

PUBLIC AND PRIVATE FINANCING OF INNOVATION:

Assessing constraints, selection process and firm performance

Anabela MARQUES SANTOS

Thèse présentée en vue de l'obtention du grade de
Docteur en sciences économiques et de gestion

Année Académique 2018-2019

Université libre de Bruxelles

Solvay Brussels School of Economics and Management

International Centre for Innovation, Technology and Education Studies (iCite) & Centre Emile Bernheim (CEB)

Anabela SANTOS

Université libre de Bruxelles

Solvay Brussels School of Economics and Management

Av. FD. Roosevelt, 50 - CP146

B-1050 Bruxelles – BELGIUM

Email: asantos@ulb.ac.be

Membres du Jury

Directeur de Thèse

Prof. Michele CINCERA (Université libre de Bruxelles, BE)

Autres membres du Jury

Prof. Bruno VAN POTTELSBERGHE (Université libre de Bruxelles, BE)

Prof. Julien RAVET (Université libre de Bruxelles, BE)

Prof. Pierre MOHNEN (Maastricht University, NL)

Prof. Maria Luisa MANCUSI (Università Cattolica, IT)

Acknowledgments

First of all, I express my deepest gratitude to my supervisor Prof. Michele Cincera for the support and assistance over the four years of my research project. I also want to thank Prof. Henri Capron who suggested I should contact Prof. Michele Cincera to be my supervisor. My thanks go also to Prof. Paulo Neto from Universidade de Évora (Portugal) and Prof. Maria Manuel Serrano from Universidade de Évora (Portugal), co-authors in Chapter 3, and Dr. Giovanni Cerulli (IRCrES – CNR, National Research Council of Italy), co-author in Chapter 5. Financial support from Université libre de Bruxelles and European Commission under H2020 is gratefully acknowledged. Special thanks go also to the members of the jury, Prof. Maria Luisa Mancusi (Università Cattolica), Prof. Pierre Mohnen (Maastricht University), Prof. Bruno van Pottelsberghe (Université libre de Bruxelles) and Prof. Julien Ravet (Université libre de Bruxelles), for the valuable comments received in the private defence.

All the work developed in the thesis has been presented and discussed at several conferences, workshops, internal iCite seminars and I3U project meetings. Earlier versions of **Chapter 2** have benefited from the comments of Dr. Marius Berger from the University of Mannheim and participants in the 7th ZEW/MaCCI Conference (Mannheim, Germany), CONCORDi 2017 (Seville, Spain) and 22^{ème} Congrès des Economistes (Brussels, Belgium). **Chapter 3** received constructive remarks from Mr. Peter Berkowitz (DG-Regio), Mr. Wolfgang Petzold (Committee of the Regions), Prof. Frank Crowley (University College Cork), Prof. Oto Potluka (University of Basel), Prof. Joaquim Ramalho (ISCTE Business School), Prof. Esmeralda Ramalho (ISEG - Lisbon School of Economics & Management) and the two anonymous referees of *Portuguese Economic Journal*, as well as from the participants in the 24th APDR Workshop 2016 (Lisbon, Portugal) and in the RSA Workshop 2016 (Brussels, Belgium). **Chapter 4** received valuable suggestions from Prof. Hugues Pirotte (Université libre de Bruxelles), Dr. Giovanni Cerulli (IRCrES – CNR, National Research Council of Italy), Prof. Adão Carvalho (Universidade de Évora), Enrique Pinzon (StataCorp) and the two anonymous referees of *Structural Change and Economic Dynamics*, as well as from the participants in the 1st Master and Doctoral Consortium for Research on Public Policy 2016 (Évora, Portugal) and in CONCORDi 2017 (Seville, Spain). In **Chapter 5** valuable remarks were received from the participants of Spring of Innovation 2018 (Rome, Italy), namely from Prof. Bianca Potì (IRCrES – CNR, National Research Council of Italy), Prof. Jaime Sierra (Pontificia Universidad Javeriana-Bogota, Colombia) and Prof. Blandine Laperche (Université du Littoral Côte d'Opale), as well as from the participants in the Economic Seminar in STATEC (Institut national de la Statistique et des Études Économiques) on 29 May 2018 in Luxembourg, namely Dr. Cesare Riillo and Dr. Serge Allegrezza. I am also grateful to the participants in the 2nd Master and Doctoral Consortium for Research on Public Policy 2018

(Évora, Portugal), specifically Prof. Adão Carvalho (Universidade de Évora), for their suggestions regarding **Chapter 5**.

