

A semi-nonparametric extended ordered probit model with selection for financial barrier perception

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Abstract

In order to contribute to the literature concerning the difficulties faced by innovative firms in terms of financing, this paper aims to investigate the perception levels of financial barriers according to their innovation intensity and analyzes determinants of financial barriers for a developing country for the most recent years. A semi-nonparametric extended ordered probit model with selection is used to establish the determinants of perception of financial barriers by employing the Business Enterprise and Environment Survey, BEEPS 2013 and BEEPS 2019. According to the findings, when there is an engagement in innovation activities, then firms are more likely to assess financial barriers as important. It is believed that these results have important implications for developing countries.

Keywords: Financial Barriers, Innovation Investments, Revealed Barriers, Semi-nonparametric, Selection Bias

JEL Codes: O30, G32, L00, C25

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1. INTRODUCTION

Changing human needs keep two main issues on the agenda. The first of these is the tendency to innovate, which is the main focus of today's entrepreneurs in order to catch up with changing human needs; while the second one is to find the necessary financing to realize the first. The newly created markets brought about by creative destruction and the desire to quickly respond to people's needs through these markets are supported by the profit motive. Today, it is known that companies that would like to maintain their profit advantage, especially after the 2000s, aim to evaluate all their opportunities for innovative activities. However, fund owners who are aware that innovative processes are full of uncertainties are more reluctant to invest their funds in these areas if they are not risk-takers. For this reason, entrepreneurs who see the hesitations of finance owners have the perception that they have difficulties in accessing finance. Even though many developed countries have more financing opportunities for risky investments such as angel investors and venture capital. For a developing country like Türkiye, it is possible to say that the financial markets are not yet fully ready for innovative product and service investments where uncertainty is intense (see detailed literature for Türkiye; (Ünlü 2022; Ünlü, Çankal and Çetin 2022)).

Many researchers have been exploring the cause of low levels of innovation across countries by emphasizing that successful innovation processes depend on important skills (D'Este et al. 2012). These skills also affect the innovation intentions of the companies (Iammarino, Sanna-Randaccio and Savona 2009; D'Este et al. 2012; Almeida, Hsu and Li 2013; Guariglia and Liu 2014). For this reason, the literature focuses on outlining the factors that determine the barriers to innovation (Tiwari et al. 2007; Canepa and Stoneman 2008; Mohnen et al. 2008). Developing countries are particularly interested in new policy frameworks related to Science, Technology, and Innovation (Santiago et al. 2017). As mentioned before, Türkiye is a country with high potential and has directed its policies towards innovation, especially in technology development regions, in the last 20 years. For this reason, it is important to determine the problems in the system from different perspectives in order for the policies to be effective at the desired level. Considering all these, in this study, the relationship between the level of perception of financial barriers and their tendency to innovate was examined in terms of enterprises. Differently from the common literature in this study, the possible selection bias is considered. Our main question is "How does the perception of financial barriers of enterprises change according to whether the enterprises tend to innovate or not". In the study, company characteristics, sectoral differences and regional differences were taken into account. Since the obstacle perception used in the study was measured with a five-point Likert scale, using the ordered probit model is appropriate. However, since it is known that the semi-nonparametric ordered probit model (SNPOPM) relaxes the normal distribution assumption, the use of SNPOPM has been preferred. Savignac (2008) suggests that there may be a selection bias towards innovative firms and non-innovative firms. While the literature defines innovative companies differently according to the survey used, our survey does not include any questions about whether the company is willing to innovate, so it is not possible to follow Savignac (2008). The reason why we follow the same structure as Männasoo and Meriküll (2020) is that we use similar survey data. To control for selection bias, we used a semi-nonparametric extended ordered probit model (SNPEOPM) with selection. Differently from the existing literature with the best knowledge of the author, this paper is the first paper that takes into account several problems such as heteroscedasticity, normality and sample bias. The analysis concluded that Turkish businesses perceive financial barriers as high when they are innovatively active, as suggested in previous literature (D'Este et al. 2012; Santiago et al. 2017; de-Oliveira and Rodil-Marzábal 2019; Ünlü, Çankal and Çetin 2022). We consider a selection model and the result of the selection model suggests that to perceive the barriers as less important firms should be aged and bigger sized.

