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Causal relationships between economic activity and the mining industry in Chile

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Abstract. The aim of this study is to examine the incidence of economic activity on soft innovation in the mining sector. Through a global analysis of indirect incidents and using the theory of forgotten effects. Thus, the case of the mining industry in Chile was analyzed, given that it is one of the industries that contributes the most to GDP in Chile. The empirical study was carried out through the application of a structured survey towards three experts from the mining sector. In addition, the study concludes with evidence that oil price has a direct incidence on investments in mining and economic expectations, and indirectly in average income middle managers, market share of the company in the mining sector, and growth of imports and exports in the mining sector.

Keywords: Soft innovation, mining industry, forgotten effects theory, monte carlo method

1. Introduction

The Economic Commission for Latin America and the Caribbean (ECLAC) foresees regional economies, pushing them to have a more favorable and international context in 2018. ECLAC also stresses the need to diversify the productive structure of said economies, with the aim of obtaining larger benefits that can incorporate sustainable use of knowledge and technology in the long term (ECLAC, 2017).

Business models provide pathways by which technological innovation and knowhow can combine with the use of tangible and intangible assets to generate profits [18]. In retrospect, innovation requires a combination of different types of knowledge, capabilities, and resources to be successful [19]. In fact, the creation and transformation of business models are better known as outputs of dynamic capabilities. These organizational innovation capabilities have direct influence in the development of sustainable strategies, the generation of competitive advantages, and the facilitation of success in the market [18].

Although dynamic capabilities are multifaceted, firms will not necessarily be strong across all dimensions [19]. Strong organizational innovation capabilities (dynamic) will signify superior ability to integrate (relative to competitors), build, and reconfigure internal competences to address and –or in some cases also– bring about changes in the business environment [18].

In this context, this study provides a first approach on soft innovation in Mining in Chile. This industry is well-known in Latin America (LATAM) due to its sizeable contributions to the region in development, innovation and GDP (Gross Domestic Product), which reached 9% in 2017. In retrospect, Chile is the most innovative LATAM economy, ranked 44th in the world with 38.4 points (OMPI, Universidad Cornell & INSEAD, 2016). However, in 2017 the country fell

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to 46th place according to the World Innovation Index (OMPI, Cornell University & INSEAD, 2017).

This study uses a case-by-case system to analyze the incidence of economic activity in the levels of innovation. The aim is to identify the indirect effects that economic decision-making has on innovation. Hence, the main research questions are:

Are there unknown (or forgotten) effects in the mining industry that are caused by economic activity? And if so, are some of these effects reflected in lightweight innovation?

The study also conducts an analysis that applies the 'Theory of forgotten effects' based on the opinions of experts, which take into account the pessimistic, the normal, and the optimistic scenarios. This makes it possible to investigate a number of possible causes that can have an incidence on the level of lightweight innovation.

To highlight the importance that lightweight innovation has, we have selected Mining as the element that measures the economic sector and level of national development. Likewise, the study also uses the '*Theory of forgotten effects*' which help demonstrate the indirect incidences that are influenced by economic activity (which in a preliminary analysis does not seem important).

Thus, the value of this research lies in its contribution of including gradual and nuanced thinking of the decision-makers in the process of determining the levels of innovation in mining. This involves and analyzes the natural way of thinking of human beings under environments with high uncertainty.

Currently, soft (lightweight) innovation is being applied more regularly in organizations than technological innovation [15]. Part of the reason for this is that soft innovation, at the cultural level, can benefit from a multi-disciplinary focus based on human creativity [10]. After analyzing the literature in the Web of Science (WoS), we have found seven articles regarding the subject. This motivates us to continue the research given: A) its originality, and B) the open field that exists to explore how this knowledge can contribute to different economic sectors (in this case in the Chilean mining industry).

The variables associated to light innovation considered are related to business management such as: workspaces, salary level, human resources management, market share, among others.

One of the main guidelines of this study is the following question: Does economic activity influence the level of innovation in the Chilean mining sector?

Thus, the objective of this research is to explore the incidence that economic activity has on the level of mining innovation.

The following parts of this article are composed of:

1) The literature review, whose aim is to conceptualize and show existing research on the subject.
2) The methodology employed in the empirical study.
3) The results.
4) The conclusions and reflections for future research.

