The impact of ambidexterity on enterprise performance: Evidence from 15 countries and 14 sectors

James Derbyshire

Abstract

The assumption made by research on ambidexterity is that enterprises operating ambidextrously perform better as a result. Similarly, the beneficial effects of ambidexterity are often assumed to be invariant across different contexts, such as sector. However, as is widely acknowledged in the literature, there is a paucity of evidence on which to base these assumptions. To address this issue, in this note we examine evidence from the Community Innovation Survey covering 15 countries and 45,113 enterprises. The paper shows a strong, positive effect on growth in sales turnover from ambidexterity in the manufacturing and the scientific and technical services sectors.

Keywords: ambidexterity; performance

1. Introduction

The concept of 'ambidexterity' features very prominently in the literature on innovation. It suggests that enterprises must achieve a balance between exploitation and exploration to survive and prosper (Andriopolos and Lewis, 2009; Duncan, 1976; Lubatkin et al., 2006). Exploitation refers to the refinement and extension of current knowledge, leading to incremental innovation (Atuahene-Gima, 2005). Exploration

refers to the development of new knowledge leading to more radical innovation (Andriopolos and Lewis, 2009).

The inherent assumption underpinning the ambidexterity concept is that enterprises operating ambidextrously perform better. Yet, despite the prominence of the concept in the literature and the testability of this underlying assumption, there is widely acknowledged to be a paucity of empirical studies examining the ambidexterity-performance relationship (De Clercq et al., 2013; He and Wong, 2004). There are also few studies examining the nature of ambidexterity in different contexts. For example, in some sectors it may be more appropriate to emphasise one or the other of exploitation or exploration, or to pursue them both but in an independent fashion, whereas in others they may be mutually enhancing, thus suggesting a need for a high level of both (McCarthy and Gordon, 2011).

In this short Research Note we provide an initial examination of the sectoral contexts in which ambidexterity affects performance positively and the nature of the ambidexterity undertaken in these varying contexts. We seek to identify those sectors in which an ambidextrous strategy may be beneficial to performance and those in which it is less likely to be beneficial. The purpose is to stimulate further, more detailed empirical examinations of the ambidexterity-performance relationship.

2. Ambidexterity

One interpretation of ambidexterity sees it as the attainment of a *balance* between exploitation and exploration whereby organisations make explicit choices to

emphasise one or the other, leading to an 'optimal mix' (March, 1991). Another interpretation implies a mutually-enhancing relationship between exploitation and exploration (Gupta et al., 2006; Jansen et al., 2006) in which exploration enhances the effect of exploitation on performance, and vice-versa, implying a simultaneous emphasis on both (McCarthy and Gordon, 2011, p.241).

A balanced (or, indeed, a mutually-enhancing) combination of exploitation and exploration can be achieved through 'structural ambidexterity' (Tushman and O'Reilly, 1996), which involves the division of responsibilities for exploitation and exploration into different organisational units. Another approach instead emphasises the design of contextually-appropriate award systems so as to enable the simultaneous achievement of exploitation and exploration within the same organisational unit (Birkinshaw and Gibson, 2004; Raisch and Birkinshaw, 2008).

Since the nature of innovation can vary considerably between sectors (Castellacci, 2008), the nature, impact (on performance), and means by which to achieve ambidexterity can also be expected to vary by sector. In some sectors the relationship between exploitation and exploration may be mutually enhancing (Gupta et al., 2006; Jansen et al., 2006). In others it may be more appropriate to emphasise one over the other, thereby targeting an ambidexterity constituting an 'optimal mix' between exploitation and exploration (March, 1991).

In the subsequent analysis we examine the nature and impact of ambidexterity by broad sector (the 14 NACE Rev. 2 sections A-N) using a sample of 45,113 enterprises from the sixth iteration of the European Commission's Community Innovation Survey

(CIS). In addition, we provide an analysis of the Manufacturing sector (NACE Rev. 2 section C) disaggregated into seven sub-sectors. The focus throughout is on understanding the impact of ambidexterity on the growth of enterprises' sales turnover[1] over the three-year period 2006-2008.

3. Data

The CIS is an extensive survey conducted bi-annually by the European Commission in order to ascertain the extent and effect of innovation across Europe. The data used in this study is from the sixth iteration (CIS2008) of the CIS conducted in 2009, which examined the performance of enterprises over the three-year period 2006-2008, the data for which has been available from 2010.

The population for the CIS2008 survey was all enterprises with 10-or-more employees operating in NACE Rev. 2 sections A-N (Eurostat, 2014). The CIS survey, therefore, provides information on the characteristics of innovation activity and performance at the *enterprise* level (Eurostat, 2014), but does not include the smallest, micro enterprises. A key advantage of the CIS is that it captures data for non-manufacturing as well as manufacturing enterprises. In the present study we make use of this important feature of the CIS data by examining the role of ambidexterity in both manufacturing and services sectors.

The CIS is implemented separately by each member state's national statistical office. While this can result in problems of comparability between member states, as well as

[1] Sales turnover is defined as 'total turnover', constituting all market sales of goods and services (including all taxes except VAT), referring to both invoiced payments and cash payments.

problems aggregating up to the European level, the CIS data has nevertheless been successfully used for pan-European and comparative studies. For example, Mate-Sanchez-Val and Harris (2014) have recently used CIS data to compare between innovation in the UK and Spain; Mention (2011) has used it to examine innovation in European service sectors; and Kohler et al. (2012) and Sofka and Grimpe (2010) have examined CIS data to understand the selective external knowledge search strategies established by enterprises when innovating across Europe.

In relation to the specific subject matter of this paper, Archibugi et al. (2013) recently used the UK returns to CIS2008 to test whether enterprises operating ambidextrously were more likely to increase investment in innovation, but did not test for the overall impact of ambidexterity on performance. In this paper we employ the same operationalization of ambidexterity as Archibugi et al. (2013) but we instead examine its relationship with enterprise performance, employing the full set of CIS2008 micro-data covering 15 countries and 14 sectors.