2. DATA AND METHOD

The data is derived from the most recent Business Environment and Enterprise Performance Survey (BEEPS) 2013 and BEEPS 2019 surveys, which include innovation activities and financial barriers (for more information: World Bank Enterprise Surveys, <http://www.enterprisesurveys.org>). The sample consists of 1344 firms for 2013 and 1663 firms for 2019. BEEPS data collect a broad set of information about innovation, perceiving access to finance as a barrier, firm characteristics, and the business environment. In the data, because only a few firms are visited again, similar to Männasoo & Meriküll (2020), it is preferred to use pooled cross-section. After cleaning the data from nonresponses, the new sample size for all 2730. The financial barrier used in the study is on a 5-point Likert scale in response to the question of "How Much of An Obstacle: Access To Finance?" (from no obstacle to very severe obstacle). The strength of this database is that it measures financial barriers directly and provides a clear indication when compared to indirect measurement based on cash flow (Männasoo and Meriküll 2020). Thus, it is possible to reach information on whether companies have problems in accessing loans.

However, by examining the distribution of financial barrier perception, whose model preference is an ordered variable, it was found appropriate to use one of the ordered type probit models. Because the ordered probit model (OPM) has the assumption that the error term should be normally distributed (Wooldridge 2013), it is necessary to test whether the appropriate model is the OPM or not. We use a semi-nonparametric (SNP) extended ordered probit model which relaxes the normality assumption (Stewart 2004)¹.

Stewart (2004) developed the SNP approach from the suggestion of that for a consistent SNP estimator, the unknown density must be sufficiently smooth with an upper bound in the tails. Just as they suggest that the estimator can accommodate density skewness and kurtosis and fail only when the density is strongly oscillating, Stewart (2004) normalizes the model using the estimation from an ordered probit for the first cutoff point. According to Stewart (2004), the SNP approach is using a pseudo maximum likelihood estimator for the vector of model parameters, to be able to do this the SNP approach estimates the unknown densities of the error terms by Hermite polynomial expansions. Different from the ordered probit model, the SNP extended probit model's interpretations depend on the K selection, where the K shows the number of values given for an ordered variable (Vieira et al. 2023). It is known that the SNP takes the K=3 as the lowest possible value and the system for K<3, the model crashes to the ordered probit state. For this reason, a model selection depends on the K and can be justified using likelihood-ratio tests or the Akaike information criterion (Doremus 2020).

Before going further in this analysis we also checked possible heteroscedasticity by using the heteroscedastic OPM (Keele and Park 2006). In this study, both industry and service sectors are included, as also applied in the study of D'Este et al. (2012). However, to ensure homogeneity, sector variables and region variables are added to the model as dummy variables. As Savignac (2008) proposes that there might be a selection bias towards innovative firms and non-innovative firms. While literature defines innovative firms differently concerning the survey used, our survey does not include any question regarding whether the firm does not innovative because of willingness, it is not possible to follow Savignac (2008). We followed the same structure with Männasoo and Meriküll (2020) and we also checked whether there is a selection bias or not. To control selection bias, we used a semi-nonparametric extended ordered probit model (SNPEOPM) with selection². To test this issue, it is used SNPEOPM with selection, which is proposed by De Luca and Perotti (2011).

Table A1 (Appendix) demonstrates the detailed information about the explanatory variables and provides information related to the descriptive statistics. The engagement level of innovation activities is determined from three main questions related to research and development activities; "*During last 3 years, establishment spent on the acquisition of external knowledge?*", "*... on R&D within the establishment?*", "*... on R&D contracted outside establishment?*". The innovation engagement has determined as if the firm answered yes to at least one of these questions. The Chi2 test is provided in Table A2 (Appendix) for the companies identifying obstacles as important based on the level of innovation participation. The outcome provides a statistically significant test statistic for the hypothesis that the degree of a firm's innovation activity is not independent of the evaluation of obstacles. It demonstrates that companies with low involvement levels are more likely than companies with high participation levels to believe that financial obstacles to innovation are substantially less relevant..

