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Abstract
In this paper we examine the importance of financial and other obstacles to innovation in the Netherlands using statistical information from the CIS 3.5 innovation survey. We report results on the effect of these obstacles on the firms' decision to abandon, prematurely stop, seriously slow down, or not to start an innovative project. These results are compared with those from other studies in the Netherlands and other countries. We end with a discussion of policy measures that have been taken to overcome, or at least attenuate these obstacles, such as R&D tax incentives, venture capital financing and policy mix pakages.

Keywords: Financial constraints, innovation, innovation policy
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1. Introduction

The Lisbon Strategy launched in March 2000 by the heads of State or Government and aimed at making the European Union the most competitive economy in the world and achieving full employment by 2010 emphasizes in the first pillar the need to adapt constantly to changes in the information society and to boost research and development.

The importance of innovative activity by firms for securing economic growth and welfare is generally recognized and widely documented in the scientific literature. While insisting on the necessity of more investment in R&D and more innovations to get Europe on a high growth path, Aghion (2006, p.1) emphasizes the need of "a comprehensive and coherent strategy which also involves: (i) more competition and entry on product market; (ii) more investment in higher education; (iii) more developed financial sectors and markets and more flexible labour markets; (iv) a more proactive macroeconomic policy over the business cycle.".[1]

Financial problems are particularly acute in the case of innovation activities due to some of their inherent characteristics (see Hall (2002) for a discussion). First of all, innovation projects are riskier than physical investment projects and therefore outside investors require a risk premium for the financing of innovation activities. Secondly, because of problems of appropriability innovators are reluctant to share with outside investors information about their innovations. This asymmetric information problem hampers the financing of innovation. Providing convincing signals about the quality of the innovation project is costly (see Bhattacharya and Ritter (1985) on this point) and sometimes leads to market failure (due to the lemon's problem). Thirdly, the difficulty of using intangible assets as collaterals also leads to increased costs of external capital in the form of a risk premium. Because of the differences between internal and external costs of capital in the case of innovation, we observe the pecking order theory of finance, where firms prefer to use internal funds over external debt and finally new equity to finance innovation investments (see e.g. Myers and Majluf, 1984).

The riskiness of innovation projects may raise other financial problems, especially in the case of young and small and medium sized firms. Some innovation projects may not be started, delayed or abandoned because of the risk of bankruptcy and the low value of intangibles in case of liquidation (see Gomes, Yaron and Zhang (2006) for modeling of this issue). Attracting additional equity to finance an innovative activity is hampered as this is likely to aggravate the agency problem and the moral hazard on the part of the inventor (reluctance to invest in risky projects due to risk aversion) arising from the separation of ownership and management of the firm (see e.g. Jensen and Meckling, 1984).

Information asymmetry, moral hazard and tax considerations (different tax treatment of external finance and finance by retained earnings) explain the positive gap between external and internal costs of capital and the preference of financing innovative activities by internal capital.

[1] A critical assessment of Aghion's recent work on these issues can be found in Brouwer (2007).

The objective of this contribution is threefold. First, in Section 2 we provide some evidence about the importance and the effect of financial and other constraints on innovations in Dutch firms using the data from the Dutch Community Innovation Survey CIS 3.5. Second, in Section 3, we compare this evidence with some other evidence about the importance of financial and other constraints on innovation from empirical studies on Dutch and other country data. Third, we discuss in Section 4 the policy implications of the empirical findings as well as some alternative solutions to remove or to by-pass these obstacles. Finally, in Section 5, some concluding remarks will be presented.