The country breakdown of the data in the present study is as follows: Bulgaria, 3,444 enterprises; Cyprus, 474 enterprises; Czech Republic, 2,699 enterprises; Germany, 4,320 enterprises; Estonia, 2,060 enterprises; Spain, 14,761 enterprises; Hungary, 1,399 enterprises; Italy, 7,459 enterprises; Lithuania, 533 enterprises; Latvia, 43 enterprises; Norway, 519 enterprises; Portugal, 3,664 enterprises; Romania, 2,223 enterprises; Slovenia, 935 enterprises; Slovakia, 580 enterprises. It should be noted, then, that a large number of these enterprises are from member states such as Spain that are not among the leading group of EU nations in terms of innovation and in which the character of innovation may be somewhat different when compared to

innovation-leading nations (Mate-Sanchez-Val and Harris, 2014). Nevertheless, innovation leading member states, such as Germany, do contribute significantly to the sample.

4. Modelling Strategy

4.1 Dependent variable: Enterprise performance

We employ growth of sales turnover over the three-year survey period of 2006 to 2008, calculated as a percentage, as the dependent variable representing enterprise performance. Outliers have been removed by only including enterprises whose growth rate over this period was 500% or lower (with the lowest possible growth rate obviously being -100%). Enterprises with a growth rate of greater than 500% over the three-year period are excluded as they are not considered to be representative of typical enterprises. In the sample used for the subsequent modelling, the enterprise with the fastest growth rate (of 500%) during the period grew its turnover from €1.6m in 2006 to €9.6m in 2008.

4.2 Independent variables: Exploitation and exploration

The operationalization of ambidexterity used by Archibugi et al. (2013) employs enterprises' responses to a question in which they are asked about the objectives of innovation in their enterprise, requiring them to indicate the importance of the relevant objective on a four-point Likert scale representing 'Not relevant', 'Low', 'Medium' and 'High'. Four objectives represent exploitation: 'Improve quality of

goods or services', 'Improve flexibility for producing goods or services', 'Increase capacity for producing goods or services' and 'Reduce labour costs per unit output'. Three objectives represent exploration: 'Increase range of goods or services', 'Enter new markets' and 'Increase market share'. Allocating scores of 0, 1, 2 and 3 to responses on the four-point Likert scale for each objective (with 0 representing 'not relevant' and 3 'high'), enterprises can therefore score a maximum of 12 points for exploitation and 9 points for exploration.

4.3 Statistical approach

We seek to model the effect of exploitation and exploration on growth of sales turnover 2006-2008 in order to understand the impact on enterprise performance of an ambidextrous interaction between the two. The above-described measures of exploitation and exploration were therefore inputted both independently and in interaction into 15 Ordinary Least Squares (OLS) regressions, one for the whole sample and one for each broad NACE Rev. 2 section (A-N). Full model results are presented for the sample as a whole and for two sectors of particular interest. Results for the remaining broad sectors are described.

A further OLS regression was conducted for each of 7 disaggregated Manufacturing (NACE Rev. 2 section C) sub-sectors, as described subsequently. In all cases, the nature and impact of the interaction representing ambidexterity is analysed by examining the marginal effect of exploitation on sales turnover growth 2006-2008 as moderated by exploration, and vice-versa (Berry et al., 2012). For the whole sample,

and for the two broad sectors of particular interest, the marginal effects are plotted. For the 7 manufacturing sub-sectors the marginal effects are described in a table.

4.4 Control variables

In order to isolate the effect of ambidexterity we control for a number of factors that could influence the results. We include a control for R&D intensity, measured as R&D investment as a proportion of turnover in 2006, as this is reflective of the enterprise's 'absorptive capacity' (Cohen and Levinthal, 1990), which is in turn related to its ability to exploit new and existing knowledge. The ability to concurrently exploit and explore may be related to enterprise size and so we include the log of enterprise sales turnover in 2006 as a control. We control for whether or not the enterprise operates in international markets (exports) and a control for whether or not the enterprise is part of a larger group or operates individually. Country dummies are included to control for the effect of differing national innovation systems.

5. Regression Analysis

5.1 Descriptive statistics

Table 1 shows the sample size, the country breakdown, and the mean score for exploitation and exploration for each NACE Rev. 2 section examined in the initial part of this study. Enterprises in the Manufacturing and Financial and insurance services sectors have high mean scores for innovation with the objective of exploitation. Enterprises in the Manufacturing, Wholesale and retail trade,

Information and communication and Financial and insurance services sectors have high mean scores for innovation with the objective of exploration.

INSERT TABLE 1 ABOUT HERE

5.2 OLS regression results: full sample

The column representing Model 1 in Table 2 shows the estimation results for the sample as a whole. The variables exploitation and exploration have been entered into the regression both independently and in interaction. The independent effect of exploitation on enterprise performance (growth of sales turnover) in the absence of exploration is not statistically significant, and vice-versa. In contrast, the coefficient of the product term (the interaction between exploitation and exploration) is highly statistically significant at the $p<0.01$ level.

However, as described by Brambor et al. (2006), the coefficient shown in the parameter table is of less importance for the detection of a significant interaction than is the marginal effect of each interaction variable on the dependent variable, as moderated by the other interacted variable. By examining these marginal effects we can ascertain the strength of the interaction as well as its direction (i.e. exploitation as moderated by exploration or exploration as moderated by exploitation). By plotting the effect on sales turnover growth of exploitation as moderated by exploration, and the reverse, we can examine visually the effect of the interaction between the two.

Fig. 1 shows the marginal effect of exploitation on sales turnover growth 2006-2008 when exploration is varied for the whole sample. The y-axis represents the marginal effect (in percentage points) on sales turnover growth from a one unit increase in exploitation. The x-axis represents the extent to which exploration is varied. The vertical ranges represent confidence intervals and the results are statistically significant at the $p<0.01$ level where the full confidence interval lays above the horizontal zero line.

As exploration is increased the marginal effect of exploitation on sales turnover growth is enhanced. When exploration is zero a one unit increase in exploitation increases sales turnover by approximately 0.2 of a percentage point. However, when exploration is high a one unit increase in exploitation increases sales turnover by just under one percentage point. Exploration therefore enhances the effect of exploitation on sales turnover. Fig. 2 suggests the effect of exploration is similarly strongly enhanced when exploitation is varied. In sum, then, both exploitation and exploration each enhances the effect of the other on sales turnover growth. For the sample as a whole there is therefore a mutually-enhancing relationship between exploitation and exploration.

