



## CUTLER - Coastal Urban developmentT through the Lenses of Resiliency

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### **Visualization widget for presenting insights about the economic activity in spatio-temporal terms**

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**Main Authors:** Yiannis Pragidis (DUTH), Vasilios Plakandaras (DUTH), Paris – Alexandros Karipidis (DUTH)



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<b>Abstract</b>	In this deliverable, we present the analytical tools developed in order to assess the economic impact of policies. Moreover, we present the corresponding software and the visualizations widgets to be used in the CUTLER platform. For each pilot city's scenario, we include a number of different analytical tools that serve as tailored made solutions for the decision maker or even for an
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	informed citizen.
<b>Keywords</b>	Econometric, Multisectoral, Multiregional, Dynamic, Input-Output, Structural Business Statistics, Surveys, Bayesian VAR, Visualization widget

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## List of abbreviations and acronyms

Abbreviation	Meaning
CGI	Common Gateway Interface
CPI	Consumer Price Index
CPS	Controlled Parking System
EC	Econometric
GDP	Gross Domestic Product
GPS	Global Positioning System
IO	Input-Output
NGO	Non-Government Organization
NUTS	Nomenclature of territorial units for statistics
SVR	Support Vector Regression

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## Executive summary

The key objective of WP4 is to provide policy making with an evidence-driven approach in the decision-making process. Following this objective, deliverable D4.2 aims to: a) describe the main tools that are used to measure the economic impact of the CUTLER pilot cases in each city, b) measure the economic impact in tailored made scenarios for each pilot city according to the scopes described in deliverable D9.1, c) designate the visualization widgets developed for each city to provide information on the economic analysis in a user-friendly environment and d) deliver policy implications based on the quantitative economic results.

The heart of the economic approach lies with an integrated model that combines the typically used in regional economic studies Input-Output table assessment (for more details see Leontief, 1936) with an econometric framework inspired by theoretical developments in the field. In doing so, the integrated Econometric – Input Output (EC-IO) approach developed can measure the economic impact of the policy interventions of pilot cities. The results of the analysis are presented in dashboards in a user-friendly way that eradicates the need that the user has expert knowledge in the field and in the same way provides the necessary information to support the decision-making process.

Apart from this general tool, we provide answers to specific questions posed by the pilot cities, using machine learning applications as auxiliary to the EC-IO model analytical tools, and provide forecasts that are important in quantifying the goals set in the program. More specifically, in Thessaloniki, the CUTLER platform will be used to plan, implement, monitor and evaluate the use of a new controlled parking system. In Antalya, CUTLER will be used to improve the touristic capabilities of the area surrounding Düden Brook Waterfalls by evaluating concrete measures and actions for accessibility, water usage, environmental protection and mobility. In Antwerp, the platform will be used to monitor and evaluate the Strategic Urban Waterplan of the city and the implementation of green streets and even steer new urban developments. Finally, Cork County Council will utilize the platform to facilitate evidence-based decisions for the touristic exploitation of Camden Fort Meagher, focusing on future access points (by land and sea), facilities (i.e. car parking) and access mechanisms (i.e. modes of transport) in the pilot area. Thus, our contribution is to provide the necessary economic assessment of these goals to assist each pilot city in moving to a data-driven decision-making process. The access to the methodological tools is available through custom city-oriented platforms and *Kibana* dashboards that provide all the necessary information from the analysis.

## Introduction

In the context of WP4 “Visualization widget for presenting insights about the economic activity in spatio-temporal terms”, we develop the analytical tools while we provide all the necessary visualizations in the form of *Kibana* dashboards, that the pilot cities will use to carry out a full lifecycle of policy design, implementation, monitoring, evaluation and revision of policies related to the water element. In this context, we follow up the analysis presented in D4.1 while we add some extra analytical features. The addition of the new analytical tools, like the support vector regression approach, came after the ongoing discussion with the pilot city partners.

The elements of this text are divided into four main categories. The first is the econometric input-output model that was introduced in D4.1. This state-of-the-art model gives the opportunity to the user to estimate the potential economic impact of various policy interventions. It applies mostly for large scale projects while its structure gives the opportunity to the developer to expand the model as new datasets come in place. Through sensitivity analysis the user or the policy maker can visualize the impact of a policy decision on the local Gross Domestic Product (GDP), employment, income, wages and so forth.

The second category includes the machine learning approach (support vector regressions). We add this element in order to give the opportunity to the user to robustly forecast revenues or expenditures that may result from new investments. In the case of the cities Thessaloniki and Cork local authorities invest on new systems (parking system) or engage in renovating expenditures like the Camden Fort Meagher in Cork. The investment costs are expected to be compensated through the revenues. Thus, it is crucial for the local authorities to have a predictor about next year’s revenues in order to be able to implement proactive measures in the case in which revenues are predicted to decrease or even increase at a lower rate than expected.

In the third category we try to establish a flow of incoming economy-related data for the city pilots. In addition to crawlers developed in WP3, in D4.2 we further develop crawlers for retrieving data regarding rental prices and the number of shops by category and place. One main problem that was highlighted in D4.1 is the lack of available data on a city level. Through these newly developed crawlers, we try to partially mitigate this problem. These data, like rental prices, are used in the analytical tools and in the visualizations widgets. For example, in the case of Antwerp, we try to link through a correlation index the rental prices per square meter with the value of damages due to floods and we find a negative relation between these two measures. However, retrieved data regarding the number of shops by category are not yet used as they not fully reflect the true picture in the local economy. However, in the near future, we expect that this database will be further enriched and eventually will become a useful data tool in the context of the CUTLER platform.

The fourth category comprises the visualization widgets. As stated above, the crawlers regarding the number of shops by category do not appear in any visualization tool as the information provided in the related website is still limited. Under the main architectural framework that was designed for the CUTLER platform, Kibana is the main dashboard for visualizing the output of the analytical tools and the crawled data described above.

In section 1, we present the theoretical background of the tools that we will use and the software requirements for developing a custom dashboard that presents this analysis. We focus on the theoretical background of the methodologies used, the econometric analysis and its results, the visualization of the results and policy-implication originating from this analysis. We abstract from many details regarding the econometric input-output model as this was fully described in the context of deliverable D4.1.

In section 2, we present analytical scenarios for each pilot-city fulfilled by the economic analysis which include econometric preparations and examination, visualizations and city specific implementation. The analytical tools have been designed to serve all cities, however in the scenarios presented in the platform are used in a tailored made fashion. Finally, section 3 draws the conclusions.

## 1. Widget architecture

The economic evaluation of the CUTLER platform is based on presenting the analysis of state-of-the-art methodological tools from the fields of regional econometrics and machine learning within a user-friendly platform. In doing so, the non-expert user can interact with the platform, insert her assumptions regarding a policy intervention on the city level and measure the economic impact of her inputs. Thus, the economic widget is focused on presenting the existing data in a manner that is assistive to the decision-making process, as well as providing all the auxiliary information from the simulation models and the econometric analysis.

### 1.1 The architecture of the model

In the following section we present the theoretical background of the methodological approaches and the particulars of the software implemented in the platform.