Special thanks go also to the European Central Bank for providing access to the SAFE database used in **Chapters 2** and **5**, as well as to the *Comissão de Coordenação e Desenvolvimento Regional do Alentejo* (CCDRA) for the information provided in the framework of the activities developed by UMPP (Unidade de Monitorização de Políticas Públicas/ Planning and Evaluation Unit for Public Policies, University of Évora - Portugal) which was used in **Chapters 3** and **4**. I also express my gratitude to Jacques Hellmans (Université libre de Bruxelles) and Bureau Van Dyck for access to the historical data about Portuguese firms used in **Chapter 4**.

I am also grateful to my colleagues, Virginie Maghe, Palina Shauchuk, Nicola Dotti, Pietro Moncada-Paterno-Castello, Nicolas Ameye, Samira Bakkali, Lauriane Dewulf and Gilles Fombasso, for the support in carrying out this research project, as well as the administrative assistance given by Anne-Marie Notarianni, Aurélie Rousseaux, Anne-Lise Remy, Nancy de Munck and Marie Cambie. I also wish to acknowledge Andrew Thomson for the English revision of the papers presented in conferences and workshops.

Finally, I want to express my deepest gratitude to my friends and my parents for moral support over the many years that this research has taken.

Index

Index.....	v
List of Tables.....	vii
List of Figures	x
I. Introduction	13
1.1. Context and motivation	14
1.2. Research objectives	17
1.3. Structure of the thesis.....	19
II. Determinants of financing constraints	21
2.1. Introduction.....	23
2.2. Background theory and literature review	24
2.2.1. Measuring financing constraints through a survey.....	26
2.2.2. Determinants of financing obstacles – Which firms are more constrained?	27
2.2.3. Determinants of innovation behavior – Which firms are more likely to innovate? ..	30
2.3. Database and sample selection.....	32
2.4. Conceptual framework and methodology	34
2.5. Results and discussion.....	39
2.5.1. Sample description: financially constrained vs non-constrained firms	39
2.5.2. Interpretation of model estimations: Financing constraints for growth ambitions:...	40
2.5.3. Complementary analysis: assessing differences regarding innovative and non-innovative firms.....	46
2.6. Conclusion and policy recommendations.....	48
Appendix A	50
III. Which projects are selected for an innovation subsidy?.....	67
3.1. Introduction.....	69
3.2. Literature review	71
3.2.1. Public support for innovation and firms’ competitiveness and internationalization .	71
3.2.2. Determinants of participation in innovation and R&D subsidy programs	72
3.3. Portuguese Innovation Incentive System (SI Innovation)	74
3.3.1. Programme description: aim, targets and selection process	74
3.3.2. Programme execution: description of approved application	80
3.4. Data and methodology	81
3.5. Results and discussion.....	88
3.5.1. Sample description	88
3.5.2. Probability of having an application approved.....	90

3.5.3. Assessing differences between approved and non-approved applications	92
3.5.4. Assessing regional differences between approved and non-approved applications ..	95
3.6. Conclusion and policy recommendations.....	96
Appendix B	99
IV. Do Selected firms show higher performance?	109
4.1. Introduction	111
4.2. Literature review	112
4.3. Data and methodology	116
4.4. Results and discussion.....	124
4.4.1. Descriptive statistics.....	124
4.4.2. Results of Propensity Score Matching	128
4.4.3. Results of Difference-in-Difference with panel data.....	134
4.5. Conclusion.....	138
Appendix C	140
V. Financing, innovation and growth Linkage	149
5.1. Introduction	151
5.2. Literature review	152
5.2.1. The financing of innovation – instruments and effectiveness	152
5.2.2. The effect of innovation on firm growth or performance.....	160
5.3. Data and methodology	161
5.4. Results and discussion.....	165
5.4.1. Data description.....	165
5.4.2. Impact of financing on innovation	168
5.4.3. Assessing output additionality on firm growth	172
5.4.4. Assessing complementarity among different sources of financing	173
5.4.5. Assessing the impact of different financing combination on innovation	175
5.5. Conclusion and policy recommendations.....	176
Appendix D	178
VI. Conclusion.....	205
6.1. Main lessons of research	206
6.2. Main limitations of the research.....	212
6.3. Further research.....	214
References	215