2. Obstacles to innovation and their impact: some facts

In the Dutch CIS 3.5 survey, covering the years 2000-2002, participating innovative or potentially innovative firms were requested to answer some detailed questions about the hampering factors and their consequences for innovative projects. The hampering factors included in the survey questionnaire are the lack of appropriate sources of finance, but also too high innovation costs, too much uncertainty of future benefits and costs, lack of qualified personnel, lack of knowledge on technologies needed, organizational rigidities within the enterprise, uncertainty of future market developments and the existence of regulation [see e.g. Statistics Netherlands, Community Innovation Survey 2000-2002 (CIS 3.5), 2002, question 9]. The firms had to answer whether in the period 2000-2002 one or several among the above obstacles lead to seriously delaying, prematurely stopping, abandoning and/or not starting innovation projects. The questions had to be answered by the innovative firms (i.e. firms that introduced or tried but failed or were still in the process of introducing a new product or a new process into the market during this period) but also by firms which stated that they did not engage in activities aimed at technological improvements despite the fact these activities were needed (question 8, CIS 3.5). Among the 10,592 firms which answered the questionnaire were 3,456 (potential) innovators. Among the (potential) innovators, 1,221 firms (11.52 % of the firms in CIS 3.5) indicated that they were hampered in one way or the other. Of the reported potential innovators that number 3,456, 264 are non-innovators who could not take up any kind of innovative activity since they were hampered by one factor or another.

In Table 1, the frequency distribution between being hampered or not is given for each hampering factor. The row totals are 1,221.

Table 1 Frequency Distribution of Being Hampered, by Obstacle[2]

	Hampered	Not Hampered
Financial Constraints	401	820
Costs Too High	410	811
Economic Uncertainty	529	692
Shortage of Personnel	373	848
Shortage of Knowledge	287	934
Organizational Rigidities	322	899
Market Uncertainty	472	749
Regulations	194	1,027
Other Factors	187	1,034
No. of Firms: 10,592		
No. of Innovators: 3,456		
No. of Hampered Firms: 1,221		

The frequencies of being hampered are fairly high across all hampering factors. Obviously, firms do not only experience financial constraints. They appear to have been hampered in various ways with costs too high, economic uncertainty and market uncertainty being mentioned more often as a hampering factor than financial constraints. Even organizational rigidities are mentioned more frequently to constrain the execution of innovative activities than financial constraints. Economic uncertainty (43.30% of the firms) and market uncertainty (38.65 %) are the most frequently listed obstacles. Of course, the obstacles are not mutually exclusive. For instance, market and economic uncertainty are likely to be closely related to the occurrence of financial constraints**.**

It is instructive to link the occurrence of hampering factors to consequences regarding the smooth realization of innovation projects. This is done in Table 2.[3]

From Table 2 it appears that the various hampering factors lead most frequently to failure of starting a project. Financial constraints, cost considerations and economic uncertainty, organizational rigidities and regulations are the reasons most often mentioned for not starting a project. This finding makes sense as firms are likely not to start projects for which the financing issue has not been resolved, the costs are too high, returns too uncertain, organizational rigidities and regulations are prohibitive. Shortage of personnel, shortage of knowledge, market uncertainty and other factors most frequently lead to seriously slowing down a project. Economic uncertainty and market uncertainty appear to be the leading obstacles for the four types of decisions.

[2] The total number of firms, the number of (potential) innovators and the number of hampered firms differ from those reported in Tiwari et al., 2008, which refer to firms present in both CIS 3 and CIS 3.5 for which no data was missing.

[3] Addition of the figures across the various actions for different types of constraints in Table 2 will not lead to the figure of the total number of hampered firms in Table 1 for different types of constraints. The reason is that a firm can have more that one project, and a single constraint can lead to different type of actions for different projects.

Table 2 Hampering Factors and Decisions to Abandon, Prematurely Stopping, Seriously Slowing Down and Not Starting at least One R&D Project

	Abandoned	Prematurely Stopped	Seriously Slowed Down	Did Not Start
Financial Constraints	162	135	220	264
Cost Too High	203	185	231	266
Economic Risk	266	238	275	327
Shortage of Personnel	151	113	246	220
Shortage of Knowledge	117	83	195	152
Organizational Rigidities	124	100	191	193
Market Uncertainty	232	187	280	265
Regulations	82	64	110	129
Other Factors	53	35	107	92
Total No. of Firms that reported Abandoning of R&D Projects: 737				
Total No. of Firms that reported Prematurely Stopping of R&D Projects: 353				
Total No. of Firms that reported Seriously Slowing Down of R&D Projects: 654				
Total No. of Firms that reported Not Starting of R&D Projects: 553				

