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A Methodology for Economic Crisis Policy Analytics

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A METHODOLOGY FOR ECONOMIC CRISIS POLICY ANALYTICS

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Abstract

The development and success of the 'business analytics' in the private sector, in combination with the growing availability of large quantities of useful data in government agencies, gives rise to the emergence of the 'policy analytics' in the public sector. However, though some knowledge has already been developed in this area, extensive research is required in order to increase our knowledge base concerning the exploitation of these exponentially increasing quantities of data available in government, in combination with data from private sector firms as well, using advanced analytical techniques (from various areas, such as machine learning, statistics, simulation, etc.), in order to provide substantial support for all stages of public policies in various important policy domains. This paper makes a contribution in this direction, by describing a methodology for policy analytics in the economic policy domain, concerning a highly important problem: the economic crises, which repeatedly occur in market-based economies being an inevitable trait of them. Our methodology aims at the identification of firm's characteristics that affect positively or negatively their sensitivity to the economic crisis, which enables a deeper understanding of the kinds of firms that exhibit higher sensitivity to economic crisis (i.e. have more negative consequences) and provides a basis for the design of public policies for supporting such firms. It exploits existing data from various public sources (e.g. Ministries of Finance, Statistical Authorities), in combination with data from private sources (e.g. business information firms, consulting firms), from which firm-level crisis sensitivity models are estimated. Furthermore, an application of the proposed methodology is presented, using data from Greek firms for the crisis period 2009 – 2014, which provides interesting insights.

Keywords: public policy; policy analytics; policy informatics; economic crisis

1 Introduction

Information and Communication Technologies (ICT) have been used in government initially for automating and supporting its complex internal processes, then for transforming them, and latter for supporting interaction with citizens (in the form of both electronic transactions and consultations) (Janowski, 2015). Currently government agencies proceed to the use of ICT for more ambitious purposes: for supporting most sophisticated functions concerning policy making for addressing the complex problems and needs of modern societies. The development and success of 'business analytics' (Davenport and Harris, 2007; Davenport et al., 2010) in the private sector, in combination with the growing availability of large quantities of data in government agencies, gives rise to the emergence of the 'policy analytics' in the public sector (Tsoukias et al., 2013; Janssen and Wimmer, 2015; Daniel et al.,

2016; De Marchi et al., 2016; Gil-Garcia et al., 2018). It is defined as the exploitation of existing data from government agencies, possibly in combination with data from private sector firms as well, using advanced analytical techniques (from various domains, such as machine learning, statistics, simulation, social network analysis, geographical information systems and visualization in general), in order to support the whole cycle of important public policies (Gil-Garcia et al., 2018). This idea is not new, as for long time there has been high interest in the use of quantitative techniques for supporting government policy making; this is quite useful for a variety of reasons: public policies represent huge allocations of social resources, and are irreversible decisions with long term horizon and impact, which involve and affect seriously many stakeholders (usually with different and sometimes conflicting objectives and values), and necessitate high levels of legitimation and accountability (Tsoukias et al., 2013; Daniel et al., 2016). However, recently there has been an exponential increase in the availability of relevant data that can be quite useful for supporting policy-making, which creates huge opportunities for extensive and highly beneficial application of the above ideas in important domains of government activity; this can provide substantial support of public policy making, and at the same time transform it radically, promoting 'evidence-based' policy making, which constitute strong drivers for the rapid development of advanced policy analytics (Janssen and Wimmer, 2015; Gil-Garcia et al., 2018). The main sources of massive policy relevant data, which can be exploited for advanced and highly beneficial policy analytics, are: a) the development of complex internal information systems (IS), as well as electronic transactions and consultations ones (based mainly on the Internet), in government agencies; b) the growing use of social media by them; c) the opening of large quantities of government data; and d) the development of the Internet of Things (IoT) especially in the context of modern cities.

Some useful knowledge has already been developed in the area of policy analytics, which includes methodologies for exploiting data, using advanced analytical techniques, in order to support some of the stages of the policy making cycle in some domains of government activity and policy, such as the environment (Ekstrom et al., 2018), the energy provision (Baer et al., 2015), the justice (vaan den Braak and Choenni, 2018) and the management of emergency crises (both natural disasters (e.g. earthquakes and hurricanes) and man-made crises (e.g. terrorism and ethnic violence)) (Hiltz et al., 2011; Park and Johnston, 2018). However, the area of policy analytics is still in its infancy, so extensive research is required in order to advance to higher levels of maturity. Substantial research is required in this area so that we can increase our knowledge concerning the exploitation of the exponentially increasing quantities of data available in government, in combination with data from private sector firms as well, using advanced analytical techniques, for supporting all the stages of public policies' development and implementation, in various important domains, with main emphasis on the most serious problems our societies and economies face. It is necessary to develop policy analytics' methodologies in a wide range of thematic policy domains, for supporting all the five main stages of public policies' cycle identified by previous relevant literature (Tsoukias et al., 2013; Daniel et al., 2016): agenda setting, policy analysis, policy formulation, policy implementation and policy monitoring and evaluation.

