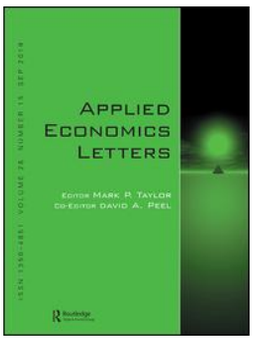

Routledge
Taylor & Francis Group

Applied Economics Letters

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rael20

An unexpected external shock and enterprises' innovation performance

Jarle Aarstad & Olav Andreas Kvitastein

To cite this article: Jarle Aarstad & Olav Andreas Kvitastein (2020): An unexpected external shock and enterprises' innovation performance, Applied Economics Letters, DOI: 10.1080/13504851.2020.1814942

To link to this article: https://doi.org/10.1080/13504851.2020.1814942

Published online: 02 Sep 2020.

APPLIED ECONOMICS LETTERS
https://doi.org/10.1080/13504851.2020.1814942

Routledge
Taylor & Francis Group

ARTICLE

OPEN ACCESS Check for updates

An unexpected external shock and enterprises' innovation performance

Jarle Aarstad and Olav Andreas Kvitastein

The Mohn Centre for Innovation and Regional Development, Western Norway University of Applied Sciences, Bergen, Norway

ABSTRACT

Previous research has shown that competition can affect innovation, but we do not know if an unexpected external economic shock, as it decreases demand that increases competition, also affects innovation. Responding to this knowledge gap, we study Norwegian enterprises before and after the sudden and unexpected price decline of crude oil by the midyear of 2014. In some regions, due to their dependency on the petroleum sector, it strongly affected enterprises operating across many industries, while other regions were practically unaffected. Among enterprises that *were* innovative before the decline, we find a borderline significant inverted U-relationship between regional oil dependency before the decline and enterprises' product innovation performance after the decline. Among enterprises that were *not* innovative before the decline, we find a robust significant positive linear relationship. The results can be a function of increased competition but particularly concerning the latter finding also better access to resources released in affected regions.

KEYWORDS

Financial crisis; economic crisis; innovation; regions; competition

JEL CLASSIFICATION

B53; D4; D21; O30; R11

I. Introduction

Aghion et al. (Aghion, Akcigit, and Howitt 2015; Aghion et al. 2005), in reference to seminal works by for instance Arrow (1962) and Schumpeter (1994[1942]), have illuminated how increasing competition has a curvilinear effect on innovation performance, taking the shape of an inverted-U. For low levels of competition, they argue, an increase will increase innovation as it encourages enterprises 'to acquire a lead over their rival' (Aghion, Akcigit, and Howitt 2015, 561). For high levels of competition, conversely, a further increase will instead decrease innovation as laggard enterprises will 'not put much weight on the (more remote) prospect of becoming a[n innovation] leader' (ibid.).

Elaborating on Aghion et al., we investigate in this study how an unexpected external shock, as it decreases demand in the overall economy that increases competition,[1] affects enterprises' innovation performance. In line with their reasoning, one may assume a curvilinear effect, but as a decrease in demand besides an increase in competition also releases resources in the economy,[2] it may induce a different innovation pattern.

Empirically, we study Norwegian enterprises before and after the sudden and unexpected price decline of crude oil by the midyear of 2014, which can be labelled as an external shock. In some regions, due to their dependency on the petroleum sector, it strongly affected enterprises operating across many industries,[3] while other regions were practically unaffected. Despite a growing body of literature investigating outcomes of an external shock (e.g., Alarcon, Aguilar, and Galan 2019; Archibugi, Filippetti, and Frenz 2013; Lee, Sameen, and Cowling 2015), previous research has not examined how it affects enterprises' innovation performance. As such, the study fills a knowledge gap and further connects research streams of innovation performance, competition, external shocks, and regional research that have not been done in previous works.

CONTACT Jarle Aarstad jarle.aarstad@hvl.no Western Norway University of Applied Sciences, Bergen NO-5020, Norway

[1]Ceteris paribus, a decline in overall demand will induce prices to fall. As prices fall more than marginal costs, at least in the short run, competition will increase (cf. Lerner 1934).

[2]The fall in demand releases resources in terms of human and physical capital as they, at least in the short run, become more abundant in supply.

[3]In addition to the very effect of the price decline of petroleum, many enterprises in affected regions reduced employment and investments that induced negative ripple effects on the overall regional consumer and industry demand. Granted, some industries were affected more than others, but the study controls for industry-specific effects. Also, the study controls for whether each enterprise's most important market is located in the region where it operates, or outside.

The study accounts for enterprises' innovation patterns before the decline to isolate the potential innovation effect of localization in regions more or less affected by the shock. Accordingly, we assess whether being located in regions to a larger or lesser extent affected by an external shock is a genuine causal agent on innovation performance in its aftermath.