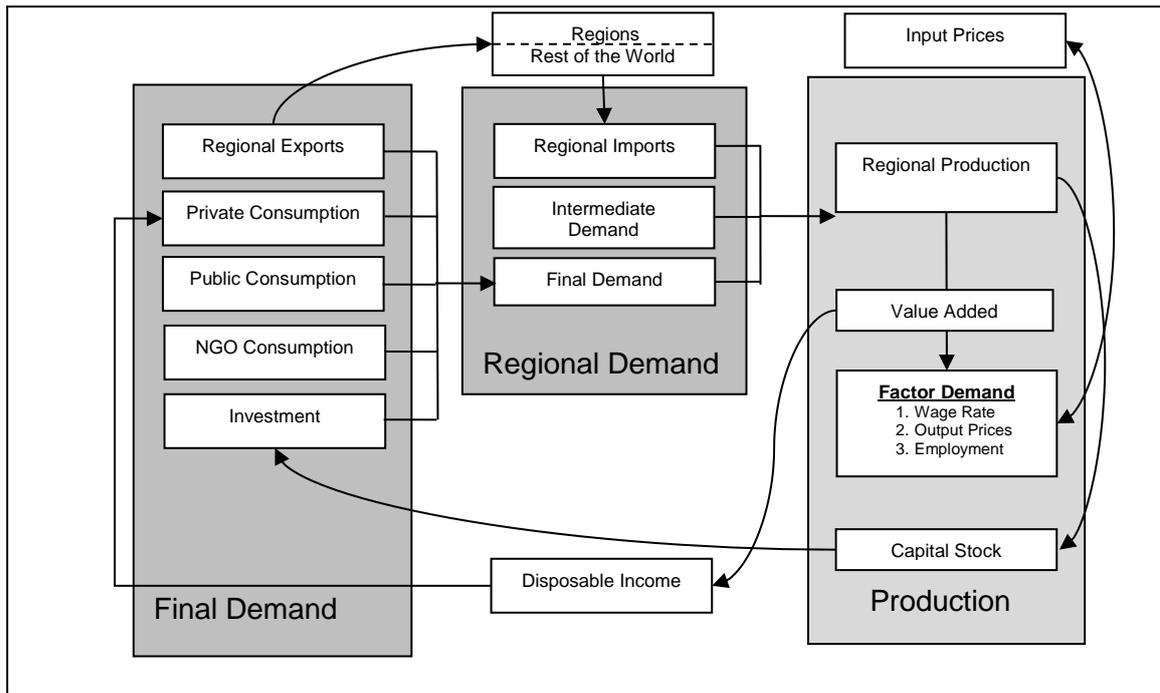
#### 1.1.1 The theoretical background

The existing literature on regional economics is vast, spanning a variety of methodological approaches and theoretical models and can be broadly separated into three categories. The first category is the family of static Input-Output (IO) models, assuming constant relationships between production sectors. All the necessary information stems from the tables, while with proper manipulation the researcher can draw inference upon the flows of commodities between sectors. This assumption is later waived in the category of dynamic IO models, where the flow of commodities and production factors between sectors adjusts dynamically over time, to account for technological advancements and other exogenous economic shocks. Finally, the last category of models integrates econometric approaches depicted by economic theory on wages, production and employment with IO models, where the demand for production factors is estimated separately in blocks of econometric equations and inference on production is drawn from the IO tables.

In our approach we follow the integrated approach, combining information from IO tables with econometric (EC) estimation (for more details on Input-Output tables, please see section 1.1.1.2). Our combined EC-IO approach features a complete two-way feedback between IO and EC models, benefiting from the advantages of either category, while it adheres closely to the relevant theoretical literature (Rey, 2000). Our integrated approach couples the information included in standard Supply and Use tables to behavioral equations, providing a holistic understanding of the functionality of the economy at the regional level, drawing linkages between policies and economic impacts. As stated in Madsen and Butler-Jenkins (1999), the combined EC-IO models are:

- Closer to theory regarding production and consumption
- Easier to formulate, develop and comprehend
- Reflect the impact of behavioral changes on regional economic terms in greater detail compared to IO models
- Make no assumptions regarding technological evolution
- Are based more on commodity demand and production than sectoral output, including trade theory within the span of the model.

While much of the relevant literature is based on the family of integrated models of Conway (1990) examining correlation-driven linkages between production sectors, our approach follows the MULTIMAC model of Kratena (1994) and the European multiregional model E3ME (Barker *et al.*, 1999) that rely on functional forms proposed in microeconomic theory. An outline of our multiregional model is depicted in Figure 1.



**Figure 1: Structure of the regional economic model**

The block of Final Demand substitutes the “institutional” demand whose elements are determined either exogenously or endogenously in the model, while the Production block (that we seek to estimate) expresses the level of regional production that meets Regional Demand. The Regional Demand block is the bridge that links regional supply to regional demand and closes the model. Thus, our model belongs to the broader category of demand driven models.

#### 1.1.1.1 Behavioral equations – Econometric element

The basic idea in our EC-IO model is to use blocks of econometrically estimated behavioral equations that determine sectoral prices, regional sectoral capital stock and sectoral wages in separate blocks of econometric equations to shape demand for production factors. Then the demand for production factors is combined with the private and public demand for commodities (consumption) to provide estimates of regional production through the structure of the IO tables. The annual data series used in our model span the period 2000-2014 and include

- Regional Output
- Value Added
- Intermediate Input Prices
- Output Prices
- Regional Investment and Capital Stock
- Wage Rate (Bill)
- Regional Employment (in total hours of production)
- Private, Public and Non-Government Organizations (NGO) Consumption
- Regional Exports and Imports
- Disposable Income

All series are derived for 64 sectors and measured at the NUTS2 regional level, due to data availability. The latest version of the NUTS classification system (Nomenclature of territorial units for statistics) is introduced in 2016 (initial introduction in 2003 with the Regulation (EC) No 1059/2003, European Union (2003)) and segregates the countries

participating to the European Union into areas of interest in three aggregation levels; NUTS 1 major socio-economic regions, NUTS 2 basic regions for the application of regional policies and NUTS 3 small regions for specific diagnoses. The specific aggregation system provides the basis for all statistical variables published in the European Union area. In our models we assume similar economic structure at the region level; an economic shock (policy intervention) in the region that results in an economic impact will be observed at the same level in the entire region. Thus, given that in CUTLER we examine impacts on pilot cities that belong to a lower aggregation level than NUTS2, we assume that the estimated impact on the regional level will be observed at the same intensity on the city level. In the following equations that describe our model we omit the regional notation, given that we focus on the region that the specific pilot city belongs to.

An initial point in the estimation of regional production is the econometric estimation of the cost factors in production; wage rates, fixed capital costs and marginal (dynamic-variable) costs. The cost factors determine production levels and the final output prices. The first factor is the wage rate (wage bill). Building on the literature of union wage bargaining, the sectoral wage rate  $wr_s$  at time  $t$  is determined between labor representatives and employers for each production sector at the national level, taking into consideration sectoral productivity and the consumer price index. We assume that the regional sectoral wage rate meets the national wage rate. Considering that wages for a given year are negotiated at the end of the previous year, we use lags of sectoral productivity and CPI, while we also consider past wage rate values to account for wage persistence. Due to data limitations, the national CPI is considered constant over all regions within the same country. The functional form of wage rate estimation is given in (1):

$$\log(wr_{s,t}) = \beta_1 + \beta_2 \log(q_{s,t-1}/l_{s,t-1}) + \beta_3 \log(CPI_{t-1}) + \beta_4 \log(wr_{s,t-1}) \quad (1)$$

where  $wr_{s,t}$  is the sectoral wage rate (bill) at current year,  $q_{s,t-1}$  is the sectoral production,  $l_{s,t-1}$  is the sectoral employment rate (expressed in full time equivalents),  $CPI_{t-1}$  is the consumer price index and  $wr_{s,t-1}$  is the sectoral wage bill.  $\beta_1, \beta_2, \beta_3$  and  $\beta_4$  are coefficients to be estimated. For most sectors the coefficients (elasticities) on productivity and inflation are positive and mimic the famous “Benya-formula”, where workers are compensated for price increases and productivity gains.