This paper makes a contribution in this direction, by describing a methodology for policy analytics in the domain of economic policy, concerning one of the most serious problems that governments repeatedly face: the economic crises, which are an inevitable trait of market-based economies (Keeley & Love, 2010; Knoop, 2015). Economic crises of varying intensities and durations occur repeatedly in the market-based economies, leading to contraction of economic activity and increase of unemployment, poverty and social exclusion, with quite negative consequences for the economy and the society in general, affecting the lives of millions of citizens. The magnitude of the problems that economic crises cause, and the big numbers of affected citizens, makes it necessary for governments to design and implement policies in order: (i) to avoid economic crises, or at least reduce their intensity, and (ii) once they occur, to reduce their negative consequences for the economy and the society. So it is imperative to develop methodologies for economic crisis policy analytics, which enable the exploitation of various types of existing data sources from the public and the private sector, using advanced analytical techniques, in order to support all the stages of economic crisis policies of the above two types (i)

and (ii): agenda setting, policy analysis, policy formulation, policy implementation and policy monitoring and evaluation. In this paper we describe a methodology for supporting the first two stages (agenda setting and policy analysis) of type (ii) firm-level economic crisis policies, aiming to reduce the negative consequences of crises on firms. In particular, the objective of our methodology is to identify firm's characteristics that affect positively or negatively their sensitivity to economic crises (i.e. increase or decrease the negative consequences of crises for the firm). This enables a deeper understanding of the kinds of firms that exhibit higher or lower sensitivity to the crisis and provides a basis for the design of public policies for supporting the former (i.e. the firms that have been more sensitive to the crisis and had more negative consequences). Our methodology exploits existing data from various public sources (such as Ministries of Finance, Statistical Authorities, etc.), in combination with data from private sources (such as business information firms, consulting firms, etc.), from which firm-level crisis sensitivity regression models are estimated. Also, an application of the proposed methodology is presented, using data from Greek firms for the crisis period 2009 – 2014, which provides interesting insights.

This paper consists of five sections. The following section 2 outlines the background of our research, while in section 3 the proposed methodology for economic crisis policy analytics is described. Then in section 4 the abovementioned application of it is presented. In the final section 5 the conclusions are summarized, and future research directions are proposed.

2 Background

2.1 Economic Crises

One of the most important problems of market-based economies are the economic crises that repeatedly occur with varying intensities and durations (Keeley & Love, 2010; Knoop, 2015). They are significant contractions of economic activity, which can be due to 'business cycles' (i.e. the fluctuations that economic activity usually exhibits, with periods of expansion followed by periods of contraction) or other events that happen in the society or in the economy (such as the oil crisis in the early 1970, or banking crises – in general significant shocks in market demand or supply can be sources of significant fluctuations of economic activities, resulting in economic crises) (Knoop, 2015). Economic crises can be of lower intensity, called 'recessions', or of higher intensity, called 'depressions': the National Bureau of Economic Research (NBER) of USA defines a 'recession' as two or more consecutive quarters of negative growth of the Gross Domestic Product (GDP) of a country, and an 'expansion' as two or more consecutive quarters of positive GDP growth; there is no formal definition of a 'depression', but an informal definition of it is an economic contraction of more than 10% (an example is the Great Depression of the 1930s in the USA).