II. Methodology

We merge the Norwegian Community Innovation Survey of 2012 (before the decline) and 2016 (after the decline), of which participation was mandatory for selected enterprises. Our sample only includes enterprises participating in both surveys. Norway is divided into 89 labour market regions, and Vatne (2013, 13) has before the decline in 51 of these estimated the amount of employment involved 'with petroleum specific activities' as an indicator of regional oil dependency varying between 0.15% and 21.8%. As such, a region's oil dependency is a constant for all enterprises located there. We use employee-level data to identify the region where each enterprise has the majority of its full-time employees.

The survey of 2016 asked whether the enterprise between 2014 and 2016 had product innovations that were new for the Norwegian market (coded 1), European market (coded 2), or the world market (coded 3). The responses were coded as an ordinal dependent variable of product innovation (zero was default value).

By using data from Statistics Norway, we control for regional population density in 2012, measured as population size divided by regional size in square kilometres. By using data from the 2012 survey, we further control for enterprise size in number of employees and revenues, productivity (revenues per employee), R&D-intensity (R&D investments per employee), and dummies reporting whether the enterprise has innovation collaboration with other organizations in the region where it is located (1 = yes, zero otherwise), nationally beyond the region (1 = yes, zero otherwise), or internationally (1 = yes, zero otherwise). Finally, we include dummies reporting whether the enterprise's most important market is in the region where it is located (default), domestically outside of the region, in Europe outside of Norway, or internationally beyond Europe. We include the control variables to account for enterprise- and regional heterogeneity.

In unreported models, we include each continuous independent variable sequentially as a second-degree polynomial term (regional oil dependency and population density, enterprise size in number of employees and revenues, productivity, and R&D-intensity) to assess potential non-linearity. We mean centre the polynomial terms, and only include in reported results those that are significant ($p < .05$) plus one borderline significant polynomial term of regional oil dependency ($p = .059$). Altogether, our study includes data from 2280 enterprises.

III. Econometric modelling and results

Econometrically, we apply in Stata 15 a random intercept multilevel ordinal logistic regression model,

$$Y_{ikr} = \sum_{j=1}^{J-1} \beta_{j0} + \sum_{h=1}^{s} \beta_h x_{hikr} + E_{ikr} + I_{0kr} + R_{0r},$$

where Y_{ikr} is the ordinal dependent variable for enterprise i in industry k (digit-two NACE-code) in region r. J is the number of ordinal values that the dependent variable takes, β_{j0} are intercepts, β_h are fixed effects regression coefficients and x_{hikr} are independent variables. E_{ikr} as enterprise residuals are not directly estimated in logistic regression (cf., Cameron and Trivedi 2010, ch. 14). I_{0kr} and R_{0r} are random effects accounting for enterprise variation within industries (digit-two NACE-code) nested in regions (I_{0kr}) and within regions (R_{0r}).

Model 1 in Table 1 only includes enterprises *with* product innovations in 2012 (that were new for the market but without specifying geographical scope), and for these enterprises, we observe that regional oil dependency has a borderline significant effect on product innovation in 2016 taking the shape of a negative second-degree polynomial (inverted-U). Model 2 only includes enterprises *without* product innovations in 2012, and for these enterprises, we observe that regional oil dependency has a significant positive linear effect on product innovation in 2016. An unreported model replicating Model 2 with a binary dependent

Table 1. Multilevel mixed-effects random intercept ordinal logistic regression.

	Model 1	Model 2
Product innovations in 2012	Yes	No
FIXED EFFECTS		
Regional level		
Reg. oil dep. (ROP)	.035 (.026)	.033 (.011)**
ROP^2	−.005 (.002)[a]	
Reg. pop. dens.	5.85e-5 (1.57e-4)	2.17e-4 (1.16e-4)
Enterprise level		
Size in employees	−5.95e-5 (3.64e-4)	−1.06e-4 (2.35e-4)
Size in revenues (SR)	4.81e-8 (8.49e-8)	9.41e-8 (2.95e-8)**
Productivity	8.87e-6 (1.80e-5)	−4.83e-5 (1.50e-5)**
R&D-intensity (R&D)	9.41e-4 (3.29e-4)**	.005 (.001)***
R&D^2		−2.65e-6 (5.78e-7)***
Reg. innov. coll.	.295 (.223)	.454 (.242)
Nat. innov. coll.	.114 (.249)	−.273 (.286)
Int. innov. coll.	.307 (.258)	.143 (.295)
National mrkt.	.187 (.198)	.417 (.137)**
European mrkt.	.629 (.275)*	.596 (.248)*
Int. mrkt.	.779 (.273)**	.716 (.230)**
RANDOM EFFECTS		
Nested industry effect	6.99e-34 (1.59e-17)	5.13e-37 (8.52e-20)
Region effect	1.23e-38 (6.41e-21)	4.07e-33 (2.20e-17)
Wald χ^2	46.9***	123.6***
Log likelihood	−642.7	−1151.2
Likelihood ratio (LR) χ^2	.00 n.s.	.00 n.s.
Number of enterprises/regions	549/45	1731/51
Numb. of industr. nested in regions	288	742
VIF concerning reg. oil dep./ ROP^2	3.67/3.31	1.19/n.a.