3. RESULTS

The results in this study follow several steps: first, we aimed to prove that there was not any heteroscedasticity problem. With the aim to reveal this, we used heteroscedastic ordered probit³ model which provides a likelihood ratio test of homoscedasticity. First, the age of firms suggests that the older firms might have the experience to deal with risky funding of innovation than the younger ones. Thus, the variance of the error terms of age may influence the variance of unobserved heterogeneity. Second, the size of the firms may also influence the variance of the unobserved heterogeneity. The results are summarized in Table A3 (Appendix) LR test gives a chi2 of 0 when the age of the firms given as a source of heteroscedasticity and a similar result seen when the source is given as employment with the chi2 of 0.14. The result shows that there is no heteroscedasticity problem for the given models.

The second step of the analysis is to investigate whether the assumption of the normality for the OPM was violated or not. Table 1 shows the OPM and SNPEOPM estimator results. It is seen from Table 1 that the likelihood ratio (LR) test of the OPM against the SNPEOPM (where K=5) gives Chi2 statistic equal to 144 and rejects the null that the OPM is more suitable than the SNPEOPM. The AIC is lowest for the case of K = 5. A LR test (4.31***)

comparing $K = 5$ to $K = 4$ can reject that $K = 4$ fits the data better. Because of the lower AIC and rejection of the hypothesis that $K = 4$ is a better fit, therefore, the results suggest to select the $K = 5$ model.

Table 1. Likelihood Ratio Test of OPM and SNPEOPM

<i>K</i>	<i>Log-likelihood</i>	<i>LR test of ordered probit</i>	<i>Degrees of freedom</i>	<i>LR test of K-1</i>	<i>AIC</i>
<i>OP</i>	-3454.78				6959
4	-3455.86	140***	2	-2.16	6963
5	-3453.71	144***	3	4.31***	6961

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

To show whether there is a selection bias or not, we have used the special model which is developed for sample selection for the SNPEOPM. While the literature proposes that the innovators behave differently than non-innovators against the financial obstacles, we proposed the model that the innovators who claim product and process innovation has been done by their company should be used as a sample selection model. As De Luca and Perotti (2011) suggest that any unobservable factors that are probable might affect the outcome of interest, which may cause inconsistent estimates of the SNPEOPM. We explained the innovators by three instruments given in the literature. According to Männasoo and Meriküll (2020), competitive features can be used, unlike the classic firm characteristics. This feature can be explained by whether firms see anti-competitive practices as a serious obstacle to the business, and obstacles to qualified personnel and training opportunities can also be used as an indicator for innovators. The results of the alternative SNPEOPM with the selection model are given in Table 2. Both LR tests and AIC are given in the table and suggest that the model with order (5,5) is more appropriate.

Table 2. Likelihood Ratio Test of SNPEOPM with Selection

<i>K</i>	<i>Log-likelihood</i>	<i>LR test of K-1</i>	<i>AIC</i>	<i>Rho</i>
(3,3)	-6541.81		13151	-0.18
(4,4)	-6505.27	73.07***	13092	-0.50
(5,5)	-6495.69	19.16***	13091	-0.59

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The result of the SNPEOPM with selection is given in Table 3 and suggests that there is a negative correlation between the error terms of the main model and selection model, which is -0.59. This indicates selection bias. However, the significant variables are still significant. And the signs of the estimators do not change. According to Table 3, it is found that if the innovation activity engagement is high then there is a significant and a positive effect on the perception of financial barriers, which suggests revealed effect as suggested by D'Este et al. (2012).

Table 3. Estimation results for OPM, SNPEOPM (K=5), and SNPEOPM with Selection (R1=5, R2=5)