Economic crises have quite negative consequences for the economy and the society. They give rise to demand reductions of most goods, which are more severe for the 'durable' ones (i.e. the goods that last for longer time periods, such as homes, cars, home appliances, etc.), and less severe for the non-durable ones (i.e. the goods with shorter life-cycles, such as food, clothing, etc.). This results in decrease of firms' sales, production and profits, which leads to reductions in personnel employment, materials' procurement (so the crisis propagates further towards the suppliers) and investment, while some weaker firms go bankrupt. For the above reasons economic crises increase unemployment, especially among some disadvantaged groups, such as the young people, the low-skilled, the immigrants and the temporary workers (Keeley & Love, 2010). This causes big social problems, increases the number of citizens living in poverty and social exclusion; at the same time it increases the required government spending for unemployment benefits, as well as for other types of social welfare and assistance for the unemployed (e.g. training), while government income from taxation decreases due to lower firms' profitability and individuals' income. Furthermore, during economic crises firms usually reduce investment in production equipment, ICT, buildings, R&D and innovation, due to the reduction

of the demand for their products and services, which makes such investment more risky, and at the same time reduce the available financial resources for investment; this is called 'pro-cyclical' investment behavior' (= investment following the ups and down of the business cycle), and has negative impact on firms' productivity and competitiveness in the medium and long term (Keeley & Love, 2010; Knoop, 2015). However, in some cases firms exhibit the opposite behavior: during economic crises increase some types of investment, such as the R&D and innovation ones, in order to take advantage of the reductions in the prices of the required inputs (such as specialized personnel and equipment) caused by such crises (Archibugi et al., 2013; Arvanitis and Woerter, 2014); this is called 'anti-cyclical' or 'counter-cyclical' investment behavior', and is quite beneficial for the economy and the society, as it generates some economic activity, which reduced the intensity of the economic crisis.

The above negative consequences of the economic crises on firms' sales, production, profits, employment, procurement and investment are not the same for all firms; some firms are more efficient than the others, offer higher value-for-money products and services, and also have the capacity to make the required adaptations to the crisis (e.g. in their products and services, as well as in their prices, distribution, etc., or even enter new markets), so they have less negative consequences. So, it is important to identify firm's characteristics that affect positively or negatively the sensitivity to economic crises. This can be quite useful for government agencies, in order to develop and implement policies for reducing the negative consequences of economic crises on firms, focusing on the ones exhibiting higher crisis sensitivity, and learning from the most crisis resistant and resilient ones; also, it can be useful for individual firms as well, in order to develop their strategies for coping with economic crises. However, this research requires theoretical foundations: frameworks or models that define the main elements and characteristics of the firm, which can provide guidance for the selection of the particular firm characteristics to be investigated concerning their effects on firm's sensitivity to the economic crisis. This is discussed in the following section 2.2.

2.2 Frameworks/Models of Firm Elements

Previous research has developed some interesting frameworks/models defining the main elements of a firm from various perspectives. The 'Leavitt's Diamond' framework (Leavitt, 1964) defines four main elements of a firm, which are strongly interconnected: a) task (= the strategies as well as the processes of the firm); b) people (= the skills of firm's human resources); c) technology (= the technologies used for implementing the above processes); and d) structure (= the organization of the firm in departments, and the communication and coordination patterns them). Subsequently it has been extended by splitting the above 'task' element into two elements: 'strategy' and 'processes' (Scott-Morton, 1991). The 'Value Chain' model developed by Porter (1985) defines nine main elements of a firm from an activity perspective: five primary activities (inbound logistics, operations, outbound logistics, marketing and sales, service), and four support activities (firm infrastructure management, human resources management, technology development, procurement). Mintzberg (1998) proposes a structural model of the firm, which defines five main elements of it from a structural perspective: i) operating core (= the basic element of firm's structure that carries out the basic work of the firm: it procures and processes the inputs (i.e. materials), produces the output (i.e. final products) and finally distributes it to customers); ii) support staff (= a structural element that support indirectly the works of the operating core); iii) technostructure (= an increasingly important structural element, which responsible for firm's change for adaptation to its environment, and for the standardization of the work processes of the operating core, their skills as and their outputs); iv) strategic apex (= the top management, which is responsible for determining the strategic directions of the firm and for high level monitoring of their implementation); and v) middle line management (= an important structural element, which connects the strategic apex with the operating core, supervising directly and coordinating the latter based on the directions of the former). Galbraith (2002) proposes the 'Star Model', aiming to be used as a founda-

tion the internal design of firms, which defines the following five main elements of a firm: strategy, processes, people, structure, and rewards.

From the above frameworks/models we finally selected the extended Leavitt's Diamond framework (Scott-Morton, 1991) to be used as theoretical foundation of the proposed methodology for economic crisis policy analytics (i.e. for providing guidance for the selection of specific firm characteristics to be examined as to their effects on firm's sensitivity to the economic crisis), for the following two reasons: a) it has a wider perspective than the structural model of Mintzberg (1998) (having a limited exclusively structural perspective – defining the main structural elements of a firm) and the 'Value Chain' model of Porter (1985) (having an limited exclusively activity perspective – defining the main activities of a firm); b) it is similar to the model of Galbraith (2002) (four common elements), but includes additionally the 'technology' element, which we believe is highly important in the modern economy for the efficiency and performance of firms, and therefore can affect significantly their capacity to cope with the crisis.