2. Literature review

The (OECD, 2008), defines the Innovation System, as a system of interaction of companies, small or large, public and private sector, universities and state agencies, oriented to the production of science and technology within national borders, where this interaction occurs between the technical, commercial, legal, social or financial units, as long as the objective of the interaction is the development, protection, financing or regulation of new science and technology. " But in the literature the term "innovation" is notoriously ambiguous and lacks a single definition [27, 30]. According to the Department of Commerce and Industry of the United Kingdom (DTI 1998), "the successful exploitation of new ideas". This holistic approach could be found in an organization, which implies a wide range of innovation types: product / service, process, administrative, technological, among others.

The most influential journals for innovation research indexed in Web of Science are: Strategic Management J, Research Policy, Academy of Management J, Organization Science and Management Science. In relation to universities, at an international level, universities in the United States and the United Kingdom are the most productive and influential institutions [28]. This is consistent with other rankings of the best universities in economics and business (QS, Shanghai ARWU). According to QS ranking: MIT, U. Cambridge and Imperial Coll. London, within the three most influential universities principals. Then, the Shanghai ranking: Harvard U, Stanford U and MIT. In the ranking proposed by Ranking [28] is presented to: U. Pennsylvania, Harvard U., MIT, Stanford U.

Most of the research conducted before 2009 speaks of innovation as functional, scientific or technological. The OECD manuals that guide the collection of data on innovation have largely reflected this perspective, with an emphasis on product and process innovation (TPP) in new products and, more recently, in services (although it is also has identified organizational and marketing innovation).

These last decades have increased in interest to develop soft innovation focused "organizational" innovation and "commercialization", arising a great interest in the creative industries. It is proven that developing soft innovation improves the profitability of companies [29].

Innovation management is clearly associated to management of change [5]. Literature suggests that companies must understand, manage, role of human resource management innovation in creating competitive advantage [31]. This means that the theory based on resources (Resource theory) considers corporate strategic management as an important corporate capability in innovation [2, 13, 21].

In retrospect, innovation is fundamental to achieve success and prosperity in the 21st Century [11]. The exemplary case of Toyota, where its success comes from technological innovation and its "Toyota's culture of contradictions", have helped develop soft innovation in the management of human resources and corporate culture [16]. The research conducted by [6] also shows the relevance that this new perspective is having on innovation, showcased by how the concepts of market orientation and design orientation have impacted online games. Choi's study [6] concludes with demonstrating the importance that the combination of technological innovation and soft innovation have in strategic corporate competitivity.

Following this idea, manage to identify the key determinants that encourage soft innovation in cultural institution [4]. They conclude that innovation is strengthened by digital literacy on the products and the consumers. Likewise, highlights the importance of soft innovation and that the discipline deserves more attention [8].

It is therefore expected to see the interest of public policy in innovation, which although recent [8], it is considered to play a key role in developing the industry and human capital. Nonetheless, these have focused mainly on the concept of innovation in science and technology, developing $I+\mathrm{D}$ [8] in the mining, agricultural, and manufacturing sectors based on the Oslo manuals and the OCDE's Frascati.

The capacity for innovation within a company will depend on its ability to recognize the value of new and external information [15].

Therefore, soft innovation is considered as a significant element of the service sector in modern economies. Furthermore, its contributions to different industries are steadily becoming better known, as well as in marketing and organizational innovation.

The variables considered in the study are related to the proposal of Adamas [27], where he points out that competitive success depends on the management of the organization of the innovation process. Within these variables are those related to the following Framework category: inputs, knowledge management, strategy, organization and culture, portfolio management, project management, Commercialization.

3. Methodology

3.1. Theory of forgotten effects

The theory of forgotten effects was proposed by Kaufman and Gil-Aluja (1988) [33] to identify indirect effects in cause-effect processes.

Given a set of causes $C = \{c_i\}, \forall i = 1 \ldots n$, and a set of effects $E = \{e_j\}, \forall j = 1, \ldots, m$, the following matrices, representing first-order effects, are built:

$$\mathbf{CC} = \left[\mu^{CC}_{i,\hat{i}}\right]_{n\times n} \quad (1)$$

$$\mathbf{CE} = \left[\mu^{CE}_{i,j}\right]_{n\times m} \quad (2)$$

$$\mathbf{EE} = \left[\mu^{EE}_{j,\hat{j}}\right]_{m\times m} \quad (3)$$

where $\mu^{CE}_{i,\hat{i}}$ is the degree of truth, in [0,1] of the statement "c_i has an incidence on $e_{\hat{i}}$" (equivalently for the other two matrices). It should be noted that given de definition of $\mathbf{CC}$ and EE, both are reflexive matrices.