INSERT TABLE 2 ABOUT HERE

INSERT FIG 1 AND FIG 2 ABOUT HERE

5.3 OLS regression results: sectors

In two broad sectors there is similarly a mutually-enhancing relationship between exploitation and exploration that is positively and significantly associated with sales turnover growth 2006-2008. The two sectors are Manufacturing (NACE Rev. 2 section C) and Professional, scientific and technical activities (NACE Rev. 2 section M). The parameter results for these two sectors are reported in Table 2 alongside those for the sample as a whole described previously.

The marginal effects of exploitation and exploration on sales turnover growth 2006-2008, as moderated by each other, are illustrated in Fig. 3 to Fig. 6 for these two sectors. As shown in Fig. 3, for Manufacturing the marginal change in sales turnover growth that results from an increase in exploitation is strongly enhanced when in combination with increased exploration, and is highly statistically significant. As shown in Fig. 4, the reverse is also true for exploration, but the effect is only significant at the $p<0.01$ level for high levels of exploration.

As shown in Fig. 5, for Professional, scientific and technical activities the marginal change in sales turnover growth that results from an increase in exploitation is enhanced when in combination with increased exploration. However, this effect is only statistically significant at high levels of exploration, and only at the $p<0.10$ level as indicated by the fact that the confidence intervals do not lay fully above zero. However, for the reverse relationship as shown in Fig. 6, the effect of exploration is strongly enhanced when exploitation is increased, and the effect is highly statistically significant.

INSERT FIG 3-FIG 6 ABOUT HERE

In addition to these two sectors in which there is a mutually-enhancing relationship between exploitation and exploration, for three other broad sectors there are also unidirectional relationships between either exploitation as enhanced by exploration, or the reverse, and sales turnover growth, but not both simultaneously. These are more akin to an 'optimal mix' strategy which implies a stronger focus on one or other of exploitation or exploration in combination with a lesser focus on the other.

In the Water supply sector (NACE Rev. 2 section E) the effect of exploration on sales turnover growth is strongly enhanced when exploitation is increased and this effect is highly statistically significant. In the Information and communication sector (NACE Rev. 2 section J) and the Financial and insurance services sector (NACE Rev. 2 section K), the effect of exploitation on sales turnover growth is strongly enhanced when exploration is increased and this effect is statistically significant at the $p<0.05$ level.

The Manufacturing sector accounts for a large proportion of the whole sample and the results for the sample as a whole are therefore strongly influenced by the results for this sector. Below we disaggregate the Manufacturing sector to examine the relationship between exploitation and exploration, and its effect on sales turnover growth, in greater detail for this sector.

5.3.1 OLS regression results: disaggregated Manufacturing sector

The CIS2008 anonymised dataset provides data for some enterprises at the NACE Rev. 2 two-digit, division level. For other enterprises sector information is only provided for a grouped, two-digit division - for example, divisions 16-18. While it is not possible, therefore, to carry out a fully-disaggregated analysis at the two-digit division level for the Manufacturing sector, it is possible to disaggregate NACE Rev. 2 Section C - Manufacturing into 7 groups of two-digit divisions. The allocation of divisions to each group, as well as the sample size, country breakdown and descriptive statistics for exploitation and exploration for each of these groups is described in Table 3. In all, 21,758 of the 24,670 enterprises that were part of the Manufacturing sector in the full-sample, broad-sector analysis can be allocated to one of the 7 disaggregated Manufacturing sub-sectors.

INSERT TABLE 3 ABOUT HERE

Table 4 shows regression results for each of the Manufacturing sub-sectors. These estimations suggest that the strong interaction between exploitation and exploration evident for the broad Manufacturing sector emanates in particular from divisions 16-18, 26-30 and 31-33.

INSERT TABLE 4 ABOUT HERE

As before, however, of more importance than these product terms for the identification of a positive interaction is the marginal effect of each variable on the dependent variable as modified by the other interacted variable (Brambor et al.,

2006). Table 5 summarises these marginal effects for the disaggregated Manufacturing sector.

INSERT TABLE 5 ABOUT HERE

As shown in Table 5, exploitation and exploration mutually enhance the impact of each other on growth in sales turnover in only one sub-sector, labelled Manufacturing 3 and corresponding to the production of wood, paper and printing products (NACE Rev. 2 div. 16-18). However, in addition, in Manufacturing 1 (NACE Rev. 2 div. 10-12), in which the focus is on manufacture of food products, exploration is enhanced by exploitation, but not the reverse. In contrast, in Manufacturing 5 (NACE Rev. 2 div. 24-25), Manufacturing 6 (NACE Rev. 2 div. 26-30) and Manufacturing 7 (NACE Rev. 2 div. 31-33), in which the focus is on manufacture of metals, computer and electrical machinery and motor vehicles in particular, the effect of exploitation on sales turnover growth is enhanced in interaction with exploration, but not the reverse.

A tentative conclusion might be that enterprises in these latter three sub-sectors target an 'optimal mix' (March, 1991, p.75) between exploitation and exploration in which the emphasis is placed more strongly on exploitation. The combining of exploitation and exploration in these sub-sectors tends to be facilitated through investment in R&D, creating absorptive capacity and allowing for both the incremental and more radical innovation characteristic of ambidexterity, as evidenced by the strong effect and high statistical significant of R&D intensity in these sub-sectors in Table 4. In contrast, in Manufacturing 1, which corresponds to the production of food products, the 'optimal mix' tends to be more focussed on exploration, as moderated by

exploitation, and this combination of ambidexterity is not facilitated by investment in R&D as shown in Table 4. This may be indicative of the less technological nature of innovation in this sub-sector.

However, an optimal mix ambidextrous relationship of either sort (either exploration as enhanced by exploitation, or the reverse) is absent in Manufacturing 2 and Manufacturing 4, in which there is also a relatively high and statistically significant investment in R&D. This suggests that additional factors also impinge upon the engagement in, and nature of, ambidexterity in different contexts, suggesting a need for further research.