3 An Economic Crisis Policy Analytics Methodology

Based on the background presented in the previous section 2 we developed a methodology for economic policy analytics, which exploits public sector data, combining them with private sector data, and estimates crisis sensitivity regression models from them, in order to identify characteristics of a firm that affect its sensitivity to the economic crisis. We can define firm's crisis sensitivity as the extent of decrease due to the crisis of important performance indicators of it, which concern various aspects of its performance, such as sales, production, profits, innovation, investment as well as employment (= job creation). Our methodology examines the effects on these multiple indicators/aspects of firm's performance of a wide range of characteristics of it, which concern the five main elements of a firm proposed by the abovementioned extended Leavitt's Diamond framework (Scott-Morton, 1991): strategy, processes, people, technology, structure. This enables a deeper understanding of the kinds of firms (with respect to these five main elements) that exhibit higher or lower sensitivity to the crisis, and provides a basis for the design of public policies for supporting the former: the firms that have been more sensitive to the crisis, and experienced more negative consequences with respect to the above important aspects of their performance. It reveals on one hand characteristics and practices of a firm (with respect to strategy, processes, people, technology and structure) that increase its sensitivity to the crisis (i.e. the negative impact of the crisis), so they have to be eliminated or at least reduced; and on the other hand it reveals characteristics/practices that reduce firm's sensitivity to the crisis, so they have to be adopted/developed. For this purpose the proposed methodology exploits existing data from the public sector, in combination with data from the private sector: a) financial data from firms' income tax returns statements concerning sales, production, profits, investment, employment, etc., possessed by Taxation Authorities (Ministry of Finance) as well as Statistical Authorities; and b) data concerning firms' technology usage (e.g. extent of use of various established as well as emerging ICT), personnel educational levels, specializations and skills, strategic orientations, processes, organization and structure from Statistical Agencies as well as private sector business information firms and consulting firms.

Using these data are estimated a series of linear regression crisis sensitivity models (using ordinary least squares, probit, logit, ordered probit, ordered logit, or multinomial logit estimation techniques, according to the type of the dependent variable – see Gujarati and Porter (2008)) having the following form:

$$\text{DEC-PI} = b_o + b_1*fch_1 + b_2*fch_2 + \ldots. + b_n*fch_n + b_{n+1}*d\_sz + b_{n+2}*d\_sec \qquad (1)$$

Their dependent variables (DEC-PIs) will be the extent of decrease due to the crisis of a series of firm's performance indicators, which concern firm's performance with respect to sales, production, profits, innovation, investment, employment, etc. Their independent variables will be firm characteristics (fch_i) belonging to the following six categories:

I) Strategy characteristics: characteristics concerning the strategic orientations of the firm; they can include the extent of adopting an innovation strategy (as this leads to new products/services, or significantly improved ones, generating additional sales revenues, which is quite useful in periods of economic crisis), or an export strategy (as this reduces the dependence of firm's sales on the market of a single country that might be in economic crisis and experience contraction of economic activity).

II) Processes characteristics: characteristics concerning firm's business processes, such as their complexity, efficiency, formality, flexibility, etc.

III) Personnel skills characteristics: characteristics concerning the level of general skills possessed by firm's personnel (that can quantified through their educational levels, e.g. the share of employees with tertiary-level education), as well as some important specific skills (such ICT-related skills, e.g. share of employees who can use ICT, share of ICT-specialized personnel); previous research has revealed that high levels of personnel skills have positive impact on organizational agility (e.g. see Sherehiy et al., 2007), which is important for coping successfully with the crisis, responding effectively to the big changes it gives rise to in firm's external environment.

IV) Technology characteristics: characteristics concerning the technologies used by the firm; they can include the extent of use of various established as well emerging ICT, such as internal operations support information systems (IS) (e.g. ERP, CRM, SCM), internal decision support IS (e.g. business analytics (BA) ones), external transaction IS (e.g. e-sales and e-procurement ones), IS for external communication and interaction with customers or potential customers (e.g. various social media platforms), etc.; previous research has found that the use of ICT can enhance organizational agility (e.g. see Lu and Ramamurthy, 2011).