To measure the impact of the obstacles on each of the four decisions[4] of abandoning (ab), prematurely stopping (ps), seriously slowing down (ssd), or not starting (ns) a project, we use a probit model with sample selection. The first equation models each of these decisions separately for innovative firms. The equation explains the probability that an innovative firm takes one of these four decisions given dummy variables for three types of obstacles, financial constraints (bfin), economic uncertainty (bec) and market uncertainty (binf), and controlling for firm size (lsize) measured in terms of number of employees We decided not to include costs too high, shortage of knowledge and shortage of personnel because we felt that they were somehow related to financial constraints. We excluded regulations and other factors because, as shown in Table 1, they were relatively minor. However, economic uncertainty and market uncertainty are forward looking and assess of the future potential benefits that a firm can receive from undertaking a R&D project. Hence these factors are about certain fundamentals that affect the firm and its R&D project. Also included are sectoral dummy variables for several sectors and an intercept (The results for the sectoral dummies and the intercept are not in Table 3). We allow size, economic uncertainty and market uncertainty to be interacted with dummies for being or not being financially constrained (denoted by –f and –nf, respectively). For instance, bec-f is the interaction between the dummy variables of being hampered by

[4] The decisions "Abandoning" and "Prematurely stopping" refer to two different questions asked to the firm. While the former refers to a question asked directly to the firm, the later refers to the kind of action taken as a consequence of being faced by a hampering factor.

economic uncertainty and being financial constrained. The selection equation explains the probability that a firm is an innovator using the following explanatory variables: the logarithm of size, the age of the firm, the market share (rlsale), a dummy variable for being a single plant firm (d-lp), dummies for some sectors and an intercept (not reported). The estimation results for each type of action separately for CIS 3.5 data using the maximum likelihood method are given in Table 3.

Table 3 Determinants of Abandoning (ab), Prematurely Stopping (ps), Seriously Slowing Down (ssd) and Not Starting (ns) of R&D Projects

	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
	ab		ps		ssd		ns	
bfin	.385	.257	.918	.301	.912	.259	1.079	.286
bec-f	.087	.135	.353	.135	-.297	.132	.622	.146
binf-f	.161	.132	.083	.124	.338	.130	.126	.142
bec-nf	.747	.098	1.291	.170	.654	.101	1.260	.112
binf-nf	.593	.096	.674	.115	1.016	.125	.733	.107
lsize-f	.174	.064	.049	.064	.071	.063	.133	.065
lsize-nf	.107	.044	.001	.057	-.027	.048	.0003	.049
Selection								
lsize	.175	.014	.177	.014	.179	.014	.177	.014
age	-.003	.001	-.003	.001	-.003	.001	-.003	.001
rlsale	.083	.008	.083	.008	.081	.008	.082	.008
d-lp	-.053	.027	-.039	.028	-.044	.027	-.047	.028
ρ	-.469	.147	-.642	.158	-.562	.180	.311	.253
l-lik	-7,342		-6,553		-7,120		-6,801	
$\chi^2(15)$	251.12		368.61		537.60		849.21	
p-val.	0.000		0.000		0.000		0.000	
$\chi^2(1)$ $\rho = 0$	6.33		6.01		5.11		1.16	
p-val.	.012		.014		.024		.281	

Table 4 Marginal Effects of the Explanatory Variables Evaluated at their Means and bfin = 1 for the Probit Equation

	Marg. effect	S.E.	Marg. effect	S.E.	Marg. effect	S.E.	Marg. effect	S.E.
	ab		ps		ssd		ns	
bfin	.153	.105	.362	.305	.328	.087	0.358	.170
bec-f	.034	.054	.139	.119	-.107	.050	.206	.072
binf-f	.064	.052	.033	.055	.122	.053	.042	.047
bec-nf	.297	.038	0.509	.395	.236	.055	0.418	.116
binf-nf	.235	.038	.266	.208	0.366	.079	.243	.075
lsize-f	.069	.024	.019	.028	.026	.026	.044	.014
lsize-nf	.042	.017	.000	.022	-.010	.017	.0001	.016

Coefficient estimates (Coeff.) and their standard-errors (S.E.) are reported in Table 3 for the main probit equation and for the selection equation that explains the probability of being an innovator. The number of observation is 10,592 with 3,456 being uncensored (innovators and potential innovators). We also report estimates of ρ, the correlation coefficient between the disturbances of the two equations, and its standard-errors. Using the $\chi^2(1)$-statistic this coefficient is found to be significantly different from zero. The $\chi^2(15)$ statistic tests the joint nullity of the coefficients in the first equation. Finally, l-lik denotes the maximum value of the log-likelihood function.