The second order effects are calculated through:

$$\mathbf{EC}^2 = \mathbf{EC}^{1+2} - \mathbf{EC} \quad (4)$$

Where:

$$\mathbf{EC}^{1+2} = \mathbf{CC} \circ \mathbf{EC} \circ \mathbf{EE} \quad (5)$$

and $\circ$ is a nonlinear and associative operator known as the maxmin convolution. In general terms, for a

Table 1
Scale for the degrees of truth of the proposition
"C has an incidence on E"

Degree of Truth	Assessment
0	False
0,1	Practically false
0,2	Almost false
0,3	Quite false
0,4	More false than truth
0,5	Neither truth nor false
0,6	More truth than false
0,7	Quite true
0,8	Almost true
0,9	Practically true
1	True

Source: Gil (1990) [32].

matrix:

$$\mathbf{A} = \left[\mu^{A}_{i,\hat{\imath}}\right]_{n\times n} \tag{6}$$

where the max-min convolution is defined as:

$$\mu^{\mathbf{A}^{1+2}}_{i,\hat{\imath}} = \max_{i,\hat{\imath}=1,\ldots,n}\left\{\min_{k=1,\ldots,n}\left\{\mu^{\mathbf{A}}_{i,k},\mu^{\mathbf{A}}_{k,\hat{\imath}}\right\}\right\} \tag{7}$$

and the second-order effects are obtained from:

$$\mu^{\mathbf{A}^{2}}_{i,\hat{\imath}} = \mu^{\mathbf{A}^{1+2}}_{i,\hat{\imath}} - \mu^{\mathbf{A}}_{i,\hat{\imath}} \tag{8}$$

Any second order effect above 0.5 is considered a forgotten effect.

3.2. Procedure of empirical data

To develop the empirical study, we had to take into account a preliminary step that consisted in defining the causes and effects that had to be considered in this research. To this end, we performed several evaluation-based interviews with a group of six researchers, which results can be seen in Table 2.

In the second stage of the study, the methodology required us to have experts complete their incidence analysis on three relationship matrices using an lhe scale of positions of eleven values (11-valued) (Table 1) [32]. Hence, we applied a structured survey to three Chilean research and economic experts, where we ask them to evaluate the degree of truth based that each "cause" has on each "effect," that each "cause" has on each "cause", and that each "effect" has on each "effect."

One of the main drawbacks of the theory of forgotten effects lies in the application to "experts" and, therefore, on the definition of what an "expert" is, a limited consensus concept as reported by Baker, Lovell, and Harris [26]. Nevertheless, for Fink et al. [25] an expert should be someone who is "representative of [her] profession, [has the] power to implement the findings," or because she will not likely be challenged as having sufficient expertise in the field. Such a definition limits the number of individuals who can then be participants in a forgotten effects study. Furthermore, in some problems, a person can be an expert on a subset of subjects, while she may be not having more knowledge than any other layman on the rest. Thus, we implemented a dual-pronged methodology to deal with both issues. First, the experts were asked to assign not a single degree of truth to each relationship, but a minimum and a maximum degree of truth, an interval in which they limit their uncertainty or confidence about the degree of truth of a statement or relationship:

$$\left[\mu^{\mathbf{A}}_{i,j,k,\min},\mu^{\mathbf{A}}_{i,j,k,\max}\right] \tag{9}$$

where $\mathbf{A} \in \{\mathbf{CC}, \mathbf{CE}, \mathbf{EE}\}$, *i,j* are the rows and columns of $\mathbf{A}$, and *k* is a given expert.