6. Discussion and conclusions

This brief study was conducted to seek empirical evidence for the concept of ambidexterity, which has received considerable attention in the literature, but relatively little empirical examination. The results provide some empirical support for the concept of ambidexterity and the assumption that enterprises operating ambidextrously perform better. The study also suggests that whether an ambidextrous strategy is employed, and its nature if it is, varies by sector.

The results suggest firstly that the concept of ambidexterity may be more applicable to sectors in which innovation is of a technological nature, such as Manufacturing and Professional, scientific and technical activities in which both exploitation and exploration were found to be mutually enhancing. Secondly, where it is employed, the nature of the ambidexterity engaged in by enterprises can vary, as was especially

evident when taking a disaggregated sectoral perspective in this study. In some contexts there is a mutually-enhancing relationship between exploitation and exploration, in others exploitation is enhanced by the presence of exploration, or the reverse, but not both simultaneously, suggesting a more nuanced strategy that emphasises one or the other of the two aspects of ambidexterity, resulting in an 'optimal mix'.

A further tentative conclusion is that an optimal mix strategy that places greater emphasis on exploitation, as moderated by exploration, may be more appropriate in contexts in which innovation is driven by the production of new knowledge through investment in R&D. The reverse optimal mix strategy focusing on exploration, as moderated by exploitation, may be more applicable in sectors in which innovation is less related to the production of new knowledge through investment in R&D. However, this requires further examination and verification, the stimulation of which was a central purpose of this short analysis. A fruitful line of enquiry for future research would be to refine understanding of the context-specific nuances associated with the type and nature of ambidexterity adopted, through comparison between and within sectors.

References

Andriopoulos, C., Lewis, M., 2009. Exploitation-exploration tensions and organizational ambidexterity: Managing paradoxes of innovation. Organization Science 20, 696–717.

Archibugi, D., Filippetti, A., Frenz, M., 2013. Economic crisis and innovation: Is destruction prevailing over accumulation? Research Policy 42, 303-314.

Atuahene-Gima, K., 2005. Resolving the capability-rigidity paradox in new product innovation. Journal of Marketing 69, 61–83.

Berry, W. D., Golder, M., Milton, D., 2012. Improving tests of theories positing interaction. Journal of Politics 74, 653-671.

Birkinshaw, J., Gibson, C. B., 2004. Building ambidexterity into an organization. Sloan Management Review 45, 47-55.

Brambor, T., Roberts Clark, W., Golder, M., 2006. Understanding interaction models: improving empirical analyses. Political Analysis 14, 63-82.

Castellacci, F., 2008. Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. Research Policy 37, 978-994.

Cohen, W. M., Levinthal, D. A., 1990. Absorptive capacity: A new perspective of learning and innovation. Administrative Science Quarterly 35, 128-152.

De Clercq, D., Thongpapanl, N., Dimov, D., 2013. Shedding new light on the relationship between contextual ambidexterity and enterprise performance: An investigation of internal contingencies. Technovation 33, 119-132.

Duncan, R., 1976. The ambidextrous organization: Designing dual structures for innovation. R. Kilman, L. Pondy, (eds) The Management of Organizational Design. North Holland, New York, 167–188.

Eurostat, 2014. CIS metadata: http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/inn_esms.htm, accessed 24th March, 2014.

Gupta, A. K., Smith, K. G. Shalley, C. E., 2006. The interplay between exploration and exploitation. Academy of Management Journal 49, 693-708.

He, Z., Wong, P., 2004. Exploration vs. exploitation: an empirical test of the ambidexterity hypothesis. Organization Science 15, 481-494.

Jansen, J., van den Bosch, F., Volbreda, H., 2006. Exploratory innovation, exploitative innovation, and performance: effects of organizational antecedents and environmental moderators. Management Science 52, 1661-1674.

Kohler, C., Sofka, W., Grimpe, C., 2012. Selective search, sectoral patterns, and the impact on product innovation performance. Research Policy 41, 1344-1356.

Lubatkin, M. H., Simsek, Z., Ling, Y., Veiga, J. F., 2006. Ambidexterity and performance in small- to medium-sized enterprises: The pivotal role of top management team behavioural integration. J. Management 32, 646–672.

March, J. G., 1991. Exploration and exploitation in organizational learning. Organizational Science 2, 71-87.

Mate-Sanchez-Val, M., Harris, R., 2014. Differential empirical innovation factors for Spain and the UK. Research Policy 43, 451-463.

McCarthy, I. P., Gordon, B. R., 2011. Achieving contextual ambidexterity in R&D organizations: a management control system approach. R&D Management 41, 240-258.

Mention, A., 2011. Co-operation and co-opetition as open innovation practices in the service sector: which influence on innovation novelty? Technovation 31, 44-53.

Raisch, S., Birkinshaw, J., 2008. Organizational ambidexterity: antecedents, outcomes, and moderators. Journal of Management 34, 375-409.

Sofka, W., Grimpe, C., 2010. Specialized search and innovation performance – evidence across Europe. R&D Management 40, 310-323.

Tushman, M. L., O'Reilly, C. A., 1996. Ambidextrous organization: managing evolutionary and revolutionary change. California Management Review 38, 8-30.