The marginal effects for the main probit equation of some of the explanatory variables, evaluated at their means and at bfin = 1, and their standard-errors are given in Table 4. The marginal effects are in general smaller than the coefficient estimates of the underlying probit equation and fewer marginal effects than coefficients of the probit equation are significant. This is not surprising given that the marginal effects are evaluated at sample means. The findings for the marginal effects basically confirm the conclusions from the estimation results in Table 3.

The estimation results show clearly that financial constraints, bfin, have a significant and positive impact on the three probabilities of prematurely stopping, seriously slowing down and not starting a project, but not on that of abandoning a project. Financial constraints affect the least the decision of abandoning a project, which is also what Table 2 revealed. This result is also reported with firm data by Savignac (2006) and by Canepa and Stoneman (2002) for a cross-section of 15 European countries from the CIS2 survey. It is likely that firms that encounter financial constraints for their innovative activities face simultaneously other hampering factors. Therefore, when we allow for different coefficients for these other obstacles depending on whether or not financial obstacles are perceived as constraining, in most cases the other obstacles (economic and market uncertainty) have less of an effect on the timely realization of the innovative projects when financial constraints are present, and this difference has been tested to be significant. It is only when the firm is financially well off that fundamentals as future economic risk and market uncertainty become relevant. Financial constraints also matter indirectly by reinforcing the hampering effect of other obstacles. With one exception of the impact of economic

uncertainty on the decision to seriously slow down a project, the simultaneous presence of financial and other constraints whenever significant has a positive sign, implying that financial constraints reinforce, or are reinforced by the other constraints.

The equations for the four types of decisions have also been estimated jointly by maximum likelihood in an ordered probit model and in a multinomial logit model with sample selection. Our main finding that the effects of financial obstacles and their interactions with market and economic uncertainty are significant and positive is basically confirmed.

3. Review of empirical evidence on financial and other obstacles to innovation

The existence of financial constraints to innovation is frequently studied by examining the sensitivity of R&D investment to financial factors. Himmelberg and Petersen (1994) find a large and significant relationship between R&D and internal finance for small US firms in the high-tech industries. Similar results have been obtained by Mulkay, Hall and Mairesse (2001) for French and US firms. Bond, Harhoff and van Reenen (2003) find that cash flow is not informative about the flow of R&D for panels of German and UK firms. They interpret their findings as indicating that UK firms face a higher wedge between the cost of external and internal finance than German firms. Actually, Stockdale (2002) reports findings from the third CIS for the UK showing that financial constraints is the second most important inhibiting factor for innovation active firms, next to high innovation costs. However, Kaplan and Zingales (1997, 2000) and Cleary (1999) provide evidence that cash flow sensitivity of investments need not identify liquidity constraints. Cash flow may also be indicative of high demand and expectations of future profits.

Several studies have regressed R&D, innovation activities, and/or innovation output, measured by the share in total sales of the sales of new products on innovation obstacles. The typical, at first sight, counterintuitive result is that innovation is positively correlated with perceived obstacles. At second thought this result can be explained by the fact that innovating firms are more likely than non-innovating firms to perceive the various obstacles that stand in their way. In other words, the perception of hampering factors is itself endogenous and co-determined by some of the same factors that condition innovation. Corrections for the endogeneity of innovation obstacles has been done in a study on French manufacturing firms by Savignac (2006) and on Dutch firm data by Tiwari et al (2008). Savignac (2006) reports that from all businesses with more than 500 employees and a sample of small business firms that 17.25 % of the firms suffer from financing constraints. In the electrical and electronic equipment sector this proportion reaches 30.18 %. She estimates that financing constraints reduce by 22% the probability to implement innovation projects, that the existence of financial constraints on innovation decreases with firm size, and that financing problems also depend on sectors, ex-ante financing structure and past economic performance. Tiwari et al. (2008) using the Dutch CIS3.5 data conclude that financial constraints adversely affect R&D, and that financial constraints are the major stumbling block in the pursuit of R&D. They also find that

older firms and firms that do belong to a group are less likely to be financially constrained.