Someone who is an expert in a subset of subjects in the problem will answer with narrower confidence intervals for the statements or relationships related to her field of expertise, while for those outside the confidence intervals would be broader. This solution, in turn, is followed by a second problem: how to deal with confidence intervals in the context of a forgotten effects study? It was decided to use a Monte Carlo [22] approach, using each confidence interval as a uniform probability distribution from which to extract a single value $\mu^{\mathbf{A}}_{i,j,k,r}$, at replicate r, for the degree of truth of the statement "in matrix A, i has in incidence on j." The set of second-order effects that occurred are then tabulated, and a new replicate is performed. By performing this process a large number of times, we obtain a frequency table of the forgotten effects identified with the intervals obtained from our experts. Therefore, a forgotten effect will sometimes appear, while others do not; it can also be observed that the degree of truth with which a second-order effect appears varies with each occurrence; hence, we calculate the average degree of truth for this effect. This process will not only help in solving the problem when uncertainty in the assessment of the degree of truth of a statement or relationship appears but also helps in coping with the problem of a small sample of experts.

Table 2
The main causes and effects that affect value-creation in the mining industry

	Causes
C1	Economic expectation of the country (Monetary, financial, fiscal and exchange): considered as a global vision.
C2	Macroeconomic environment (fiscal policy, monetary policy, Exchange rate policy, competitive policy, financial policy): considered as a global vision.
C3	International financial environment and Country risk.
C4	Infrastructure (land, sea, air).
C5	Infrastructure (New Technologies of Information and Communication).
C6	Country educational level (Tertiary, Secondary, Primary): Global vision.
C7	The people's capabilities to administer businesses (Human Resource in the Company).
C8	Energy availability (secure source).
C9	Energy availability (low cost).
C10	Natural resources (Mineral law – Law on minerals).
C11	Stock of physical capital of the Company (infrastructure, land, capital, etc.).
C12	Regulatory system and Import barriers.
C13	Regulatory system and Export barriers.
C14	I+D+i (Investigation, Development, Innovation).
C15	I+D+i (Investigation, Development, Innovation): Country level.
C16	Copper Price.
C17	Labor conditions (Staff training, vacations, wages, work environment, schedules, contract types, etc.): at the general level.
C18	Petroleum/Oil prices.
	Effects
E1	Growth in mining GDP.
E2	Employment rate.
E3	Investment in mining as a percentage of GDP.
E4	Investment level in relation to total income of the sector.
E5	Growth in exports in the mining sector.
E6	Growth in imports in the mining sector.
E7	Environmental effects due to mining activity.
E8	Corporate reputation
E9	Company Market Price.
E10	Market diversification (geographic, goods and services).
E11	Financial economics situation of the mining Company.
E12	Traceability of real estate.
E13	Organizational environment.
E14	Produced product quality of the mining sector.
E15	Market share of the mining sector.
E16	Average Income of upper echelons (High executives, Directors, etc.).
E17	Average income of mid and lower tier levels (Managers, Supervisors, etc.)
E18	Delivery time of goods: Fulfillment of schedules and deadlines.

Source: Own Elaboration.

3.3. *The analysis process*

The data was analyzed with a Monte Carlo experiment with 100,000 replicates. Based on the randomly selected values in each replicate for each expert k, we constructed matrices with their averages, such that:

$$\mu^{\mathbf{A}}_{i,j,r} = \frac{1}{3}\sum_{k=1}^{3}\mu^{\mathbf{A}}_{i,j,k,r} \tag{10}$$

With the matrices obtained from this process, the second-order effects were calculated in a given replicate, their frequency, and their average degree of truth were updated. Therefore, the most important forgotten effects are the ones that appear more frequently, while the most sporadic forgotten effects are the ones that of minor importance.

4. Results

By using the proposed methodology, 314 forgotten effects were observed based on experts' opinions, ranging from a single unique appearance (25 effects) to 100% appearance (two effects); Nonetheless, to serve as an example and due to the constraints on the size of this article, we present 20 of the most recurring forgotten effects (see Table 3).