VARIABLES	OPM	SNPEOPM	SNPEOPM with Selection
Engagement To Innovation Activities	0.21*** (0.057)	0.12*** (0.049)	0.12*** (0.045)
Age	-0.045 (0.029)	-0.046*** (0.023)	-0.103*** (0.021)
Size	-0.067*** (0.018)	-0.029** (0.015)	-0.047*** (0.015)
Learning by Export	-0.000 (0.055)	-0.026 (0.044)	0.023 (0.045)
Group Engagement	0.189*** (0.068)	0.114*** (0.055)	0.145*** (0.053)
Sector dummies	Included	Included	Included
Regional dummies	Included	Included	Included
Year 2019	Included	Included	Included
Sample selection model			
Competition as an obstacle			0.370*** (0.09)
Uneducated workers as an obstacle			0.418*** (0.125)
Training for employees			0.219*** (0.092)
Intercept			-1.241
Cut 1	-0.274		
Cut 2	0.264		
Cut 3	1.270		
Cut 4	2.032		
Thresholds 1		-0.27 (Fixed)	0.64 (Fixed)
2		0.14 (0.07)	1.09 (0.03)
3		0.96 (0.21)	1.95 (0.09)
4		2.13 (0.43)	3.00 (0.15)
SNP Coefs.		estimated	estimated
LR Chi2	683***		
Wald Chi2		33.55**	
Pseudo R2	0.088		
OBSERVATIONS	2730	2730	2570
Estimated moments of errors distribution		Main Equation	Selection Equation
Standard Deviation		1.457927	2.099603
Variance		2.125552	4.408331
Skewness		-1.080913	-4.749198
Kurtosis		4.668988	2.24423

Note: a) Standard errors are given in parentheses. b) *** p<0.01, ** p<0.05, * p<0.1. c) **OPM:** ordered probit model, **SNPEOPM:** semi-nonparametric extended ordered probit model and **SNPEOPM with selection:** semi-nonparametric extended ordered probit model with selection, respectively.

Table 4. Hypothesis Testing

Null Hypothesis	LRT	DF	p-value
Engagement to Innovation Activities has no influence on perception of financial barriers, all else equal	46.21	10	0.000

Note: LRT, DF and p-value represent likelihood ratio tests, degrees of freedom (equivalent to the number of constraints imposed on the model) and test p-values (for a chi square distribution).

This result is also consistent with our hypothesis (Table 4) that innovative-active firms are more likely to face financial barriers to innovation and therefore more likely to perceive financial barriers as significantly higher. As the literature suggests, firm size significantly affects the perception of barriers to innovation. More specifically, larger companies perceive financial barriers as less relevant than smaller companies. The case of older / mature firms similarly perceives financial barriers less using their experience. While “learning by export” is statistically nonsignificant, it is seen that firms in a group have an increasing effect on the perception of financial barriers contrary to what is expected. It is seen that the impact differs according to the sectors and regions. The sectoral divergence is also seen from the study, that the garments and other manufacturing firms are more likely to face financial barriers rather than service sectors. The selection model has significant explanatory variables.

4. CONCLUSION

In this study, it was investigated which companies felt the financial barriers. In particular, the perception of companies engaged in intensive innovation activities was examined. In the study, the BEEPS data was used for Türkiye, and the years 2013 and 2019 were included. Although barriers have been examined in various studies before, models measuring perception at different levels are less common in the literature. For this reason, the use of the ordered probit model was preferred in the study. Sample selection model is included to address this issue as selection bias can be an issue. In addition, as a result of the control of the assumptions, the use of semi-non parametric model was found more appropriate. The study differs from other studies in terms of method. When the results are examined, as expected, age and size, which are the main characteristics of the company, affect the perception of financial barrier. Beck et al. (2006) supports our finding that age and size have negative effect, which means that younger and smaller firms are feeling major financial obstacles. While the existence of entrepreneurs being a member of a business group creates a significant effect, firms that export unexpectedly do not have any significant effect. Especially in the study, the result of the significant effect of companies with innovation activities that carry out risky activities is striking. According to the literature, it was expected that firms belonging to a business group would face lower financing barriers as they have access to the group’s internal cash flow, but the positive and significant sign obtained is that if Turkish firms are included in the group, they tend to have difficulties to diverge in income and expenses both in the same business line or in different business lines. For this reason, if a member has financial difficulties, it may be due to the fact that other members have similar problems. This draws our attention as an issue that needs to be studied in the future.

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Conflict of Interest

All authors declare that there is no conflict of interest.

Submission Declaration Statement

We confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.

Endnotes

¹ More detail about the SNP extended probit model can be seen from the Stewart (2004).