Using CIS 2 data for European countries, Canepa and Stoneman (2002) find that financial constraints have more of an impact on not starting, delaying or postponing projects than other internal or external hampering factors. Financial constraints are found to matter more in market based systems than in bank based systems (a finding that is in line with that of Bond et al. (2003) for Germany and the UK) and the more the riskier and newer industries are. Both Savignac (2006) and Canepa and Stoneman (2002) confirm our finding reported in section 2 that financial constraints lead less often to the abandonment of projects than to them not being started or being delayed.

Another sort of evidence that R&D is contrained by financing difficulties are the studies conducted in many countries about the effectiveness of R&D tax incentives. In a recent econometric study on the effectiveness of the Dutch WBSO scheme (Wet bevordering speur - en ontwikkelingswerk) Lokshin and Mohnen (2007) conclude that the WBSO program has been effective in reducing the user cost of R&D and therefore successful in stimulating firm R&D expenditures. According to their results WBSO has the largest impact in the first period after which the effect of the tax incentives declines. They find that the effect is the larger for smaller firms and is smaller for the larger firms. The R&D additionality of WBSO points to the existence of financial constraints. By lowering the cost of conducting R&D, the R&D incentive scheme stimulates additional R&D expenditures by private business firms.

Financial constraints as a hampering factor for innovations has been extensively dealt with in the literature. Other obstacles to innovations have received some attention too in the theoretical and empirical literature. For instance, Aghion, Bloom, Blundell, Griffith and Howitt (2005) and Aghion, Blundell, Griffith, Howitt and Pranti (2006) provide evidence on the increased beneficial effects of competition and entry respectively on innovative activity in industries close to the technology frontier. Aghion, Fally and Scarpetta (2006) find positive effects on entry of new firms and their post-entry growth of financial development, regulations affecting start-up costs and regulations on hiring and firing employees. As these other obstacles have been found to have a significant impact on innovative activity, they deserve more attention by researchers.

4. Discussion of the empirical findings and of their policy implications

The finding that about 11.52 % of the firms that answered the questionnaire reported to have been hampered in one way or the other and that about 3.8 % reported to have been financially constrained may be reassuring, especially when it is compared to the 17.25 % of firms in France found by Savignac (2006) to be financially constrained.

Realizing that almost one out of three innovative or potentially innovative firms (i.e. 1,221 out of 3,456 firms or 35.3 %) have been hampered and 15,3 % of innovative firms (529 out of 3,456 firms) have been hampered by at least one factor and that the major hampering factors were found to have a significant detrimental impact on decisions of abandoning, prematurely stopping, seriously slowing down or not starting

innovative projects (See Table 3) should be reason for serious concern. There is even more reason for being concerned when one realizes that these figures might underestimate the true proportions of constrained innovative firms. Reasons for underestimation are the likely higher attrition rate among constrained firms leading to a survivorship bias of unconstrained firms.

Another reason might be that because a combination of a census of large enterprises (firms with 250 or more employees) and a stratified random sample is used for the CIS, small firms are underrepresented in the survey. Small firms often face more severe constraints than large enterprises so that figures for the complete survey are not necessarily representative for the population of small firms.

To assess the importance of the figures on financial constraints, one has to realize that policy measures have been taken long ago and that venture capital and other forms of private equity have become a major source of financing of innovation activities. Since long tax subsidies are provided through expensing R&D in many countries, special financing schemes are available for small, innovative enterprises in many countries (e.g. the US SBIR/SBIC programs, financing of patent projects by the Swedish government, see Svensson, 2007).

Moreover, in the last decade venture capitalists have provided an increasing share of the financing of early stage investment. For instance, Engel and Keilbach (2007) state that between 1995 and 2000 the volume of newly closed deals by venture capital in Germany increased by a factor 8, in the years between 2001 and 2004 however it decreased. Kortum and Lerner (2000) provide evidence that while the ratio of venture capital to R&D averaged less than 3 % from 1983-1992, venture capital may have accounted for 8 % of innovations in the same period.

Venture capital provides financing and contributes to reducing the information asymmetry and the moral hazard through active involvement with the enterprise and through increased leverage (see e.g. Kaplan and Stromberg (2000) on the complexity of the VC contracts and Gompers (1995) on the structure of staged venture capital investments when agency and monitoring costs exist). Hellmann and Puri (2002) provide evidence for Silicon Valley start-ups that venture capitalists play important roles in the professionalization of these start-ups over and beyond those of traditional financial intermediaries.