Table 1
Country breakdown and exploitation and exploration by sector

NACE Rev. 2 section	Countries (*n.*)	Exploitation (Min=0, Max=12)		Exploration (Min=0, Max=9)	
		Mean	S.D	Mean	S.D.
A - Agriculture, forestry and fishing (*n.*303)	ES(106); NO(16)	6.63	3.62	4.16	3.18
B - Mining and quarrying (*n.*440)	BG(34); CY(7); CZ(29); DE(71); HU(14); IT(58); LT(8); NO(12); PT(53); RO(27); SI(10); SK(13)	6.58	3.88	4.19	3.23
C – Manufacturing (*n.*24,670)	BG(2,417); CY(237); CZ(1,449); DE(2,325); EE(1,232); ES(8,050); HU(807); IT(3,403); LT(226); LV(28); NO(301); PT(2,041); RO(1,288); SI(569); SK(297)	7.37	3.54	5.60	2.89
D – Electricity and gas (*n.*488)	BG(23); CY(1); CZ(42); DE(119); EE(50); ES(50); HU(31); IT(75); LT(25); PT(14); RO(27); SI(11); SK(20)	5.82	3.83	3.16	2.96
E – Water supply (*n.*1,177)	BG(16); CY(15); CZ(78); DE(227); EE(78); ES(191); HU(63); IT(205); LT(36); NO(3); PT(146); RO(74); SI(24); SK(21)	6.39	3.82	3.56	3.12
F – Construction (*n.*2,090)	CZ(108); ES(743); HU(61); IT(1,058); LT(39); NO(1); PT(29); SK(51)	6.56	3.40	4.15	2.92
G – Wholesale and retail trade (*n.*4,695)	BG(410); CY(94); CZ(205); DE(147); EE(168); ES(1,561); HU(105); IT(965); LT(55); LV(4); NO(25); PT(465); RO(329); SI(91); SK(71)	6.61	3.53	5.03	3.06
H – Transportation and storage (*n.*2,185)	BG(176); CY(29); CZ(99); DE(308); EE(162); ES(482); HU(81); IT(367); LT(19); NO(3); PT(268); RO(111); SI(48); SK(32)	6.57	3.88	4.28	3.24
I - Accommodation and food services (*n.*549)	CZ(40); ES(183); IT(326)	6.58	3.44	4.32	2.80
J – Information and communication (*n.*3,154)	BG(205); CY(25); CZ(243); DE(309); EE(158); ES(1,165); HU(96); IT(338); LT(53); LV(6); NO(89); PT(246); RO(101); SI(92); SK(28)	6.95	3.44	5.88	2.81
K – Financial and insurance services (*n.*1,653)	BG(64); CY(59); CZ(100); DE(142); EE(80); ES(300); HU(95); IT(428); LT(11); LV(4); PT(189); RO(103); SI(49); SK(29)	7.55	3.27	5.69	2.74
L – Real estate activities (*n.*93)	CZ(12); ES(50); IT(31)	5.38	3.38	3.59	2.81
M – Prof. sci. and tech. services (*n.*2,891)	BG(99); CZ(205); DE(450); EE(116); ES(1,232); HU(46); IT(170); LT(61); LV(1); NO(69); PT(213); RO(163); SI(41); SK(18)	6.69	3.62	5.05	3.03
N - Admin. And support services activities (*n.*725)	CZ(89); DE(222); EE(16); ES(363); IT(35)	5.39	4.19	3.39	3.33
Total (*n*. 45,113)	BG(3,444); CY(474); CZ(2,699); DE(4,320); EE(2,060); ES(14,761); HU(1,399); IT(7,459); LT(533); LV(43); NO(519); PT(3,664); RO(2,223); SI(935); SK(580)	7.05	3.59	5.24	3.01

Table 2
Results of OLS regressions for full sample and two broad sectors

	Model 1 (whole sample)	Model 2 (NACE Rev. 2 section C – Manufacturing)	Model 3 (NACE Rev. 2 section M – Professional, scientific & technical services)
Exploitation	0.19 (0.15)	0.27 (0.19)	-0.74 (0.71)
Exploration	0.18 (0.2)	-0.23 (0.25)	0.08 (0.93)
Exploitation x Exploration	0.07*** (0.03)	0.08*** (0.03)	0.24* (0.12)
R&D intensity	0.33*** (0.01)	0.51*** (0.04)	0.19*** (0.02)
Export (*d*)	3.08*** (0.63)	0.79 (0.83)	6.03** (2.91)
Turnover 2006 (log)	-6.20*** (0.18)	-5.70*** (0.24)	-11.3*** (1.06)
Part of company group (*d*)	11.17*** (0.66)	10.40*** (0.85)	13.3*** (3.18)
Countries			
CY (*d*)	-15.29*** (2.79)	-4.08 (3.56)	-68.3** (27.8)
CZ (*d*)	-10.53*** (1.51)	-7.36*** (1.81)	-37.7*** (8.89)
DE (*d*)	-28.87*** (1.38)	-18.6*** (1.62)	-58.2*** (8.13)
EE (*d*)	-26.57*** (1.62)	-21.3*** (1.89)	-67.8*** (9.84)
ES (*d*)	-28.05*** (1.15)	-25.4*** (1.32)	-41.0*** (7.68)
HU (*d*)	-22.11*** (1.83)	-12.4*** (2.18)	-64.3*** (12.7)
IT (*d*)	-73.53*** (1.52)	-64.1*** (1.86)	-124.*** (10.4)
LT (*d*)	-8.34*** (2.65)	-5.62 (3.65)	-30.8*** (11.6)
LV (*d*)	-14.27* (8.65)	-7.94 (9.87)	39.7 (71.4)
NO (*d*)	-17.31*** (2.73)	-12.9*** (3.27)	-29.0** (11.6)
PT (*d*)	-31.78*** (1.38)	-26.1*** (1.62)	-56.9*** (8.82)
RO (*d*)	0.76 (1.56)	3.90** (1.83)	-33.3*** (9.28)
SI (*d*)	-20.60*** (2.12)	-17.80*** (2.49)	-29.9** (13.3)
SK (*d*)	2.16 (2.56)	11.0 (3.24)	-52.3 (18.2)
NACE Rev. 2 sections			
B - Mining & quarrying (*d*)	2.14 (4.22)		
C – Manufacturing (*d*)	3.37 (3.28)		
D – Electricity & gas (*d*)	15.56*** (4.18)		
E – Water supply (*d*)	19.10*** (3.67)		
F – Construction (*d*)	17.62*** (3.5)		
G – Wholesale & retail trade (*d*)	8.35** (3.36)		
H – Transportation & storage (*d*)	12.85*** (3.48)		
I – Acc. & food services (*d*)	-1.48 (4.06)		
J – Information & comm. (*d*)	16.35*** (3.41)		
K – Fin. & insurance services (*d*)	26.29*** (3.58)		
L – Real estate activities (*d*)	-4.18 (6.68)		
M – Prof. sci. & tech. services (*d*)	12.21*** (3.43)		
N - Admin. & support serv. act. (*d*)	17.49*** (3.87)		
Constant	124.89*** (4.16)	118.91*** (3.45)	233.73*** (15.5)
N	45,113	24,670	2,891
R-squared	0.10	0.09	0.12
F-test	154.26***	113.16***	19.11***

Standard errors in parentheses.
(*d*) Dummy variable
*p<0.10. **p<0.05. ***p<0.01.