As can be seen, the effect $C_7 \rightarrow E_4 \rightarrow E_7$ appears in 83% of the replicates, while the effects $C_2 \rightarrow$

Table 3
Forgotten effects

From	Through	To	$\bar{\mu}$	Freq.
C2	C1	E2	0,666669593	100000
C18	E3	E17	0,674440941	100000
C18	E3	E15	0,599247284	99992
C1	C2	E1	0,711503723	99980
C18	E3	E6	0,580190142	99436
C18	E3	E5	0,581778303	97313
C18	C1	E17	0,674429812	97098
C18	C1	E15	0,599261789	96996
C18	C1	E5	0,581767135	96685
C2	E13	E2	0,666662322	94643
C7	C5	E7	0,647610583	91769
C11	C14	E11	0,549307179	90230
C11	E16	E11	0,549310801	89735
C18	C3	E18	0,687488603	89448
C18	C1	E6	0,580188284	88007
C18	E3	E10	0,550417951	86459
C18	C1	E7	0,543658835	86331
C15	C1	E15	0,602454595	84463
C18	C1	E10	0,550432237	83905
C7	E4	E7	0,645948185	83012

Note. B1: Growth in mining GDP: B2 Employment level: B3: Investment in mining as a percentage of GDP. B17: Average income of mid and lower tier levels (Managers, Supervisors, etc.). B15: Market share of the mining sector. A1: Economic expectation of the country (Monetary, financial, fiscal and exchange): considered as a global vision. A2: Macroeconomic environment (fiscal policy, monetary policy, Exchange rate policy, competitive policy, financial policy): considered as a global vision. A11: Stock of physical capital of the Company (infrastructure, land, capital, etc.). A18: Petroleum/Oil prices.
Source: Own Elaboration.

$C_1 \rightarrow E_2$ and $C_{18} \rightarrow E_3 \rightarrow E_{17}$ appear in 100% of them. The origin, C_{18} (Price of oil) appears in 60% of the sample. We can also see two noteworthy midpoints in C_1 (country economic expectations, 40%) and E_4 (Investment level in relation to the total income of the sector, 25%). However, it is important to mention that none of the endpoints in the forgotten effects reported appear disproportionally in the sample. Besides, the effect that had a higher average degree of truth (0.71) was $C_1 \rightarrow C_2 \rightarrow E_1$.

The first analysis set shows the indirect incidence that economic activity has on the level of soft innovation in the mining industry. These results come from the preliminary analysis of economic activity and of innovation in Chile's mining sector, which shows that macroeconomic conditions and oil price volatility indirectly affect the level of worker's average income in the sector (Table 3). As can be seen, oil prices are shown to have a significant role in the industry.

When viewed together, these results suggest that there is an association between the level of soft innovation and the oil price. Furthermore, it shows an indirect incidence in the average income of the workers that are within and outside the sector.

5. Discussion

In retrospect, oil price shocks are closely related to economic fluctuations [3]. It is important to note that some regions respond differently to oil market shocks, this is the case of Asia and South America in relation to Europe and North America, where the former are less negatively affected [1]. In addition, it is necessary to differentiate between oil-exporting countries from oil-importing countries when investigating effects of oil price shocks, In net oil-importing countries the effects of aggregate demand uncertainty on stock markets much smaller and less persistent than net oil-exporting countries [17]. There is a variety of studies on the complex and varied relationship between oil prices and the stock market, the conclusions vary depending on whether the studies are symmetric or asymmetric changes in the price of oil, or unexpected changes in this, most of them the studies show oil price volatility transmits to stock market volatility [24]. With this study we can affirm that oil price is a major economic incentive for the activities in the mining sector [23].

By reviewing the literature, we found data regarding the association between oil price changes and GDP growth [7]. One such study, presented by Hamilton [12], identifies a nonlinear relationship between oil price changes and GDP growth. Other prior studies analyzed data from a micro data panel and noted the correlations between oil price shocks and output, real wages, and employment shares [14].

In addition, there is evidence that increases in the price of oil causes a significant decrease in real wages for all workers but increases the relative wage of skilled workers [14]. A study carried out in the USA in 2001 shows that Employment growth has an asymmetrical relationship with price of oil [9].

Several reports have also shown that less oil price volatility is key in reducing US macroeconomic instability [3]. However, very little was found in the literature on the question of the relationship between the macroeconomic environment (fiscal, monetary, exchange policy, competitiveness and financial policy) and employment level.

An initial objective of this study was to identify the forgotten effects from economic activity in the level of innovation in the mining sector. With respect to the first research question, we discovered that this really has an indirect impact on the average wages of workers and workers in the sector.

We discovered that this really has an indirect impact on the average wages of workers and workers in the sector.

Another important finding was the demonstration of the possible dependence of the mining industry on the price of oil, and how this situation can indirectly affect the level of technological innovation (as soft innovation).