However, venture capital is not the panacea. The findings for German firms by Engel and Keilbach (2007) which are somewhat at variance with those of Kortum and Lerner (2000) suggest that the higher innovativeness and growth rates of venture-funded enterprises is due to the selection process by venture capitalists using patent applications as a selection criterion. This would mean that venture capital is not available for firms that are not able to convincingly signal growth perspectives to an external investor by providing patent applications. The importance of patents as signals to attract venture capital is also documented for Quebec biotechnology firms by Niosi et al. (2002).

Gompers, Kovner, Lerner and Scharfstein (2007) document the venture capitalist industry's volatility over the period 1975-1998 and show that its investments are closely tied to valuations in public stock markets, i.e. they increase when signals of

public stock markets become favorable. Rates of return on venture capital appear to be highly correlated with those on public stock markets (see also Cochrane, 2005, Kaplan and Schoar, 2005, Ljungqvist and Richardson, 2003). More generally, as shown by Black and Gilson (1997) and Rajan and Zingales (2001) venture capital works best when there is an active equity market which allows investors to exit by selling their shares.

Another policy aspect that has been shown to be important by looking at the responses to the obstacles to innovation is the issue of complementarity of innovation policies, something that is also called "the policy mix" in current discussions in European policy circles. Indeed, as the descriptive statistics reported in Section 2 have shown, firms face a number of obstacles in their attempts to innovate. If only one obstacle was important, the problem would be easy to solve, but if various obstacles co-exist, it is necessary to introduce a policy package, taking into account the complementarity and substitution between various policies. In two similar studies examining the joint occurrence of reported innovation obstacles in innovation surveys, Mohnen and Rosa (2002) on Canadian data and Galia and Legros (2004) on French data conclude that many signs exist of complementarity between obstacles, in the sense that obstacles tend to be reported jointly even after controlling for other covariates.

Mohnen and Röller (2005) consider the obstacles to innovation as indications of failures or weaknesses in the corresponding innovation policies. They examine whether innovation policies are complements or substitutes in the sense of reinforcing their negative effect on innovation behavior and innovation output. They conclude that the two phases of innovation, i.e. the probability of becoming an innovator and the intensity of innovation, are subject to different constraints. The evidence seems to suggest that substitutability among policies is more often the norm as far as the intensity of innovation is concerned and complementarity as far as making firms innovative is concerned. When it comes to turn non-innovators into innovators, it is important to remove a bunch of obstacles at the same time. Governments should adopt a mix of policies, for instance easing access to finance and allowing firms to cooperate with other firms and technological institutions, or increasing the amount of skilled personnel and reducing the regulatory burden. When it comes to increasing the amount of innovation, one or the other policy will do: easing access to finance, making more skilled labor available, or allowing for more collaborations.

5. Concluding remarks

In this paper we have analyzed the nature and the degree of obstacles, in particular financial constraints, to innovative activity using statistical information from CIS 3.5 for the Netherlands. We have studied the impact on firm decisions to abandoning, prematurely stopping, seriously slowing down or desisting from starting an innovative project as a result from the occurrence of hampering factors. Our analysis led us to conclude that the constraints faced by innovative firms are important and have had a major negative impact on innovative activity. Financial constraints continue to hamper innovative activity despite the fact that the tax treatment of R&D is favorable to innovations, that there exist programs to support small innovative firms and that the venture capital sector experienced a significant growth over recent decades. Other types of financing of innovations such as business angel finance contribute to mitigate

the financing problem of many young, small firms but in terms of size this type of finance is of less importance than venture capital (see Berger and Udell, 1998).

Our empirical findings are very much in line with the conclusions by Aghion (2006) about the important beneficial effects on economic growth of the absence of barriers to competition and entry, of spending on education reducing the shortage of qualified labor, of financial development or appropriate fiscal policy providing the required finance to innovative activity and of increased flexibility of labor market and reduction of regulation affecting start-up costs.

Hampering factors such as shortage of qualified human resources have received less attention in the innovation literature than financial constraints. This is an unjustified omission which calls for more research into the obstacles to innovative activity and economic growth and also for collecting more refined statistical information on these obstacles and their economic impact.

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