Table 3
Disaggregation of Manufacturing (NACE Rev. 2 Section C)

Label	NACE Rev. 2 Divisions	Countries (*n.*)	Exploitation (Min=0, Max=12)		Exploration (Min=0, Max=9)	
			Mean	S.D.	Mean	S.D.
Manufacturing 1 (*n.*288)	10 Food products; 11 Beverage products; 12 Tobacco products	IT(288)	7.90	2.87	5.98	2.33
Manufacturing 2 (*n.*2,188)	13 Textiles; 14 Wearing apparel; 15 Leather & related products	BG(450); CY(5); CZ(68); DE(116); EE(126); ES(514); HU(37); IT(366); LT(10); LV(1); NO(15); PT(246); RO(180); SI(41); SK(13)	6.73	3.67	5.27	2.88
Manufacturing 3 (*n.*2,441)	16 Wood; 17 Paper; 18 Printing	BG(178); CY(34); CZ(110); DE(240); EE(226); ES(653); HU(61); IT(448); LT(42); LV(4); NO(10); PT(249); RO(106); SI(50); SK(30)	7.60	3.62	5.27	2.99
Manufacturing 4 (*n.*4,955)	19 Coke & petroleum prods; 20 Chemicals; 21 Pharmaceutical prods; 22 Rubber & plastic; 23 Non-metallic mineral prods	BG(348); CY(63); CZ(327); DE(410); EE(204); ES(1,889); HU(167); IT(633); LT(49); LV(8); NO(49); PT(430); RO(214); SI(100); SK(64)	7.36	3.52	5.76	2.83
Manufacturing 5 (*n.*3,522)	24 Basic metals; 25 Fabricated metal prods	BG(306); CY(26); CZ(192); DE(317); EE(96); ES(1,195); HU(90); IT(506); LT(23); NO(34); PT(442); RO(147); SI(111); SK(37)	7.58	3.62	5.31	3.00
Manufacturing 6 (*n.*5,754)	26 Computer, electronic & optical prods; 27 Electrical equipment; 28 Machinery & equipment; 29 Motor vehicles; 30 Other trans. equipment	BG(376); CY(15); CZ(472); DE(778); EE(222); ES(1,886); HU(252); IT(704); LT(34); LV(6); NO(157); PT(305); RO(278); SI(178); SK(91)	7.60	3.36	6.08	2.71
Manufacturing 7 (*n.*2,610)	31 Furniture; 32 Other manufacturing; 33 Repair and installation of machinery & equipment	BG(287); CY(17); CZ(121); DE(250); EE(172); ES(722); HU(73); IT(458); LT(34); LV(1); NO(17); PT(224); RO(163); SI(49); SK(22)	7.06	3.54	5.42	2.87

Table 4
Results of OLS regressions for disaggregated Manufacturing sector
Standard errors in parentheses.

	Manufacturing 1 (NACE Rev. 2 div. 10-12)	Manufacturing 2 (NACE Rev. 2 div. 13-15)	Manufacturing 3 (NACE Rev. 2 div. 16-18)	Manufacturing 4 (NACE Rev. 2 div. 19-23)	Manufacturing 5 (NACE Rev. 2 div. 24-25)	Manufacturing 6 (NACE Rev. 2 div. 26-30)	Manufacturing 7 (NACE Rev. 2 div. 31-33)
Exploitation	-0.69 (1.41)	-0.23 (0.69)	-0.13 (0.48)	0.55 (0.39)	0.59 (0.47)	-0.07 (0.47)	-0.49 (0.67)
Exploration	1.37 (1.78)	0.37 (0.88)	-0.50 (0.74)	0.41 (0.47)	-0.09 (0.70)	-0.93* (0.56)	-2.03** (0.84)
Exploitation x Exploration	0.14 (0.22)	0.06 (0.11)	0.18** (0.08)	-0.00 (0.06)	0.03 (0.08)	0.14* (0.07)	0.26** (0.11)
R&D intensity	0.05 (1.45)	1.01*** (0.37)	0.36 (0.27)	0.45*** (0.08)	0.71*** (0.19)	0.50*** (0.06)	0.53*** (0.15)
Export (*d*)	0.64 (3.93)	2.05 (3.12)	4.06* (2.18)	5.03*** (1.60)	1.49 (2.23)	2.34 (2.22)	0.71 (2.77)
Turnover 2006 (log)	-1.74 (1.11)	-9.26*** (0.94)	-6.15*** (0.74)	-5.59*** (0.47)	-5.40*** (0.69)	-5.86*** (0.53)	-7.86*** (0.96)
Part of company group (*d*)	-4.97 (4.35)	10.0*** (3.32)	8.34*** (2.47)	11.3*** (1.58)	6.84*** (2.29)	11.2*** (1.82)	13.7*** (3.10)
Countries							
CY (*d*)	-	-7.73 (24.5)	-7.52 (8.38)	2.83 (6.08)	1.90 (10.7)	0.13 (14.5)	-19.40 (14.4)
CZ (*d*)	-	-2.92 (7.35)	-4.71 (5.64)	-10.8*** (3.53)	-15.8*** (5.05)	0.65 (4.02)	-8.40 (6.65)
DE (*d*)	-	-3.79 (6.23)	-17.1*** (4.82)	-21.3*** (3.37)	-27.3*** (4.5)	-8.04** (3.70)	-22.90*** (5.55)
EE (*d*)	-	-6.20 (5.84)	-27.1*** (4.79)	-23.8*** (4.01)	-22.3*** (6.29)	-11.9** (4.82)	-18.90*** (5.95)
ES (*d*)	-	-8.59** (4.24)	-19.1*** (4.13)	-28.4*** (2.74)	-34.6*** (3.64)	-19.1*** (3.30)	-32.30*** (4.52)
HU (*d*)	-	-7.53 (9.55)	-1.64 (6.74)	-19.3*** (4.27)	-24.5*** (6.42)	-5.30 (4.65)	-9.89 (7.79)
IT (*d*)	-	-64.1*** (5.74)	-63.6*** (5.53)	-64.8*** (3.84)	-70.4*** (5.26)	-58.3*** (4.47)	-82.70*** (6.60)
LT (*d*)	-	-27.0 (17.6)	-4.21 (7.75)	-17.5*** (6.80)	-13.1 (11.3)	2.67 (9.97)	10.50 (10.6)
LV (*d*)	-	17.6 (54.6)	-27.1 (22.3)	-7.39 (15.8)	-	-0.77 (22.8)	-13.50 (57.4)
NO (*d*)	-	5.34 (14.6)	-34.9** (14.6)	-27.6*** (6.91)	-16.0* (9.68)	-7.15 (5.46)	5.20 (14.7)
PT (*d*)	-	-10.8** (4.72)	-24.3*** (4.59)	-30.0*** (3.27)	-30.1*** (4.03)	-15.5*** (4.38)	-27.20*** (5.38)
RO (*d*)	-	9.56* (5.03)	4.89 (5.54)	0.95 (3.89)	-1.95 (5.33)	14.1*** (4.44)	-4.19 (5.84)
SI (*d*)	-	-2.17 (9.25)	-13.7* (7.37)	-18.3*** (5.12)	-29.3*** (5.98)	-11.3** (5.19)	-19.00** (9.17)
SK (*d*)	-	31.2 (15.5)	3.45 (8.94)	-3.97 (6.09)	17.9* (9.19)	17.5 (6.58)	32.00 (12.9)
Constant	26.61**(12.70)	144.68*** (11.9)	115.73*** (10.4)	111.62*** (6.90)	127.35*** (9.71)	119.12*** (7.76)	160.09*** (12.7)
N	288	2,188	2,441	4,955	3,522	5,754	2,610
R-squared	0.06	0.10	0.09	0.10	0.10	0.08	0.11
F-test	2.73***	11.28***	12.06***	26.52***	18.77***	22.41***	15.20***