Apart from wage rates, another important cost factor in production are fixed production costs, as reflected in regional capital stock formation, given that an investment to fixed capital is necessary for production. Demand for investment for each sector is determined indirectly through an “optimal” regional stock adjustment process (Czerny *et al.*, 1997), determined from sectoral productivity in (2):

$$\Delta \log(k_{s,t}) = a_k + \beta_k \log(q_{s,t}) + \tau_1 \log(k_{s,t-1}) + \tau_2 \Delta \log(k_{s,t-1}) \quad (2)$$

where  $k_{s,t}$  is the sectoral capital stock, coefficient  $\tau_1$  defines the adjustment of capital to an equilibrium state and coefficient  $\tau_2$  expresses the adjustment speed to equilibrium. If  $\tau_2$  is negative capital adjusts to equilibrium through a dampened oscillation. Assuming a constant rate of capital depreciation rate  $\delta_s$ , investment demand is given by identity (3):

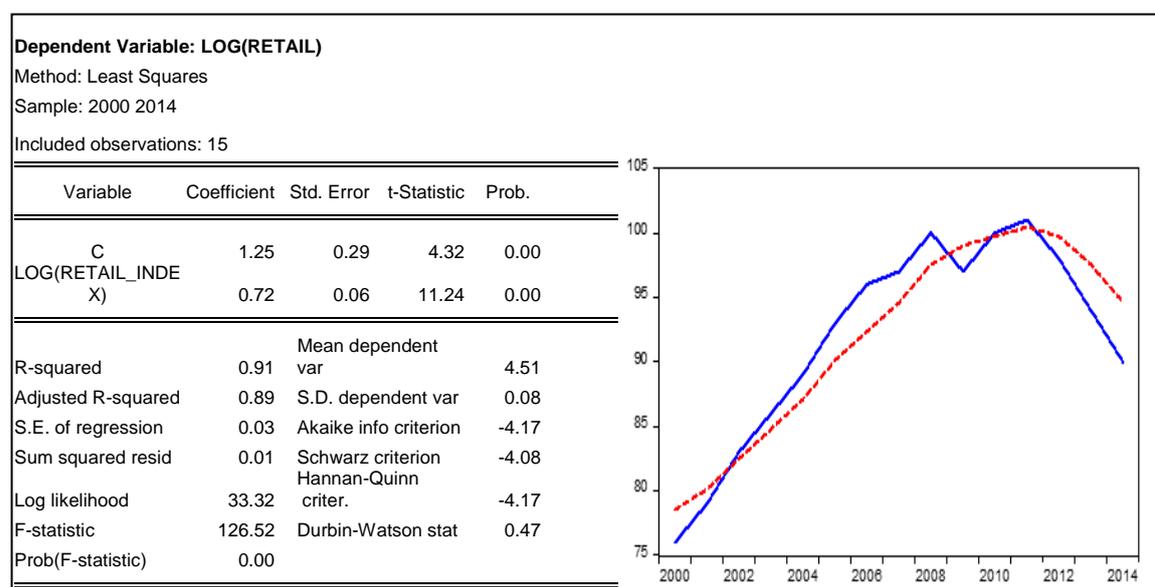
$$I_s = \Delta \log(k_{s,t}) + \delta_s k_{s,t-1} \quad (3)$$

Marginal costs in production are modeled as fluctuations to input prices of commodities used in production. In order to link output prices (final prices of commodities after production) to input prices (commodities used as inputs during production) we create a

surrogate index of input prices that takes into account the commodity participation share in final production. The sectoral commodity input share is the weighted average of all sectoral output prices, with the weights derived from the sectoral demand for commodities from the Use table (for more detail on the Use and Supply Tables, please refer to section 1.1.1.2). More specifically, the commodity share is the ratio of a commodity input to a given sector in the Use table to the total intermediate demand for this commodity to regional production. This surrogate index attributes different importance to commodity prices according to their importance in sectoral regional production; thus input and output prices are indirectly linked through commodity shares. The surrogate index is regressed to input prices in (4):

$$ps_{s,t} = \alpha_{ps} + \beta_{ps}ps\_index_{s,t} \quad (4)$$

An alternative approach would be to use input prices directly, but this would treat input prices as exogenous variables and thus deter a dynamic treatment of marginal production costs. In Figure 2 we depict the surrogate and the price index for sector G47 - Retail trade, except of motor vehicles and motorcycles for Thessaloniki.



**Figure 2: Surrogate (dashed red) and Actual (continuous blue) input price index for sector G47 - Retail trade, except of motor vehicles and motorcycles for the area of Thessaloniki.**

As we observe, the surrogate index adheres closely to the actual input price index, providing a simple but yet reliable bridge between input and output prices. The coefficient of determination (R-squared) is high and close to 1 (0.91), suggesting an excellent fit between the surrogate index and the actual input prices. The time variation of the surrogate index provides an additional flexibility to the model, as it follows the evolution of the Use table and thus the evolution of the production structure of the regional economy.

In the vein of Conrad and Seitz (1994) and Meade (1998), the estimation of sectoral wage rates, fixed and marginal production costs (demand in production factors), allows to model production as a function of labor, input prices and capital stock. Building on Diewert (1971) and including a trend to capture technological progress (Morrison, 1989), a Generalised Leontief cost function for each sector can be determined as:

$$GL(q, ps, x, t, s) = q_s \left[ \sum_{i=1}^{ci} \sum_{j=1}^{ci} (ps_{i,s,t} ps_{j,s,t})^{1/2} + t^{1/2} \sum_{i=1}^{ci} \beta_{i,s,t} ps_{i,s,t} + t \sum_{i=1}^{ci} \beta_{i,s,t} ps_{i,s,t} \right] + q_s^{1/2} \left[ \sum_{i=1}^{ci} \sum_{j=1}^m \beta_{i,j,s,t} ps_{i,j,s,t} x_{j,s}^{1/2} + 2 \sum_{i=1}^{ci} \beta_{j,s,t} ps_{i,s,t} t^{1/2} x_{j,s}^{1/2} \right] + \sum_{i=1}^{ci} ps_{i,s,t} \sum_{i=1}^m \sum_{j=1}^m \beta_{i,j,s,t} (x_{i,s,t} x_{j,s,t})^{1/2} \quad (5)$$

where  $q_s$  is the sectoral output,  $ci$  are the commodity-inputs per sector,  $ps_{i,s,t}$  is the sectoral input price,  $x$  is the vector of sectoral production factors (wage rate, investment and input prices),  $m$  represents the number of factors and  $\beta$  are coefficients to be estimated. Given the homogeneity of degree one and the symmetry condition ( $\beta_{i,j} = \beta_{j,i}, \forall i \neq j$ ), the cost function is concave in factor prices. Applying Shepard's Lemma, the factor demand equations for intermediate inputs and labor can be obtained by taking the first derivatives with respect to (factor) input prices  $ps$  and wage rate (labor cost)  $wr$ . Imposing the symmetry condition and dividing by sectoral total output  $q_s$  we get the share of each input factor as a share of total output in equations (6) and (7):

$$\frac{\partial GL}{\partial ps} \cdot \frac{1}{q_{s,t}} = \frac{qi_{s,t}}{q_{s,t}} = \beta_{ss,s} + \beta_{sw,s} \left( \frac{wr_{s,t}}{ps_{s,t}} \right)^{1/2} + \beta_{st,s} t^{1/2} + \beta_{tt,s} t + \beta_{tci,s} \left( \frac{k_{s,t}}{q_{s,t}} \right)^{1/2} t^{1/2} + 2\beta_{tci,s} \left( \frac{k_{s,t}}{q_{s,t}} \right)^{1/2} + \beta_{cici,s} \left( \frac{k_{s,t}}{q_{s,t}} \right)^{1/2} \quad (6)$$

$$\frac{\partial GL}{\partial wr} \cdot \frac{1}{q_{s,t}} = \frac{l_{s,t}}{q_{s,t}} = \beta_{ww,s} + \beta_{sw,s} \left( \frac{ps_{s,t}}{wr_{s,t}} \right)^{1/2} + \beta_{wt,s} t^{1/2} + \beta_{tt,s} t + \beta_{wci,s} \left( \frac{k_{s,t}}{q_{s,t}} \right)^{1/2} t^{1/2} + 2\beta_{tci,s} \left( \frac{k_{s,t}}{q_{s,t}} \right)^{1/2} + \beta_{cici,s} \left( \frac{k_{s,t}}{q_{s,t}} \right)^{1/2} \quad (7)$$