V) Structural characteristics: characteristics concerning firm's structure: organization in departments, and communication and coordination between them; they can include the extent of use of 'organic' structural forms, in addition to their hierarchical structures, such as teamwork, decentralization and job rotation, which can enhance organizational agility (e.g. see Sherehiy et al., 2007).

VI) Size and sector control variables: it is also necessary to include firm size and sector control independent variables (d-sz and d-sec), in order to examine the effects of firm size and sector on crisis sensitivity.

Furthermore, beyond the estimation of linear regression models with the above form (1), we can also estimate non-linear models having the same dependent and independent variables, using Machine Learning methods, such as decision tree classifiers (Witten and Hall, 2011); this will enable the identification of non-linear effects of the above firm characteristics on crisis sensitivity.

In general, we expect that firm's crisis sensitivity will be shaped by: (a) its general efficiency level, enabling it to offer products and services of high value-for-money; (b) its capacity to sense and understand in depth the specific changes caused by the crisis in its external environment, and then design and implement effective responses, such as appropriate adaptations in its products/services, or even development of new/products/services (e.g. simpler and lower cost ones), entry in new markets, changes in internal processes and organization, etc. As both (a) and (b) are affected to a significant extent by firm's characteristics (especially with respect to strategy, processes, people, technology and structure), we expect that the latter will have significant impact on firm's crisis sensitivity.

The practical application of the above methodology includes the following steps:

I. Selection of the dependent variables: crisis-induced decreases of specific firm's performance indicators we are interested in.

II. Selection of the independent variables: firm's characteristics (concerning strategy, processes, personnel, structure, size and sector) we want to examine as to their effects on the crisis-induced decreases of the above firm's performance indicators.

III. Selection of the model estimation techniques: they can be linear regression ones (such as ordinary least squares, probit, logit, ordered probit, ordered logit, or multinomial logit estimation techniques), or non-linear ones (such as decision tree classifiers' construction).

IV. Calculation of descriptive statistics of the dependent variables: averages and standard deviations for continuous dependent variables, and relative frequencies for discrete values dependent variables, in order to gain an understanding of the level of decrease that the crisis has caused in these specific firms' performance indicators.

V. Estimation of the models

VI. Identification of firm's characteristics affecting negatively the crisis-induced decreases of these firms' performance indicator, which indicate characteristics and practices that have to be adopted/developed in order to reduce firm's sensitivity to the crisis.

VII. Identification of firm's characteristics affecting positively the crisis-induced decreases of these firms' performance indicator, which indicate characteristics and practices that have to be eliminated or at least reduced in order to reduce firm's sensitivity to the crisis.

4 Application

The economic policy analytics methodology described in the previous section 3 has been applied for the identification of characteristics of Greek firms that affect the sensitivity to the crisis of an important aspect/indicator of their performance, their sales revenue, using linear regression estimation. In Greece there has been an intensive and deep economic crisis from 2009 until today (Gourinchas et al., 2016), which however has not affected all firms homogeneously: some firms had experienced quite negative consequences, some others only moderate ones, while some firms were not affected, or even had increases in their sales revenues (e.g. they managed to gain some of the market share of firms that went bankrupt during the crisis, or introduced new simpler and lower cost products, which were attractive to numerous customers with reduced income due to the crisis). So it is quite useful for government policy makers to know what kind of firms (with respect to sector, size, strategy, processes, personnel, technology, structure, etc.) had more negative consequences from the Greek economic crisis, in order to design and implement public policies for supporting them; and also to identify firm's characteristics/practices that enable a better management of the crisis, in order to promote with various policies their wider adoption and development.

For this purpose, we have exploited and combined Greek firm's data for the period 2009-2014 from two sources: the Ministry of Finance (mainly data from firms' income tax returns statements for the period 2009 – 2014, from which the decrease of sales revenue in this period can be calculated), and ICAP S.A., a well-known business information consulting firm (data concerning firms' characteristics and practices). In particular, we have used data from 363 Greek firms (40.2% of them were from manufacturing sectors, 9.4% from constructions and 50.4% from services sectors; 52.6% of them were small, 36.1% medium and 11.3% large ones), from which a crisis sensitivity regression model for the sales revenue was estimated. Our dependent variable was the percentage of sales revenue decrease due to the economic crisis in the period 2009 – 2014, which was discretized into a variable with 13 possible discrete values (DEC-SAL): increase by more than 100%; increase by 80-100%; increase by 60-80%; increase by 40-60%; increase by 20-40%; increase by 1-20%; unchanged sales; decrease by 1-20%; decrease by 20-40%; decrease by 40-60%; decrease by 60-80%; decrease by 80-100%; decrease by more than 100%. The independent variables were:

- for strategy: adoption of an innovation strategy (INN) (quantified through the percentage of sales revenue of the last three years coming from new products/services), adoption of an export strategy (EXP) (binary variable);

- for personnel: number of employees with tertiary-level education as percentage of the total number of firm's employees (TERT), number of ICT-specialized personnel as percentage of the total number of firm's employees (ICTP);

- for technology: use of internal operations' support IS (INT-IS = average of three 5-levels variables assessing the extent of using an ERP, a CRM and a SCM system respectively), use of internal decision support IS (BA-IS = extent of using a business analytics (BA) system), use of e-sales IS (ES-IS – bina-

ry variable), use of social media (SM – binary variable) and use of cloud computing (CLO - binary variable);

- for structure: use of 'organic' structural forms, such as teamwork, decentralization and job rotation (ORG – binary variable);

- size and sector control variables: two control variables for size: D-L (taking value 1 for large firms having more than 250 employees and 0 for all other firms) and D-M (taking value 1 for medium-size firms having 50 - 250 employees and 0 for all other firms); and one control variable for sector: D-SE (taking value 1 for manufacturing or construction sectors' firms, and 0 for service sectors' firms).

In Table 1 we can see the relative frequencies of the values of our dependent variable: percentage of sales revenue decrease due to the crisis. They reveal a high heterogeneity of the firms of the sample with respect to the impact of the crisis on their sales revenue: 37.9% of the firms of our sample experienced reductions in their sales revenue (most of them reductions of 1-20% (14.8%) or 20-40% (13.4%)), in 14.8% of them the sales revenue did not change, while the remaining 47.3% experienced an increase in their sales revenue (most of them increases of 20-40% (23.1%) or 40-60% (10%)).

Reduction by more than 100%	Reduction by 80-100%	Reduction by 60-80%	Reduction by 40-60%	Reduction by 20-40%	Reduction by 1-20%	Unchanged sales	Increase by 1-20%	Increase by 20-40%	Increase by 40-60%	Increase by 60-80%	Increase by 80-100%	Increase by more than 100%
0%	1.1%	2%	6.6%	13.4%	14.8%	14.8%	8.8%	23.1%	10%	3.7%	0.6%	1.1%

Table 1. Relative frequencies of the values of the dependent variable: percentage of sales revenue decrease due to the crisis

In Table 2 we can see the estimated crisis sensitivity model for the sales revenue decrease, using ordinary least squares estimation. For each independent variable is shown its standardized regression coefficient, with the statistically significant ones at the test levels of 1%, 5% and 10% shown with ***, ** and * respectively. The correlations between the variables of this model are shown in the Appendix. This model reveals five characteristics of a firm that have statistically significant negative effects on its crisis sensitivity with respect to sales revenue (i.e. reduce the negative effects of the crisis on firms' sales revenue): the use of 'organic' structural forms (such as teamwork, decentralization and job rotation) (ORG), which has the strongest negative effect (standardized coefficient -0.193), the adoption of an export strategy (EXP) and the adoption of an innovation strategy (INN), which have similar lower negative effects (standardized coefficients -0.158 and -0.153 respectively), the size of the firm (D-L) (with large firms exhibiting lower sensitivity - standardized coefficient -0.114) and finally use of business analytics (BA-ICT) (standardized coefficient -0.108). From the correlations table shown in the Appendix we can see that there are two more independent variables that have statistically significant negative correlations with the dependent variable: the number of ICT personnel as percentage of the total number of firm's employees (ICTP) (-0.119), and the use of internal operations' support IS (INT-IS) (-0.124). As both these variables have medium or high correlations with several other independent variables, for each of them we removed the independent variable with the highest correlation with it (TERT and BA-IS respectively), and estimated the model again, as a robustness check; however, in both these models the effects of ICTP and INT-IS are not statistically significant, and this indicates the robustness of our findings.