Surprisingly, $I+$D+I (investigation, development and innovation) was found to no have influence in wages of workers and worker share in the sector. An expert commented on the existence of high innovation in the management process in the Chilean industry and determined the existence of stagnation in technological innovation.

We emphasize that these results are consistent with the data obtained from the literature regarding oil prices [7, 12, 20].

This study also raises the possibility that it can delve and be used to analyze light innovation in different industries. As demonstration, it is important to note that this study was originally created to analyze the mining sector, from which we have successfully applied the same techniques to conduct an analysis on the agribusiness sector. The relevance of this is great, as it will allow us to learn from various industries and their relationship with innovation.

In addition, the results are significant in at least two major ways: 1) It shows that oil price is an economic variable that affects the mining industry in different areas, as innovation in human resource management, and strong market share. 2) It demonstrates the indirect relationship between the macroeconomic environment and the level of employment in the sector.

We have left to reflect, if for the mining industry in general, the savings from oil price drops are greater than the costs because it goes up [23]. Is this the explanation of what we see as forgotten effects? Low oil prices substantially increase the country's economic expectations and investment in mining, which activates many effects simultaneously? Are these effects related to light innovation?

6. Conclusions

Our aim in this research was to examine the forgotten effects from economic activity and the level of innovation in the mining sector. The investigation questions were:

Are there unknown (or forgotten) effects in the mining industry that are caused by economic activity? And if so, are some of these effects reflected in lightweight innovation?

In relation to them, this study has found that generally there is not a great number of forgotten effects related to economic activity and soft innovation in the mining industry. However, there is an important finding in how oil price has an indirect incidence in workplace innovation, job, and market share.

The macroeconomic studies done in USA and China supports another conclusion of this paper: That there is a straight relationship between macroeconomic instability and employability.

Furthermore, the evidence of this study suggests that soft innovation levels in the industry is either still very low, or not widely known.

With the aforementioned, the contribution of this study has been in confirming that the low levels of innovation in the Chilean mining sector may be influenced by copper price, another variable, or that there is low innovation investment (a trend) in the sector.

It is important to note that this research was limited due to the absence of variable control as described by the three experts who collaborated with the investigation. The limited number of experts interviewed is explained, t from the difficult nature we had in obtaining people that fit the required profile for this study.

Nonetheless, it is worth mentioning that this study should be repeated in other industries, as these should be further bolstered by comparison studies with other developing economies which can help reduce certain variables and give us a more precise view. In addition, experimental investigations are needed to estimate soft innovation specific activities.

As a final conclusion, another important and practical implication is to motivate creativity and innovation in different industries, as it is clear (according to expert opinions) that non-technological innovation is fairly known to be common in the mining sector.

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References

[1] K.A. Aastveit, H.C. Bjørnland and L.A. Thorsrud, What drives oil prices? Emerging versus developed economies, *Journal of Applied Econometrics* **30**(7) (2015), 1013–1028.

[2] S.N. Bhuian, B. Menguc and S.J. Bell, Just entrepreneurial enough: The moderating effect of entrepreneurship on the relationship between market orientation and performance, *Journal of Business Research* **58**(1) (2005), 9–17.

[3] H.C. Bjørnland, V.H. Larsen and J. Maih, Oil and macroeconomic (in) stability, *American Economic Journal: Macroeconomics* **10**(4) (2018), 128–151.

[4] K.J. Borowiecki and T. Navarrete, Digitization of heritage collections as indicator of innovation, *Economics of Innovation and New Technology* **26**(3) (2017), 227–246.

[5] M.E. Burkhardt and D.J. Brass, Changing patterns or patterns of change: The effects of a change in technology on social network structure and power, *Administrative Science Quarterly* (1990), 104–127.

[6] J. Choi, Evolution of innovation focus of online games: From technology-oriented, through market-oriented, and to design-oriented soft innovation, *Asian Journal of Technology Innovation* **19**(1) (2011), 101–116.

[7] J.C. Cuestas and J. Ordóñez, Oil prices and unemployment in the UK before and after the crisis: A Bayesian VAR approach. A note, *Physica A: Statistical Mechanics and Its Applications* **510** (2018), 200–207.

[8] S. Cunningham and P. Stoneman, Soft innovation: Economics, product aesthetics and creative industries, (2011). Springer.