[a]p = .059, * p < .05, ** p < .01, *** p < .001, conservative two-tailed tests. Standard error in parentheses. Intercepts omitted.

variable (enterprises reporting product innovations in 2016 that were new for the market but without specifying geographical scope) informs that the probability of a product innovation after the decline is about 100% higher in a region of maximum oil dependency as compared to a region of minimum oil dependency.

Concerning the models' continuous control variables, most of them have non-significant or linear significant effects on product innovation. Observing in Model 2 that product innovation is a function of R&D-intensity taking shape as a negative second-degree polynomial, is in line with previous research (Artz et al. 2010). The parameters show that R&D-intensity has an increasing effect on product innovation at a decreasing rate. Also, some dummy variables have significant effects on product innovation. Variance inflation factors (VIFs) concerning regional oil dependency taking low values, in particular in Model 2, indicate that multicollinearity is not a problem. The random effects are non-significant, but the industry effect is significant in unreported models that exclude the regional variable.

IV. Discussion

For enterprises with product innovations in 2012, the effect of regional oil dependency on product innovation in 2016 takes the shape of an inverted-U. The finding is in line with Aghion et al. (2005) as the price decline of petroleum in 2014 presumably increased competition in the most affected regions (cf. Footnote 1 and 3). However, as the finding is borderline significant, one should be cautious concerning statistical conclusion validity.

For enterprises without product innovations in 2012, the effect of regional oil dependency on product innovation in 2016 is significantly positive. For low to medium regional oil dependency, the finding is in line with Aghion et al. (2005), indicating that enterprises aim 'to acquire a lead over their rival' (561). However, for medium to high dependency, the finding is contrary to Aghion et al., due to the positive linear trend. As such, it appears that for enterprises with limited innovation experience (as they did not have product innovations in 2012), the releasing of resources in the regional economy (cf. Footnote 2) appears to trigger their innovation potential. The finding informs policymakers that a crisis can be positive for severely affected regions, and future research should investigate potential long-term effects. The finding has particular relevance for the Norwegian context studied as the economic activity in the country needs to become more diversified and less dependent on the dominating oil and gas industry.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Norges Forskningsråd [272054].

ORCID

Jarle Aarstad http://orcid.org/0000-0002-6650-6667

References

Aghion, P., U. Akcigit, and P. Howitt. 2015. "The Schumpeterian Growth Paradigm." *Annual Review of Economics* 7 (1): 557–575. doi:10.1146/annurev-economics-080614-115412.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt. 2005. "Competition and Innovation: An Inverted-U Relationship." *The Quarterly Journal of Economics* 120 (2): 701–728. doi:10.1093/qje/120.2.701.

Alarcon, J. C., R. Aguilar, and J. L. Galan. 2019. "Determinants of Innovation Output in Spanish Knowledge-intensive Service Firms: Stability Analysis Throughout the Economic Crisis of 2008." *Structural Change and Economic Dynamics* 49: 228–244. doi:10.1016/j.strueco.2018.10.006.

Archibugi, D., A. Filippetti, and M. Frenz. 2013. "Economic Crisis and Innovation: Is Destruction Prevailing over Accumulation?" *Research Policy* 42 (2): 303–314. doi:10.1016/j.respol.2012.07.002.

Arrow, K. 1962. "Economic Welfare and the Allocation of Resources for Invention." In *The Rate and Direction of Inventive Activity: Economic and Social Factors*, 609–626. National Bureau of Economic Research. Princeton: Princeton University Press.

Artz, K. W., P. M. Norman, D. E. Hatfield, and L. B. Cardinal. 2010. "A Longitudinal Study of the Impact of R&D, Patents, and Product Innovation on Firm Performance." *Journal of Product Innovation Management* 27 (5): 725–740. doi:10.1111/j.1540-5885.2010.00747.x.

Cameron, A. C., and P. K. Trivedi. 2010. *Microeconometrics Using Stata*. Revised ed. College Station, Texas: Stata Press.

Lee, N., H. Sameen, and M. Cowling. 2015. "Access to Finance for Innovative SMEs since the Financial Crisis." *Research Policy* 44 (2): 370–380. doi:10.1016/j.respol.2014.09.008.

Lerner, A. P. 1934. "The Concept of Monopoly and the Measurement of Monopoly Power." *The Review of Economic Studies* 1 (3): 157–175. doi:10.2307/2967480.

Schumpeter, J. A. 1994 [1942]. *Capitalism, Socialism and Democracy*. 5th ed. London: Routledge.

Vatne, E. 2013. *Den spesialiserte leverandørindustrien til petroleumsvirksomhet: Omfang og geografisk utbredelse i Norge [in Norwegian]*. Vol. 02/13. Bergen, Norway: Samfunns- og Næringslivsforskning AS.