Independent variable	Standardized Coefficient
INN	- 0.153***
EXP	- 0.158***
TERT	0.008
ICTP	- 0.091

INT-IS	0.050
BA-IS	-0.108*
ES-IS	0.068
SM	-0.015
CLO	-0.011
ORG	-0.193***
D-L	-0.114**
D-M	-0.038
D-SE	-0.014
Dependent variable = DEC_SAL N= 337 R^2 = 0.130	

Table 2. Estimated crisis sensitivity model for the sales revenue decrease

None of the examined personnel-related variables (neither the share of tertiary education graduates (TERT) nor the share of ICT-specialized personnel (ICTP)) has statistically significant effect on firm's crisis sensitivity with respect to sales revenue. This indicates that the acquisition of highly skilled human resources is not sufficient for increasing firm's capacity to cope with the crisis and reduce its negative impact. It is necessary to adopt appropriate forms of organization of these human resources, which facilitate the exchange of knowledge among them (concerning the complex and multi-dimensional changes caused by the crisis in firm's external environment, and also possible actions for managing them successfully), as well as their co-operation (for the design and implementation of effective responses to these changes), such as teamwork. Furthermore, it is necessary to decentralize competences and decision making to lower hierarchical levels: the crisis increases the complexity of the external environment and therefore the quantity of external knowledge that has to be acquired and processed by firms, and this cannot be done exclusively at the higher hierarchical levels, so decentralization of such tasks towards the lower hierarchical levels can be quite beneficial.

Furthermore, from the model of Table 2 we can see that four out of the five technology-related variables, which concern the use of internal operations' support IS (INT-IS), e-sales IS (ES-IS), and also the use of social media (SM) and cloud (CLO), do not have statistically significant effects on firm's crisis sensitivity with respect to sales revenue; only the one concerning the use of BA has (BA-IS). These indicate that the BA technology is the important for coping with the crisis and reducing its negative impacts, as it allows advanced analysis of the raw data concerning firm's internal operations, external transactions (sales) and textual communications with customers or potential customers, which are generated by the other four types of IS mentioned above, which can generate valuable insights and conclusions that can be useful for managing the crisis. On the contrary, our results indicate that sample firms do not exploit their internal operations' support IS, e-sales IS, and also the cloud and the social media for coping with the crisis and reducing its negative impacts (e.g. for supporting the design and production of new simpler and lower cost products and services, the expansion of their sales to new customer groups and geographic regions, and the improvement of their understanding of the crisis-induced changes in the needs and preferences of the customers).

Summarizing, from the above application of the proposed methodology it has been concluded that Greek firms making innovations and exports experienced less negative impacts of the crisis on their sales revenue; on the contrary, firms not making innovations and exports suffered more negative consequences. Also, larger firms experienced less reduction of their sales due to the crisis. Therefore, the design and implementation of public policies for promoting, facilitating and supporting the innovation and export activities of firms, especially of the small and medium ones, would contribute to the reduc-

tion of the negative firm-level consequences of the economic crisis. Also, it has been concluded that the use of BA technologies and 'organic' structural forms (such as teamwork and decentralization) increase the capacity of firms to cope with the crisis and reduce its negative impact; so the design and implementation of public programs and training that facilitate and support the adoption and effective application of such technologies and organizational practices by firms, especially of the small and medium ones, would be quite beneficial.

5 Conclusions

The first generation of ICT use in government focused on the automation and support, and then on the transformation, of its complex internal processes. Later, a second generation of ICT use in government focused on the support, and then on the transformation, of its communication and interaction with citizens. Recently a new and more ambitious generation of ICT use in government emerges, which aims to support the most sophisticated tasks of government agencies: the design and implementation of public policies for addressing the complex problems and needs of modern societies. This gives rise to the development of the 'policy analytics' area, which aims to exploit the large quantities of data available in various public sector organizations, possibly in combination with data from private sector firms (such as business information and consulting firms), using advanced analytical techniques, in order to support the whole cycle of important public policies. However, the area of policy informatics is still in its infancy, and so extensive research is required in order to advance it to higher levels of maturity, and create a large knowledge base of it, enabling the provision of substantial support of all the stages of public policies in various important domains, with main emphasis on the most serious problems our societies and economies face.