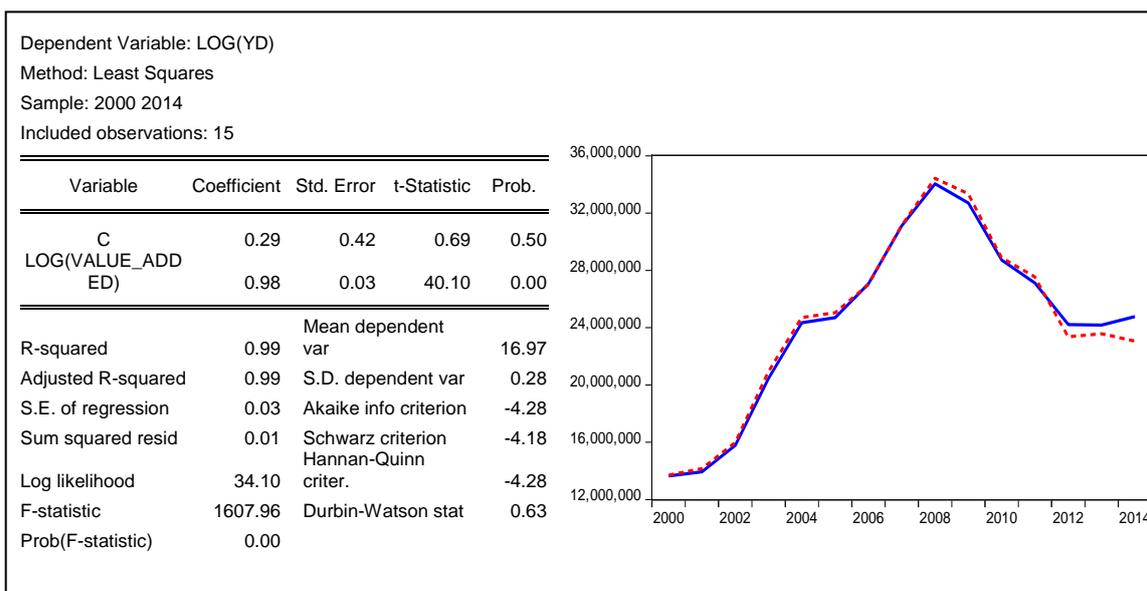
where  $s$  is the sector index,  $qi_{s,t}$  is the intermediate demand for commodities per sector in production,  $l_{s,t}$  is the sectoral employment rate (in time equivalents),  $k_{s,t}$  the sectoral capital stock and  $t$  a linear trend. The system is further expanded with a price equation (8) assuming that output prices equal marginal costs multiplied by a fixed mark-up  $\mu$  (determined during estimation):

$$\frac{\partial GL}{\partial ps} (1 + \mu_{s,t}) = (1 + \mu_{s,t}) \left[ \beta_{ss,s} ps_{s,t} + \beta_{sw,s,t} (ps_{s,t} \cdot wr_{s,t})^{1/2} + \beta_{ws,s,t} (ps_{s,t} \cdot wr_{s,t})^{1/2} + \beta_{ww,s,t} wr_{s,t} + \beta_{st,s,t} ps_{s,t} t^{1/2} + \beta_{wt,s,t} wr_{s,t} t^{1/2} + \beta_{tt,s,t} t (ps_{s,t} + wr_{s,t}) + \frac{1}{2} \left( \frac{k_{s,t}}{q_{s,t}} \right)^{1/2} \left( \beta_{sci,s,t} ps_{s,t} + \beta_{wci,s,t} wr_{s,t} + 2t^{1/2} \beta_{tci,s,t} (ps_{s,t} + wr_{s,t}) \right) \right] \quad (8)$$

Thus, estimating the system of equations (6), (7) and (8) provides the demand for factor costs in production. The econometric part of the model advances with modeling in (9) private consumption (and thus final demand) as a function of output. In doing so, the regional disposable income  $YD$  is estimated as a function of Value Added; the difference between total output and intermediate demand for commodities. Although it is a very simple specification, it yields a very good fit:

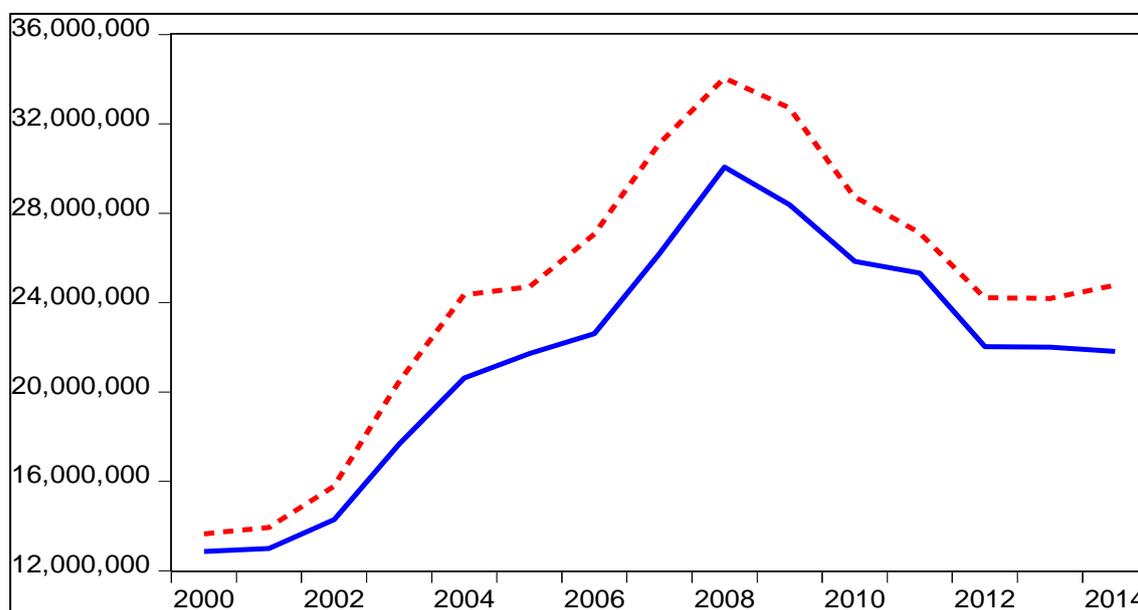
$$\log(YD_t) = \alpha_{YD} + \beta_{YD} \log(\sum_{i=1}^{ci} (q_{s,t} - qi_{s,t})) \quad (9)$$

where  $ci$  is sector index. In Figure 3 we depict the actual and the forecasted disposable income for Thessaloniki.



**Figure 3: Forecasted (dashed red) and Actual (continuous blue) disposable income in thousands of Euros for the area of Thessaloniki.**

Due to lack of available data, we further assume that all disposable income is consumed inside the region, assuming a common place-of-work and place-of-residence. Following the co-integration theory, disposable income and private consumption ( $CP$ ) should be cointegrated; they are linked by a linear one-by-one relationship. In Figure 4 we depict the evolution of disposable income and total household consumption for Thessaloniki.