(*d*) Dummy variable
*p<0.10. **p<0.05. ***p<0.01.

Table 5
Marginal effects of exploitation and exploration for disaggregated Manufacturing sector

Manufacturing sub-sector	Marginal effect on sales turnover growth 2006-2008 of exploitation when varying exploration	Marginal effect on sales turnover growth 2006-2008 of exploration when varying exploitation
Manufacturing 1 (NACE Rev. 2 div. 10-12)	No effect	Strong, positive and statistically significant effect
Manufacturing 2 (NACE Rev. 2 div. 13-15)	No effect	No effect
Manufacturing 3 (NACE Rev. 2 div. 16-18)	Strong, positive and statistically significant effect	Strong, positive and statistically significant effect
Manufacturing 4 (NACE Rev. 2 div. 19-23)	No effect	No effect
Manufacturing 5 (NACE Rev. 2 div. 24-25)	Positive, statistically significant effect	No effect
Manufacturing 6 (NACE Rev. 2 div. 26-30)	Strong, positive and statistically significant effect	No effect
Manufacturing 7 (NACE Rev. 2 div. 31-33)	Strong, positive and statistically significant effect	No effect

Fig. 1. Change in sales turnover growth 2006-2008 from a one unit change in level of exploitation when varying exploration, for whole sample (with 95% conf. int.)

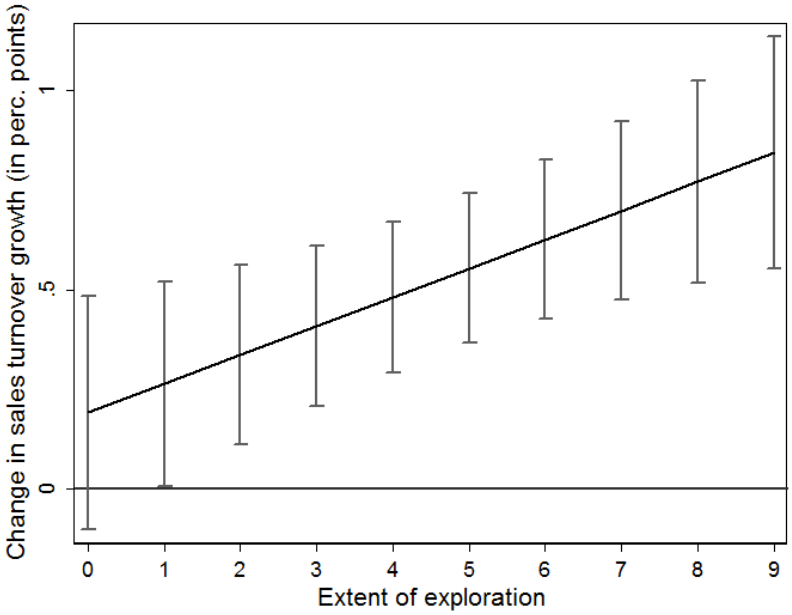

Fig. 2. Change in sales turnover growth 2006-2008 from a one unit change in level of exploration when varying exploitation, for whole sample (with 95% conf. int.)

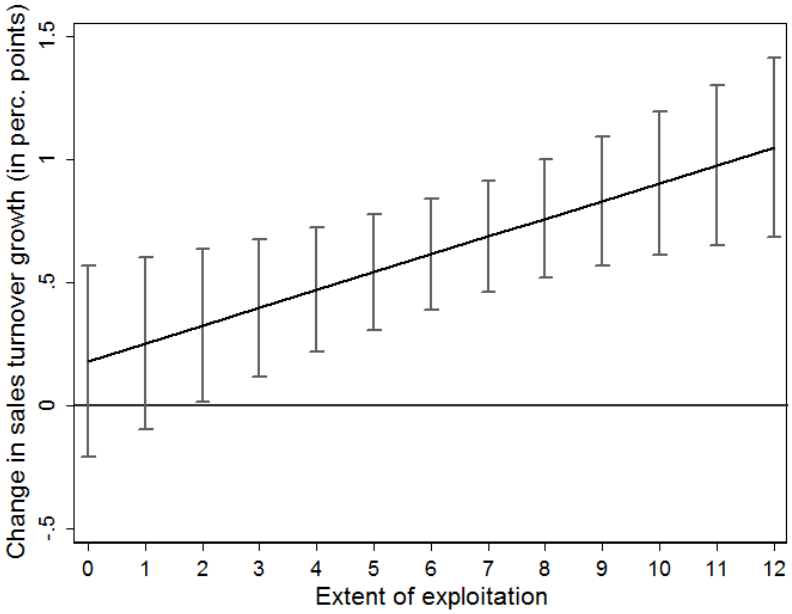

Fig. 3. Change in sales turnover growth 2006-2008 from a one unit change in level of exploitation when varying exploration, for Manufacturing – Nace Rev. 2 Section C (with 95% conf. int.)