² More detail about the SNP extended probit model with selection can be seen from the De Luca and Perotti (2011).

³ The estimates are done by using stata command hetoprobit.

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APPENDIX

Table A1. Description of Variables and Descriptive Statistics

Type	Variable	Description	N	Mean	Std. Dev.	Overall Sample	
						Min.	Max.
Dependent Variables	Financial Obstacles	=1 No Obstacle =2 Minor Obstacle =3 Moderate Obstacle =4 Major Obstacle =5 Very Severe Obstacle		2.27	1.19	1	5
Independent Variables	Innovation Active	=1 if the firm has at least one innovation activity =0 otherwise	2730	0.19	0.39		
	Export	= 1 if the share of direct and indirect exports in firm sales higher than 50% =0 otherwise		0.28	0.45		
	Part of Large Group	=1 if the firm is the part of Large Group =0 otherwise		0.12	0.32		
	Innovative Firms	=1 if the firm has introduced new or significantly improved products or Services, or introduced new or significantly improved process, =0 otherwise		0.19	0.39	0	1
	Compete	=1 if the anticompetitive practices are a serious concern for the firm, =0 otherwise	2628	0.26	0.44		
	Uneducated workforce	=1 if the firm perceives Inadequately educated workforce as "Major obstacle" or "Very severe obstacle", =0 otherwise	2697	0.21	0.40		
	Training	=1 if Formal Training Programs For Permanent, Full-Time Employees is given in Last FY =0 otherwise	2694	0.35	0.47		
Firm Characteristics	Age of the Firm	Log(age)		2.67	0.77	0	4.59
	Size of the Firm	Log (employee)		3.40	1.37	0	8.55
Sector (S) 1	Food			0.12	0.32		
S2	Textiles		2730	0.12	0.32		
S3	Garments			0.11	0.31		
S4	Fabricated Metal Products	Dummy variable		0.11	0.31	0	1
S5	Machinery and Equipment			0.05	0.23		
S7	Construction			0.06	0.25		
S8	Retail			0.10	0.30		
S9	Other Services			0.08	0.28		
Region (R) 1	Marmara			0.27	0.44		
R2	Aegean			0.14	0.34		
R3	Mediterranean			0.16	0.36		
R4	Central Anatolia			0.11	0.32		
R5	Black Sea			0.13	0.33		
R6	Eastern and Southeastern Anatolia			0.17	0.38		
Year 2013				0.44	0.49		
Year 2019				0.55	0.49		

Table A2. The Percentage Of Firms Reporting Barriers As Important By Degree Of Engagement In Innovative Activities

<i>Financial Barriers</i>	<i>Engagement to innovation activities</i>	
	No	Yes
<i>No Obstacle</i>	38.76	32.10
<i>Minor Obstacle</i>	15.59	24.54
<i>Moderate Obstacle</i>	29.57	27.68
<i>Major Obstacle</i>	12.25	9.96
<i>Very Severe Obstacle</i>	3.84	5.72

Note: Pearson Chi2=31.29 and p=0.000

Table A3. Heteroskedastic OPM Results

VARIABLES	Financial Obstacles	Financial Obstacles
	Age as a source of heteroskedasticity	Size as a source of heteroskedasticity
Engagement To Innovation Activities	0.21*** (0.059)	0.22*** (0.060)
Age	-0.044 (0.030)	-0.046 (0.030)
Size	-0.06*** (0.019)	-0.07*** (0.021)
Learning by Export	-0.000 (0.055)	0.000 (0.057)
Group Engagement	0.18*** (0.069)	0.19*** (0.071)
Sector dummies	Included	Included
Regional dummies	Included	Included
Year 2019	Included	Included
lnsigma	Age -0.001 (0.025)	Size -0.008 (0.014)
Cut 1	-0.273	-0.279
Cut 2	0.264	0.264
Cut 3	1.267	1.300
Cut 4	2.027	2.083
LR test of lnsigma=0	0.00	0.35
Chi2	Pr=0.96	Pr=0.55
Wald test of lnsigma=0	0.00	0.35
Chi2	Pr=0.96	Pr=0.55
OBSERVATIONS	2730	2730