**Figure 4: Regional Disposable Income (dashed red) and regional total Household consumption (continuous blue) in thousands of Euros for the area of Thessaloniki.**

We model the relationship between disposable income and total household consumption based on the two-step error correction model of Engle and Granger (1987) in (10):

$$\Delta \log(CP_t) = \alpha_0 + \beta_{CP} \Delta \log(YD_t) + a_{CP}(CP_{t-1} - CP_{t-1}^*) \quad (10)$$

$$\text{where } CP_{t-1}^* = CP_{t-1} - (\beta_{YD,0} + \beta_{YD,1}YD_{t-1})$$

In Table 1 we report the characteristics of the error-correction model for Thessaloniki.

**Table 1: Error Correction model results for disposable income and total household consumption for the area of Thessaloniki.**

Panel A: First Step (log regression in levels)					Panel B: Second Step (log regression in first differences including correction)				
Dependent Variable: LOG(CP)					Dependent Variable: DLOG(CP)				
Method: Least Squares					Method: Least Squares				
Sample: 2000 2014					Sample: 2000 2014				
Included observations: 15					Included observations: 15				
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.15	0.52	2.20	0.045	C	0.001	0.01	1.07	0.31
LOG(YD)	0.93	0.03	30.20	0.00	DLOG(YD)	0.73	0.07	10.39	0.00
					$CP_{t-1} - CP_{t-1}^*$	-0.85	0.23	-3.65	0.00
R-squared	0.99	Mean dependent var	16.86		R-squared	0.96	Mean dependent var	0.04	
Adjusted R-squared	0.98	S.D. dependent var	0.27		Adjusted R-squared	0.95	S.D. dependent var	0.10	
S.E. of regression	0.032	Akaike info criterion	-3.86		S.E. of regression	0.02	Akaike info criterion	-4.58	
Sum squared resid	0.01	Schwarz criterion	-3.76		Sum squared resid	0.01	Schwarz criterion	-4.45	
Log likelihood	30.95	Hannan-Quinn criter.	-3.86		Log likelihood	35.09	Hannan-Quinn criter.	-4.59	
F-statistic	912.38	Durbin-Watson stat	0.87		F-statistic	130.85	Durbin-Watson stat	2.48	
Prob(F-statistic)	0.00				Prob(F-statistic)	0.00			

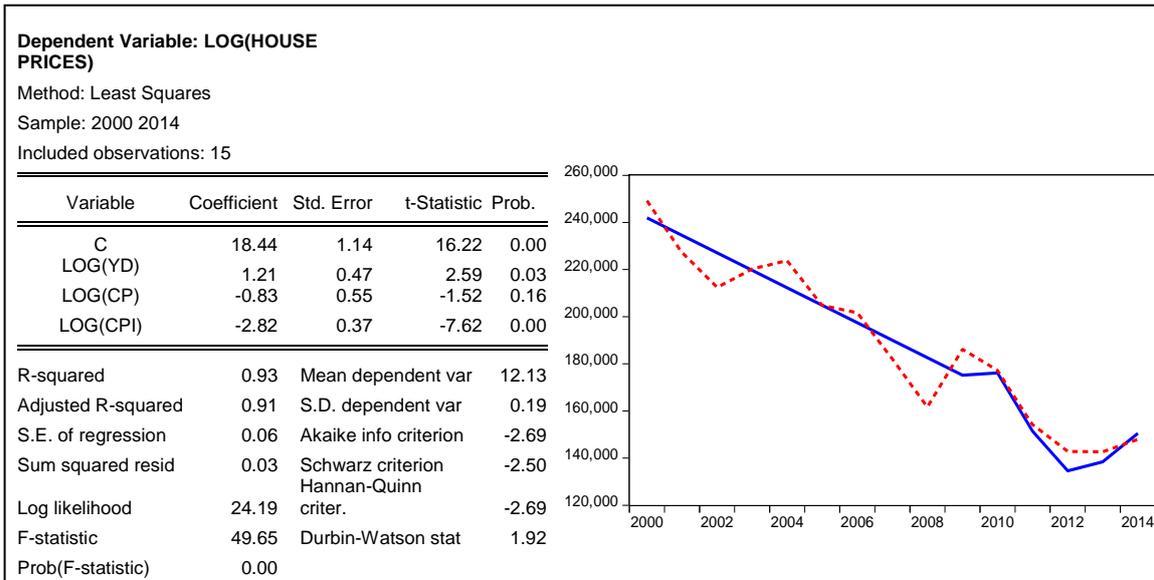
The long-run elasticity between disposable income and total private consumption is 0.93 which is close to 1, suggesting that the two variables are cointegrated; a change of 1% in disposable income would cause approximately a 1% change in total private consumption. The short-run relationship between the two variables is 0.73 implying a highly dependence between the two variables even in the short run. The coefficient of the error correction term (-0.85) is negative as expected for two cointegrated series and its absolute value is again close to 1, suggesting a high speed of convergence towards the long-run equilibrium. Both coefficients of long and short-run dependence and the coefficient of the error term are statistically significant at the 5% level of significance.

The econometric part of the model closes with equation (11), that measures house prices as a function of disposable income, aggregate consumption and CPI. The intuition in the selection of the explanatory variables is straightforward, given that disposable income and private consumption determine the ability of a household to invest in the housing sector.

$$\log(\text{House Prices}_t) = a_{hp} + \beta_{hp,1}\log(YD_t) + \beta_{hp,2}\log(CP_t) + \beta_{hp,3}\log(CPI_t) \quad (11)$$

In Figure 5, we report the details of the house prices model for Cork.

All other variables (i.e. imports, exports, government consumption and NGO consumption) are treated as exogenous.

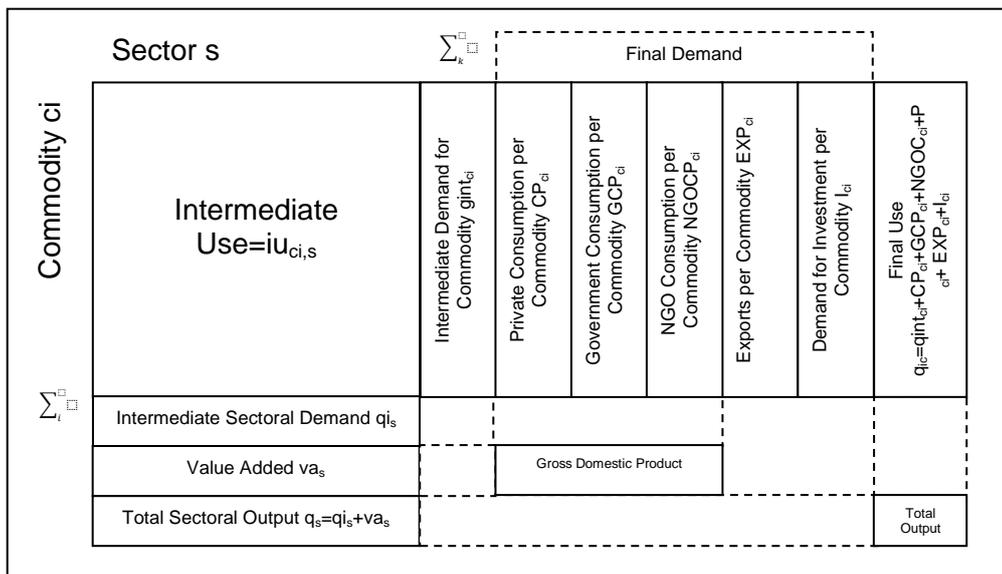


**Figure 5: Residential Dwelling Property Prices (continuous blue) and fitted values (dotted red) in thousands of Euros for Cork.**

1.1.1.2 Input-Output tables

In our approach we draw information from the Use and Supply (Make) IO tables. The Use table reflects the demand side of the economy, reporting the intermediate demand for commodities in production and the final demand (consumption) for commodities by households, firms (private) and the government (public). The Use table is a commodity (rows) by sector (columns) matrix. Along the columns, the Use table expresses the amount of commodity used in the production of each sector. Total use of each commodity is recorded along the rows. In rows the table is also extended by private consumption, public and NGO consumption, demand for investment and exports, all measured in economic value per commodity. Along the columns, the Use table is extended by sectoral Value Added in production, that along with the intermediate demand for commodities per sectoral production add to total output per sector. The summation of total sectoral output is the regional total output and equals the summation of final use over commodities.