This paper makes a contribution in this direction. It describes a methodology for policy analytics, concerning one of the most serious problems of the economic policy domain: the economic crises, which repeatedly occur in market-based economies, affecting negatively the lives of millions of people. The objective of the proposed methodology is to provide support for the first two stages (agenda setting and policy analysis) of type (ii) economic crisis policies (according to the terminology of the Introduction), aiming at the reduction of the negative consequences of crises on firms. In particular, the goal of our methodology is the identification of firm's characteristics that affect positively or negatively its sensitivity to the economic crisis. This enables a deeper understanding of the kinds of firms that exhibit higher sensitivity to economic crisis (i.e. have more negative consequences from it) and provides a basis for the design of public policies for supporting such firms. For this purpose, it exploits existing data from various public sources (e.g. Ministries of Finance, Statistical Authorities), and combines them with data from private sources (e.g. business information firms, consulting firms), from which firm-level crisis sensitivity regression models are estimated. A first application of the proposed methodology has been made, using data from Greek firms for the crisis period 2009 – 2014, which provides some first evidence of its usefulness and value: it has led to the identification of five characteristics of Greek firms that affect negatively the sensitivity of their sales revenue to the crisis, which provide the basis for the development of public policies for reducing the negative consequences of the crisis on the Greek firms. At the same time revealed a lack of exploitation of firms' IS (with the only exception of the BA ones) as well as human capital (both general and ICT-related) for coping with the crisis and reducing its negative impacts.

The research presented in this paper has two main limitations. First, the application of the proposed methodology has focused on the identification of characteristics of Greek firms affecting the crisis sensitivity of only one (however quite important) aspect/indicator of their performance: their sales revenue. So similar research has to be conducted for other aspects/indicators of firm's performance, such as profitability, innovation performance, various types of investment (e.g. in production equipment, ICT, buildings, etc.), employment (= job creation), etc., in various national contexts (with different levels of economic development and different cultures). Also, a wider range of firm's character-

istics have to be investigated as to their impact on the crisis sensitivity of various aspects/indicators of business performance. Furthermore, the first application of the proposed methodology was based on the estimation of a linear regression model, so it would be interesting to investigate the estimation of non-linear models as well (e.g. the construction of decision trees) with the same dependent and independent variables for this purpose, for the identification of non-linear effects of firm characteristics on crisis sensitivity. The second limitation is that the proposed policy analytics methodology aims to support the first two stages (agenda setting and policy analysis) of type (ii) economic crisis policies (concerning the reduction of the negative consequences of crises on firms), So further research is required for the development of policy analytics methodologies for supporting the next stages (policy formulation, policy implementation and policy monitoring and evaluation) of type (ii) economic crisis policies, as well as for supporting all the stages of type (i) economic crisis policies (aiming to avoid economic crises, or at least to reduce their intensity).

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Appendix: Correlations between Model Variables

	DEC-SAL	INN	EXP	TERT	ICTP	INT-IS	BA-IS	ES-IS	SM	CLO	ORG	D-L	D-M	D-SE
DEC-SAL	1	-.187**	-.146**	-.066	-.119*	-.124*	-.160**	-.014	-.083	-.084	-208**	-.107*	-.013	.023
INN	-.187**	1	.013	.222**	.383**	.088	.056	.157**	.111*	.223**	.092	-.072	-.057	-.194**
EXP	-.146**	.013	1	.025	.026	.151**	.082	.059	-.020	-.010	.019	.008	.108*	.132*
TERT	-.066	.222**	.025	1	.487**	.077	.068	.075	.105*	.340**	.045	-.124*	-.137**	-.318**
ICTP	-.119*	.383**	.026	.487**	1	.096	.051	.148**	.194**	.275**	.040	-.153**	-.180**	-.298**
INT-IS	-.124*	.088	.151**	.077	.096	1	.647**	.175**	.196**	.177**	.204**	.113*	.160**	-.100
BA-IS	-.160**	.056	.082	.068	.051	.647**	1	.127*	.192**	.157**	.143**	.195**	.155**	-.113*
ES-IS	-.014	.157**	.059	.075	.148**	.175**	.127*	1	.242**	.111*	.200**	-.020	.056	-.279**
SM	-.083	.111*	-.020	.105*	.194**	.196**	.192**	.242**	1	.148**	.145**	.053	-.015	-.212**
CLO	-.084	.223**	-.010	.340**	.275**	.177**	.157**	.111*	.148**	1	.146**	.035	-.003	-.243**
ORG	-.208**	.092	.019	.045	.040	.204**	.143**	.200**	.145**	.146**	1	.038	.060	-110*
D-L	-.107*	-.072	.008	-.124*	-.153**	.113*	.195**	.-.020	.053	.035	.038	1	-.245**	-.033
D-M	-.013	-.057	.108*	-.137**	-.180**	.160**	.155**	.056	-.015	-.003	.060	-.245**	1	.082
D-SE	.023	-.194**	.132*	-.318**	-.298**	-.100	-.113*	-.279**	-.212**	-.243**	-.110*	-.033	.082	1