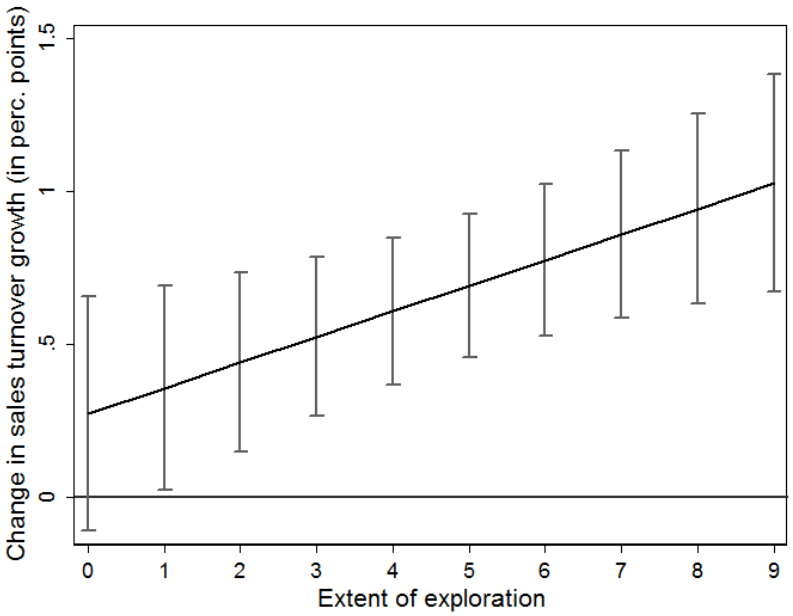

Fig. 4. Change in sales turnover growth 2006-2008 from a one unit change in level of exploration when varying exploitation, for Manufacturing – Nace Rev. 2 Section C (with 95% conf. int.)

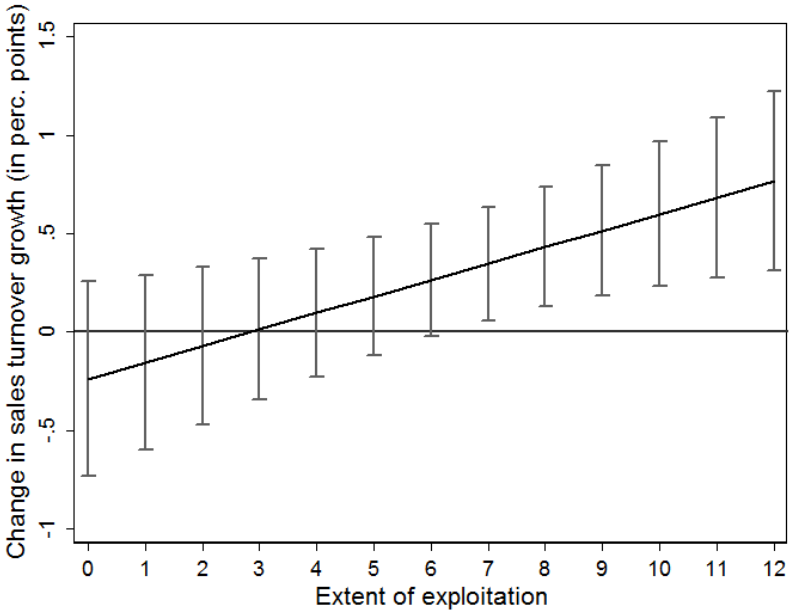

Fig. 5. Change in sales turnover growth 2006-2008 from a one unit change in level of exploitation when varying exploration, for Professional, scientific & technical services – NACE Rev. 2 Section M (with 95% conf. int.)

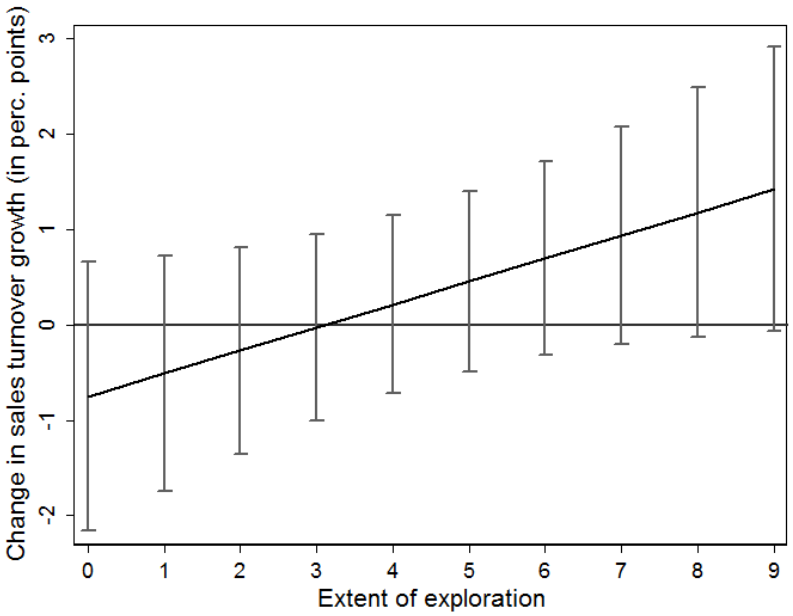

Fig. 6. Change in sales turnover growth 2006-2008 from a one unit change in level of exploration when varying exploitation, for Professional, scientific & technical services – NACE Rev. 2 Section M (with 95% conf. int.)