The structure of the Use table is depicted in Figure 6.



**Figure 6: The Use table**

On the supply side, the Supply (Make) table reflects the production side of the economy reporting sectoral production and production per commodity. The Supply table is again a commodity (rows) by sector (columns) matrix that is extended by imports per commodity and the Total Supply per commodity, respectively. Along the columns the table describes the total output per sector, while along the rows we find the production per commodity of the economy. The structure of the Supply table is depicted in Figure 7.

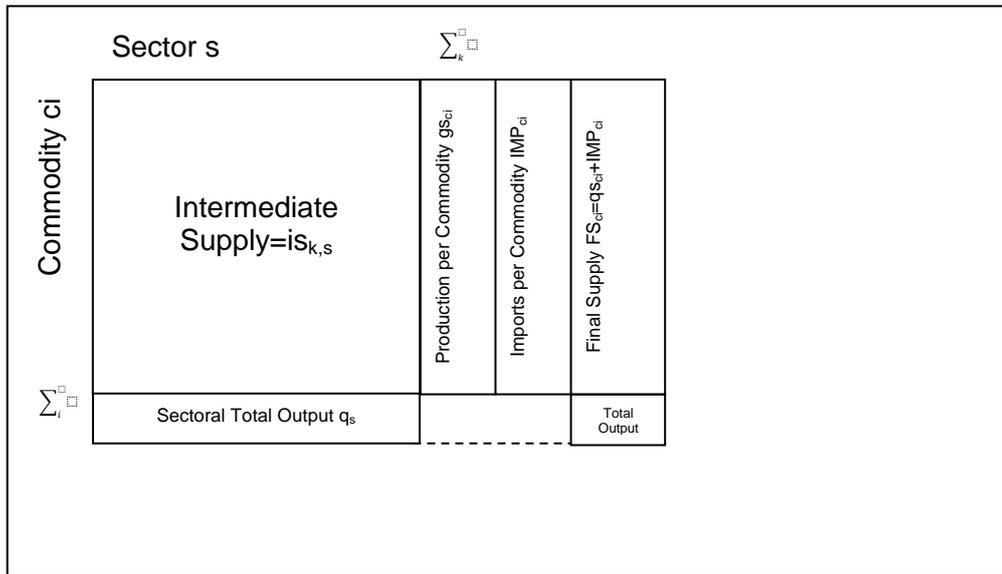


Figure 7: The Supply table

The construction of the Use and Supply tables follows the basic identity of the IO approach that the Final Use per commodity equals Final Supply per commodity, which sets the equilibrium point between the demand and the supply side of the economy. As already mentioned, our approach is demand driven, meaning that we seek to find the necessary level of regional production of commodities that meets regional demand. By regional demand for commodities we mean both the intermediate demand for commodities in the production process and the final demand (consumption) by private and public agents. According to the commodity equivalence assumption (12), the regional output per commodity  $ci$  should equal the regionally produced commodity  $gs_{ci}$  plus the imported commodity  $IMP_{ci}$ :

$$g_{ci} = gs_{ci} + IMP_{ci} = gint_{ci} = gint_{ci} + f_{ci} \tag{12}$$

where  $g_{ci}$  is the total output per commodity  $ci$  in the region,  $gs_{ci}$  is the regionally produced quantity of commodity  $ci$ ,  $IMP_{ci}$  is the regional and foreign import of commodity  $ci$  in the region,  $gint_{ci}$  measures the intermediate demand for commodity  $ci$  and  $f_{ci}$  depicts the final demand for commodity  $ci$ . The final demand vector  $f_{ci}$  is derived from identity (13):

$$f_{ci} = CP_{ci} + GCP_{ci} + NGOCP_{ci} + EXP_{ci} + I_{ci} \tag{13}$$

with  $CP_{ci}$  expressing private consumption per commodity,  $GCP_{ci}$  the public consumption per commodity,  $NGOCP_{ci}$  the NGO consumption per commodity,  $EXP_{ci}$  the foreign and regional exports per commodity and  $I_{ci}$  the investment demand per commodity (changes in inventories, infrastructure, investment etc.). Utilizing information from Supply table  $V$ , we derive the market shares matrix which is the ratio of each element of the Supply table divided by sectoral output as expressed in (14):

$$\bar{V} = \frac{V}{q_s} \quad (14)$$

The market shares matrix describes the commodity structure of sectoral output and thus it varies across time according to total sectoral output variations, assuming a constant Supply table. Then, given that by construction  $g_{ci} = \bar{V} \cdot q_s$ , we can find a level of sectoral production that satisfies the demand for commodity  $g_{ci}$  as in (15):

$$q_s = \bar{V}^{-1} \cdot g_{ci} \quad (15)$$

### 1.1.1.3 Updating the IO tables

An issue of interest in the IO literature is the way that the Use and Supply tables are updated over time. Given that typically IO tables are available every 5 years and published with a delay of at least 4 years from current year, the issue of updating the elements of IO tables has attracted significant interest in the literature. Kratena and Zakarias (2004) demonstrate the superiority of updating IO tables over keeping all elements constant over time, given that it adheres more closely to technological changes (growth in information technology) and changes in the production process (vertical integration, outsourcing etc.).

All data on IO tables that we use in our models are compiled from the World Input-Output Database (WIOD, Timmer et al., 2015) project and more specifically the WIOD 2016 release. They cover the period 2000-2014. In our approach, we follow Kratena and Zakarias (2004) and update IO tables for the period 2015-2029 where we perform our forecasts, while for the period 2000-2014 we use the available data. Updating the technical coefficients of the IO tables is necessary only for the Use table, given that we assume a constant Supply table and allow for the total sectoral output to vary over time, leading to a dynamic market shares matrix. We utilize our updating process on the technical coefficient matrix  $A$ , where each element is given by  $a_{k,s} = iu_{k,s}/q_s$ . The selection of the technical coefficient matrix is preferable to updating the Use table directly, in order to avoid distortions that stem from the different arithmetical range of the elements of the Use table. In contrast, given that the technical coefficient matrix  $A$  expresses the ratio of intermediate demand for a commodity in production, its elements are all in the range  $[0,1]$ .

The process calls for an update along the rows and along the columns of the table. Moreover, according to the constraint during the construction of the Use table, we need the total sum along the columns (summation of the sectoral intermediate demand per commodity in production) and the total sum across the rows (summation of the intermediate demand for commodities) to be equal. The vector of sums along the columns is directly available in (6) from the estimation of  $qi_{s,t}$ . So, the issue of updating the technical coefficient matrix  $A$  boils down to calculating the new sum along the rows vector, and then perform a full bi-proportional adjustment that updates all the elements of matrix  $A$  to satisfy the new column and row sum vectors<sup>1</sup>.