[9] S.J. Davis and J. Haltiwanger, Sectoral job creation and destruction responses to oil price changes, *Journal of Monetary Economics* **48**(3) (2001), 465–512.

[10] B. Eltham, Three arguments against 'soft innovation': Towards a richer understanding of cultural innovation, *International Journal of Cultural Policy* **19**(5) (2013), 537–556.

[11] H. Hall, Exploring Innovation in Northern Canada with Insights from the Mining Innovation System in Greater Sudbury, Ontario, *Northern Review* (45) (2017), 33–56.

[12] J.D. Hamilton, What is an oil shock? *Journal of Econometrics* **113**(2) (2003), 363–398.

[13] G.T.M. Hult and D.J. Ketchen Jr, Does market orientation matter?: A test of the relationship between positional advantage and performance, *Strategic Management Journal* **22**(9) (2001), 899–906.

[14] M.P. Keane and E.S. Prasad, The employment and wage effects of oil price changes: A sectoral analysis, *The Review of Economics and Statistics* **78** (1996), 389–400.

[15] W.M. Cohen and D.A. Levinthal, Absorptive Capacity: A New Perspective on Learning and Innovation, *Administrative Science Quarterly* **35**(1) (1990), 128–152.

[16] H. Takeuchi, E. Osono and N. Shimizu, The contradictions that drive Toyota's success, *Harvard Business Review* **86**(6) (2008), 96–104.

[17] Y.D. Wang, C.F. Wu and L. Yang, Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries **41**(4) (2013).

[18] D.J. Teece, Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance, *Strategic Management Journal* **28**(13) (2007), 1319–1350.

[19] D.J. Teece, Business models and dynamic capabilities, *Long Range Planning* **51**(1) (2018), 40–49.

[20] A. Ten Cate and M. Mulder, Impact of the oil price and fiscal facilities on offshore mining at the Dutch Continental Shelf, *Energy Policy* **35**(11) (2007), 5601–5613.

[21] K.Z. Zhou, C.K. Yim and D.K. Tse, The effects of strategic orientations on technology-and market-based breakthrough innovations, *Journal of Marketing* **69**(2) (2005), 42–60.

[22] D.P. Kroese, T. Brereton, T. Taimre and Z.I. Botev, Why the Monte Carlo method is so important today, *Wiley Interdisciplinary Reviews: Computational Statistics* **6**(6) (2014), 386–392.

[23] J. Elder and A. Serletis, Oil price uncertainty, *Journal of Money, Credit and Banking* **42**(6) (2010), 1137–1159.

[24] S. Degiannakis, G. Filis and V. Arora, Oil Prices and Stock Markets: A Review of the Theory and Empirical Evidence **39**(5) (2018), 85–130.

[25] A. Fink, J. Kosecoff, M. Chassin and R.H. Brook, Consensus methods: Characteristics and guidelines for use, *American Journal of Public Health* **74**(9) (1984), 979–983.

[26] J. Baker, K, Lovell and N. Harris, How expert are the experts? An exploration of the concept of 'expert'within Delphi panel techniques, *Nurse Researcher* **14**(1) (2006).

[27] R. Adams, J. Bessant and R. Phelps, Innovation management measurement: A review, *International Journal of Management Reviews* **8**(1) (2006), 21–47.

[28] C.A. Cancino, J.M Merigó and F.C. Coronado, A bibliometric analysis of leading universities in innovation research, *Journal of Innovation & Knowledge* **2**(2) (2017), 106–124.

[29] D. Añón Higón and P. Stoneman, Trade in Final Goods and the Impactof Innovation, *Economics Letters* **110**(3) (2011), Elsevier, Amsterdam, 197–99.

[30] P. Stoneman, The Diffusion of Innovations: Some Reflections, *International Journal of the Economics Of Business* **25**(1) (2018), 85–95.

[31] U. Amarakoon, J. Weerawardena and M.L. Verreynne, Learning capabilities, human resource management innovation and competitive advantage, *The International Journal of Human Resource Management* **29**(10) (2018), 1736–1766.

[32] A.M. Gil Lafuente, El análisis financiero en la incertidumbre. Editorial: Ariel Economía, Barcelona, España (1990).

[33] A. Kaufmann and J. Gil-Aluja, Modelos para la investigación de efectos olvidados. Santiago de Compostela: Milladoiro (1988).