List of Tables

Table II-1. Definition of Micro, small and medium-sized enterprises.....	33
Table II-2. Results of Recursive Bivariate Probit Model	42
Table II-3. Some marginal effects of RBPM with panel data: results of equation 2 – Being financially constrained	45
Table II-4. Marginal effects of Probit model: Being financially constrained, by innovation behaviour	47
Table II-5. Survey of literature: Financing constraints, R&D investment and Innovation	50
Table II-6. Variable definition and description	54
Table II-7. Assessing the relationship between future expectation and present statement	56
Table II-8. T-tests on the equality of means: financing constrained versus non-constrained	57
Table II-9. Collinearity Diagnostics: correlation matrix and VIF	58
Table II-10. Defining financing constraints level: results univariate Probit Model	59
Table II-11. Robustness test: RBPM without weighted sample	60
Table II-12. Robustness test: Descriptive statistics panel data (2014 and 2015).....	61
Table II-13. Robustness test: RBPM with panel data (2014 - 2015).....	62
Table II-14. Robustness test: Results of Seemingly Unrelated Regression (SURE)	63
Table II-15. Robustness test: Results of Pooled OLS for the degree of access to finance pressing problem	64
Table II-16. Results Probit Model: Being financially constrained, by innovation behavior	65
Table II-17. T-tests on the equality of means: innovative versus non-innovative firms.....	66
Table III-1. Common selection criteria for SI Innovation	78
Table III-2. Approved applications to SI Innovation, 2007 – 2013, by region at NUTS 2 level: N° of applications, investment (€ millions) and subsidy (€ millions)	80
Table III-3. Covariate description	84
Table III-4. Innovative behavior in pre-intervention period by activity sector.....	89
Table III-5. Results of logistic regression: Probability of having an application to SI Innovation approved	90
Table III-6. ATET: Foreseen impact of investment project to SI Innovation.....	93
Table III-7. Comparing performance between regions NUTS 2 level.....	96
Table III-8. Survey of literature: Determinants of receiving a public subsidy	99
Table III-9. Descriptive Statistics: Mean, Standard deviation, Minimum and Maximum.....	100
Table III-10. Mean-comparison tests: approved versus non-approved applications	101
Table III-11. Economic activities by sector groups.....	102
Table III-12. Variance Inflation Factors (VIF) and correlation matrix.....	104
Table III-13. Results of logistic regression: Probability of having an application to SI Innovation approved (alternative models).....	105
Table III-14. Propensity Score (PS) before and after matching.....	106
Table III-15. Co-variants means before and after matching	107
Table III-16. ATET: Foreseen impact of investment project in SI Innovation, by NUTS 2 level region.	108

Table IV-1. List of data sources	118
Table IV-2. Steps in sample construction.....	118
Table IV-3. Assessing the representativeness of the sample (treated firms)	119
Table IV-4. Co-variants included in PS model: variable name and description.....	122
Table IV-5. T-tests on the equality of means by groups in pre-intervention period.....	124
Table IV-6. Achieved outcome, mean value, by time period	125
Table IV-7. Achieved outcome (% planned outcome), mean value, by time period.....	127
Table IV-8. N° of firms achieving the planned outcome, by time period.....	127
Table IV-9. Results of Logit Estimation: probability of having an application approved.....	129
Table IV-10. Average treatment effect on the treated firms (ATET), differences compared to pre-intervention, by period.....	132
Table IV-11. Average treatment effect on the treated firms (ATET), achieved outcome (% planned outcome), by time period.....	133
Table IV-12. Results of Difference-in-Differences models.....	135
Table IV-13. Results of Difference-in-Differences models by years	135
Table IV-14. Results of Difference-in-Differences models, for innovation indicators	137
Table IV-15. Survey of literature: Regional and Industrial Policy – impact assessment of subsidized firms’ performance.....	141
Table IV-16. Survey of literature: Innovation Policy – impact assessment of subsidized firms’ performance	143
Table IV-17. Descriptive Statistics: Mean, Standard Deviation, Minimum and Maximum.....	145
Table IV-18. VIF and Correlation Matrix	146
Table IV-19. Robustness Test - Probability Function: Logit model.....	147
Table IV-20. Balancing test - Difference of means before and after matching	148
Table V-1. Main financing sources by type of expenditure.....	158
Table V-2. Different link function for binary choice models	164
Table V-3. Financing instruments by innovation behavior	166
Table V-4. Financing instruments: used alone or in combination with other(s).....	167
Table V-5. Combination of two financing instruments	167
Table V-6. Effect of financing in period ‘T-1’ on innovation behavior in period ‘T’	168
Table V-7. Effect of financing in period ‘T-1’ on innovation behavior in period ‘T-1’	171
Table V-8. Complementary log-log regression results: average marginal effect of output additionality on firm growth by source of financing	172
Table V-9. Effect of different financing in period ‘T-1’ on innovation behavior in period ‘T’	173
Table V-10. Complementary log-log regression results: average marginal effect of output additionality on firm growth by n° of financing sources	174
Table V-11. Effect of different financing combinations in period ‘T-1’ on innovation behavior in period ‘T’	175
Table V-12. Definition of main types of PE investors	178
Table V-13. Survey of literature: effect of public support on firm innovation.....	179
Table V-14. Survey of literature: effect of equity financing on firm innovation.....	181