The determination of the rows sums of matrix  $A$  follows the “hypothetical” estimation of deviations of total intermediate demand from its actual (observed) values. Starting from the base year (year 2000) we determine the constraint for the row sum as in (16):

$$g_{ci} = A \cdot q_s + f_{ci} = gint_{ci} + ci \quad (16)$$

<sup>1</sup> Given that the vector of column sums is provided from the econometric estimation of the previous section, we scale rows sums to meet the total sum of column sums in order to satisfy the equality assumption between the sum of columns and the sum of rows.

and with little manipulation and adding a time subscript (16) becomes (17):

$$gint_{ci,t} = g_{ci,t} - f_{ci,t} = A_t \cdot q_{s,t} \quad (17)$$

Given that we have annual data that span the period 2000-2014, we assume that the coefficient matrix  $A$  is constant over time and compute the difference between the two sides of the equality; the observed and the constant values. The deviation of the actual intermediate demand from the “hypothetical” one (when we keep the technical coefficients in matrix  $A$  constant) can be attributed to changes in matrix  $A$ . Thus, based on equation (17), we can find a vector of time changes  $r_t$  that satisfies (18) and reflects the evolution of  $A$  in order to satisfy the row equality condition

$$r_t \cdot A \cdot q_{s,t} = gint_{ci,t} \quad (18)$$

The values of  $r_t$  are estimated from the period 2000-2014 and are used to the updating period 2015-2029. Given the sums of rows and columns, we proceed to a full bi-proportional updating algorithm as in Kratena and Zakarias (2004).

The basic idea is to update all the technical coefficients in a way that meets the column and row sum equality constraint. As an example, let us consider the following 2X2 technical coefficient matrix  $A$  in Table 2:

$a_{11}$	$a_{12}$	$a_{1j}$
$a_{21}$	$a_{22}$	$a_{2j}$
$a_{i1}$	$a_{i2}$	$a_{ij}$

where  $a_{1j} = a_{11} + a_{12}$  and  $a_{2j} = a_{21} + a_{22}$  are the row sums,  $a_{i1} = a_{11} + a_{21}$  and  $a_{i2} = a_{12} + a_{22}$  the column sums and  $a_{1j} + a_{2j} = a_{i1} + a_{i2} = a_{ij}$  is the sum of all elements. Our goal is to update all elements according to the new row and column sums subject to the equality restriction. Considering scaling factors  $r_1, r_2$  for updating rows and  $s_1, s_2$  for updating columns, we follow an iterative procedure till convergence, described in the pseudo-code of Figure 8.

*Repeat until  $r_1 = r_2 = s_1 = s_2 = 1$  OR iterations=50,000*

$$r_1 = a\_new_{1j} / (a_{11} + a_{12})$$

$$r_2 = a\_new_{2j} / (a_{21} + a_{22})$$

$$s_1 = a\_new_{i1} / (a_{11} + a_{21})$$

$$s_2 = a\_new_{i2} / (a_{12} + a_{22})$$

$$a_{11} = a_{11} \cdot r_1 \cdot s_1$$

$$a_{12} = a_{12} \cdot r_1 \cdot s_2$$

$$a_{21} = a_{21} \cdot r_2 \cdot s_1$$

$$a_{22} = a_{22} \cdot r_2 \cdot s_2$$

*End*

**Figure 8: Updating procedure of the technical coefficients matrix  $A$ .**

The first four rows of the pseudo-code determine the row ( $r$ ) and the column ( $s$ ) scaling factors according to the new row/column sums, while the last four rows update the existing coefficients. Given that with each update the scaling factors continue to adjust, we iterate the procedure until no further update is performed.

#### 1.1.1.4 Integrated EC-IO approach

Our model is inheritably a demand driven model that attempts to establish a link between demand and supply, starting from the demand side. Demand is determined by

the components of final demand and intermediate demand in production. After the determination of a possible level of demand per commodity, the IO part is used to estimate a level of production that meets demand, while the EC part of the model provides estimates on the cost factors in production. In more detail, the model is estimated in the following steps:

1. Compute the coefficients of the EC part using the available data for each year and fix all coefficients to their respective values.
2. Start with some initial guess regarding the components of final and intermediate demand (private and public consumption, investment and exports). Given the availability of data for the period 2000-2014, we start our simulation from the actual values and find the steady state of the system.
3. Exports in the regional level and foreign exports are added exogenously. We correct the regional demand for commodities by subtracting commodity imports in order to find the actual regional demand that is met by the regional production level.
4. Determine the regional production using the structural market shares matrix  $\bar{V}$  and the desired level of demand.
5. Based on the estimated sectoral levels of production, input prices and wage rates, we estimate the Generalized Leontief cost functions in order to derive the ratio of intermediate production to total production, employment and output prices. Input prices, capital formation and wage rates are determined in separate blocks of equations, according to the desired level of regional production and fed to the Generalized Leontief cost functions.
6. With the new levels of regional production, we estimate the sectoral Value Added, find the estimated disposable income and through the structure of the error-correction model, reach to a new level of regional consumption.
7. Assuming constant consumer attitudes, we disaggregate the new level of total consumption to consumption per commodity. This feature can be expanded in a future version to include varying budget shares for households.
8. From the new levels of household consumption, we find the new level of final demand and iterate everything from step 2 to convergence.
9. After convergence of step 8, move forward in time. In case that our estimation exceeds 2014, update the technical coefficient matrix  $A$  using previous year's data, to obtain the new levels of intermediate demand for commodities. Start over from step 2.

The aforementioned analysis provides values for regional sectoral production, total regional production, regional Gross Domestic Product, regional sectoral employment and wage rate (bill), regional disposable income, regional consumption, regional demand for investments and regional capital stock. We can also observe regional input and output prices per commodity, since their levels are determined at the national level.

This scenario is considered as the baseline scenario, where no interventions is made to the regional economy and the model is free to converge to its natural steady state. In contrast, we can assume a policy intervention to the regional economy, where decisions of policy authorities or other exogenous events (economic, environmental, political etc.) affect the level of final demand. These changes are fed into the model, leading to a new steady state. Thus, by comparing the two scenarios (the baseline and the policy scenario) we can infer upon the economic impact of an intervention. In the next section we describe the process we follow to regionalize our data.

#### 1.1.1.5 Data and regionalization process

Examining pilot cities in an alphabetical order, Antalya is the fifth largest city of Turkey and the capital of the Province of Antalya. In its long history the city of Antalya has

become a center of commerce, while it is among the largest Mediterranean sea-resorts (Turkish Statistical Institute, 2011). We develop a model that is tailored-made to adhere to the economic activity in the region.

Given that Antalya is the first city under examination, we include a general description of all the necessary data for the estimation for the EC-IO model, which we do not repeat on the other pilot cities and refer only to the regionalization process. Our primary source of data is the World Input-Output Database (WIOD, Timmer *et al.*, 2015) project and more specifically the WIOD 2016 release. This release covers the Turkish economy for the period 2000-2014 and provides data for the Use and Supply tables at the national level, as well as additional data on sectoral capital stock formation, sectoral wage rates, sectoral employment and input and output prices. All variables are expressed in thousands of local currency units, except from employment data that is in millions of time equivalents and prices indices that are indices (base year 2010=100).

The Use and Supply tables are provided as  $64 \times 64$  dimension matrices, meaning 64 commodities (rows) by 64 sectors (columns). In Table 3 we report the 64 sectors that we use in our EC-IO model. We study 64 sectors by 64 commodities resulting in  $64 \times 64 = 4,096$  variables, observed for 15 years (2000-2014). Moreover, adding the final demand elements we also gather an additional 320 variables and 64 variables for the sectoral Value Added over the same time span. Overall, from the Use table we gather 4,480 variables.

From the Supply table, we compile  $64 \times 64 = 4,096$  variables and an additional 64 variables from commodity imports. In this, we do not take into consideration the intermediate demand for commodities, total consumption or total sectoral output that are derived from the other elements of the table. From the additional variables, we also compile  $64 \times 3 = 192$  variables (capital formation, wage rate and employment), while the annual CPI and the annual disposable income are retrieved from the database of the Turkish Statistical Institute. While CPI is readily available, we could not compile the annual disposable income directly, so we used the GDP per capita multiplied by the population of each Province as a proxy. Overall, we compile a total of 8,770 variables, spanning the period 2000-2014, on the national level, apart from annual disposable income that is estimated on the regional level.

