0.07)***	7.04 (0.15)***	9.34 (0.09)***	7.70 (0.11)***
BNDES*	0.27 (0.02)***	0.37 (0.05)***	0.29 (0.05)***	0.19 (0.06)***
Innovation*	1.06 (0.09)***	0.82 & (0.18)***	& (0.26)***	(0.32)***
Ln (Employment)	0.21 (0.02)***	0.29 (0.03)***	0.23 (0.02)***	0.28 (0.03)***
Observations	8195	8157	7785	7762
R ²	0.35	0.19	0.32	0.22
F	159.15***	69.20***	132.83***	78.60***
Notes: (1) P-value 0.01 (***), 0.05 (**), and 0.10 (*); (2) All regressions include controls for locations and sector; (3) Standard errors between parentheses ; (4) Sample weights are used.				

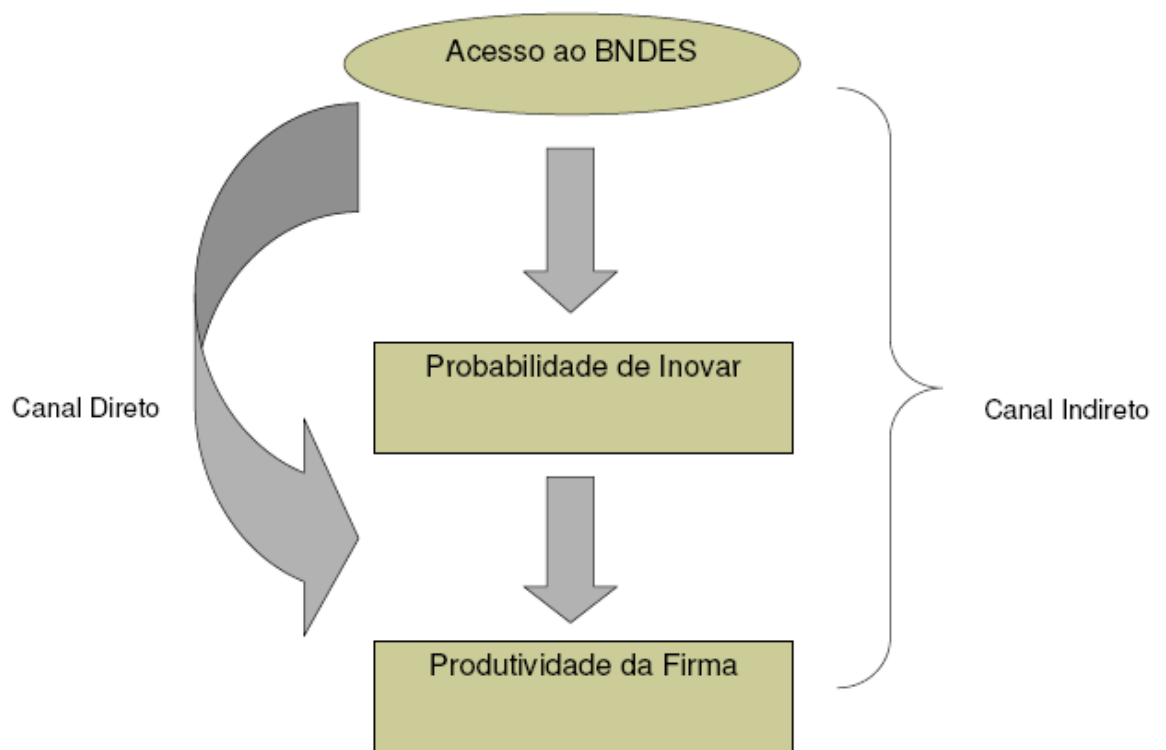


Figura 1: Decomposição Efeitos BNDES