Table V-15. Survey of literature: effect of innovation on firm growth or performance	183
Table V-16. Variable name and description	185
Table V-17. Descriptive Statistic: Mean, Standard Deviation, Minimum and Maximum.....	187
Table V-18. Collinearity diagnostics: VIF and correlation matrix and (co-variants in PS).....	188
Table V-19. Results of Propensity Score model: Probability to obtain or to use a source of financing ...	189
Table V-20. Propensity Score (PS) before and after matching, by financing instrument.....	190
Table V-21. Selecting link function for binary choice models: Probability of increase turnover using equity financing	191
Table V-22. Results of Cloglog regression estimation: Probability of increasing turnover with dummy innovation measure.....	192
Table V-23. Results of Cloglog regression estimation: Probability of increasing employment with dummy innovation measure.....	193
Table V-24. Results of Cloglog regression estimation: Probability of increasing turnover with count data innovation measure.....	194
Table V-25. Results of Cloglog regression estimation: Probability of increasing employment with count data innovation measure	195
Table V-26. Propensity Score (PS) before and after matching, by n° financing instruments used together	196
Table V-27. Results of Cloglog regression estimation: Probability of increasing turnover with dummy innovation measure.....	197
Table V-28. Results of Cloglog regression estimation: Probability of increasing employment with dummy innovation measure.....	198
Table V-29. Results of Cloglog regression estimation: Probability of increasing turnover with count data innovation measure.....	199
Table V-30. Results of Cloglog regression estimation: Probability of increasing employment with count data innovation measure	200
Table V-31. Assessing the relationship between financing need, innovation and growth: T-test differences of mean for the size of bank loan by innovative behavior and growth status'	201
Table V-32. Assessing the relationship between financing need, innovation and growth: Spearman's rank correlation coefficients	201
Table V-33. Propensity Score (PS) before and after matching, by financing instrument combination	202
Table V-34. Results Z-test differences between coefficients (ATET): financing in T-1 in innovation T 203	
Table V-35. Results Z-test differences between coefficients (ATET): combination of financing instruments	204

List of Figures

Figure I-1. Main sources of finance.....	15
Figure I-2. Main dimensions of public policy evaluation.....	17
Figure I-3. The link between the chapters of the thesis	18
Figure II-1. Sample repartition by group.....	33
Figure II-2. Conceptual framework timeline	35
Figure II-3. Model structure	37
Figure II-4. Average probability of being financially constrained, by country	44
Figure II-5. Geographical distribution of the sample	55
Figure II-6. Robustness test: Geographical distribution of the sample - panel data (2014 - 2015)	61
Figure III-1. National Strategic Reference Framework, Portugal 2007 – 2013, budget allocation by programme and funds	75
Figure III-2. Axis of Operational Competitiveness Programme (COMPETE).....	75
Figure III-3. Interaction and mechanism behind SI Innovation.....	76
Figure III-4. From knowledge and creativity to innovation	77
Figure III-5. Innovation score of approved applications to SI Innovation, 2007-2013, by region NUTS II level	81
Figure III-6. Translation of SI Innovation objectives in quantifiable individual targets	85
Figure III-7. Kernel density plots for raw and balanced data: all Portuguese regions	106
Figure III-8. Kernel density plots for raw and balanced data: Norte region	106
Figure IV-1. Effects of public support on firm investment: additionality and crowding-out	113
Figure IV-2. Timeline analysis – conceptual framework	116
Figure IV-3. Kernel density plots for raw and balanced data	130
Figure IV-4. Evolution DID – N° Employees	136
Figure IV-5. Evolution DID – Sales	136
Figure IV-6. Evolution DID – TFP	136
Figure IV-7. Evolution DID – Fixed Assets	136
Figure IV-8. Gross domestic product at market prices (volume change rate), Portugal, 2006 - 2014.....	140
Figure IV-9. Work productivity, constant price (2006), Portugal, 2006 - 2014	140
Figure IV-10. Unemployment rate (%), Portugal, 2006 - 2014	140
Figure IV-11. Innovation Union Scoreboard, EU28 and Portugal, 2006 – 2014.....	140
Figure V-1. Timeline of the database	162
Figure V-2. Steps of methodological approach	163
Figure V-3. Financing effect on innovation (dummy variable: Yes/No), by time period.....	171
Figure V-4. Financing effect on innovation (count data: 0-4), by time period.....	171
Figure V-5. Balancing test: Distribution of treated and non-treated firms according to the covariates by source of financing	190

Figure V-6. Balancing test: Distribution of treated and non-treated firms according to the covariates by n° financing instruments used together	196
Figure V-7. Balancing test: Distribution of treated and non-treated firms according to the covariates by financing instrument combination	202
Figure VI-1. Methodological approach Chapter 5	209
Figure VI-2. Effect of different types of financing on the number of different types of innovation	209
Figure VI-3. Average marginal effect of output additionality on firm growth (TURNOVER) by source of financing	210
Figure VI-4. Average marginal effect of output additionality on firm growth (EMPLOYMENT) by source of financing	210