**Table 3: Sectoral structure of our EC-IO model**

No	ESA 2010 Acronym	Sectoral Description
1.	A01	Crop and animal production, hunting and related service activities
2.	A02	Forestry and logging
3.	A03	Fishing and aquaculture
4.	B	Mining and quarrying
5.	C10_12	Manufacture of food products, beverages and tobacco products
6.	C13_15	Manufacture of textiles, wearing apparel and leather products
7.	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
8.	C17	Manufacture of paper and paper products
9.	C18	Printing and reproduction of recorded media
10.	C19	Manufacture of coke and refined petroleum products
11.	C20	Manufacture of chemicals and chemical products
12.	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
13.	C22	Manufacture of rubber and plastic products
14.	C23	Manufacture of other non-metallic mineral products
15.	C24	Manufacture of basic metals
16.	C25	Manufacture of fabricated metal products, except machinery and equipment
17.	C26	Manufacture of computer, electronic and optical products
18.	C27	Manufacture of electrical equipment
19.	C28	Manufacture of machinery and equipment n.e.c.
20.	C29	Manufacture of motor vehicles, trailers and semi-trailers
21.	C30	Manufacture of other transport equipment
22.	C31_32	Manufacture of furniture; other manufacturing
23.	C33	Repair and installation of machinery and equipment
24.	D	Electricity, gas, steam and air conditioning supply
25.	E36	Water collection, treatment and supply
26.	E37_39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
27.	F	Construction
28.	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
29.	G46	Wholesale trade, except of motor vehicles and motorcycles
30.	G47	Retail trade, except of motor vehicles and motorcycles
31.	H49	Land transport and transport via pipelines
32.	H50	Water transport
33.	H51	Air transport
34.	H52	Warehousing and support activities for transportation
35.	H53	Postal and courier activities
36.	I	Accommodation and food service activities
37.	J58	Publishing activities
38.	J59_60	Motion picture, video and television program production, sound recording and music publishing activities; programming and broadcasting activities
39.	J61	Telecommunications
40.	J62_63	Computer programming, consultancy and related activities; information service activities
41.	K64	Financial service activities, except insurance and pension funding
42.	K65	Insurance, reinsurance and pension funding, except compulsory social security
43.	K66	Activities auxiliary to financial services and insurance activities
44.	L68	Real estate activities without imputed rents
45.	M69_70	Legal and accounting activities; activities of head offices; management consultancy activities
46.	M71	Architectural and engineering activities; technical testing and analysis
47.	M72	Scientific research and development
48.	M73	Advertising and market research
49.	M74_75	Other professional, scientific and technical activities; veterinary activities
50.	N77	Rental and leasing activities
51.	N78	Employment activities
52.	N79	Travel agency, tour operator reservation service and related activities
53.	N80_82	Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support activities
54.	O	Public administration and defence; compulsory social security
55.	P	Education

56.	Q86	Human health activities
57.	Q87_88	Social work activities
58.	R90_92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities
59.	R93	Sports activities and amusement and recreation activities
60.	S94	Activities of membership organisations
61.	S95	Repair of computers and personal and household goods
62.	S96	Other personal service activities
63.	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
64.	U	Activities of extra-territorial organizations and bodies

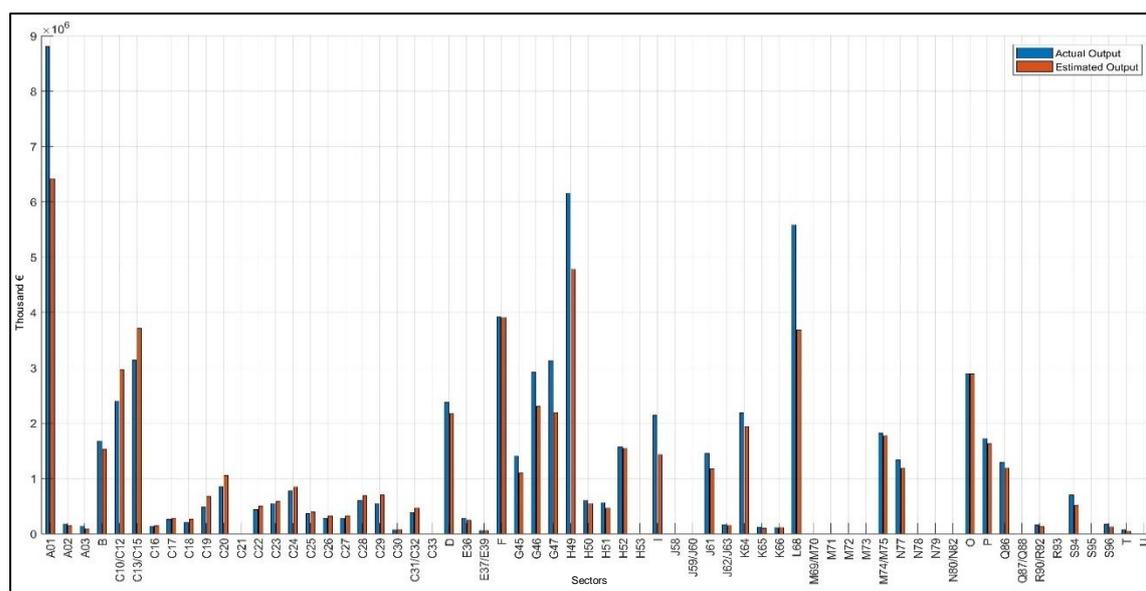
In order to regionalize our data, we compare the sectoral regional production of the Province of Antalya with the sectoral production of the entire Turkish economy to create a regional production ratio. This ratio is used to provide an estimate on the sectoral production level for the Province of Antalya and regionalize national data. Unfortunately, the Turkish Statistical Institute database provides estimates of regional production in three highly aggregated sectors: Agriculture, Industry and Services. So, we build a bridge matrix that disaggregates this classification to our 64-sector classification system, reported in Table 4.

**Table 4: Sectoral classification for the Province of Antalya as reported from the Turkish Statistical Institute**

No	ESA 2010 Correspondence	TurkStat Acronyms	Sectoral Description
1	A01,A02,A03,B	T	Agriculture
2	C10/C12, C13/C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31/C32, C33	S	Industry
3	D, E36, E37/E39, F, G45, G46, G47, H49, H50, H51, H52, H53, I, J58, J59/J60, J61, J62/J63, K64, K65, K66, L68, M69/M70, M71, M72, M73, M74/M75, N77, N78, N79, N80/N82 ,O, P, Q86, Q87/Q88, R90/R92, R93, S94, S95, S96, T, U	H	Services

We use the national level of CPI and input and output prices, given that the average regional production of the Province of Antalya for the period 2000-2014 is small at the 10.18% of the total production of the Turkish economy. Thus, we do not expect to find great differences on the regional level with the national one.

After regionalizing all data according to the regional production ratio per sector, we estimate the baseline scenario, assuming no intervention to the regional economy. Due to model stability reasons, sectoral employment is treated as an exogenous variable (not determined endogenously by output and wage rates) for sectors (a) Fishing and aquaculture, (b) Rental and leasing activities, (c) Activities of membership organizations, (d) Other personal service activities, (e) Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use and (f) Scientific research and development. Such stability issues are expected, given the lack of detailed data for each sector and the use of proxies to the sectoral output production. In Figure 9 we depict the estimated and the actual sectoral output for the Province of Antalya at 2010.



**Figure 9: Estimated and actual sectoral output for the Province of Antalya at 2010.**

As we observe, the sectors with the largest regional output are (a) Crop and animal production, Hunting and related service activities (A01), (b) Land Transportation (H49), (c) Real estate activities without imputed rents (L68) and (d) Construction (F). Several sectors appear to have no output. Our examination of the Turkish Statistical Institute database verified that there exists no recorded data on production for these sectors. Of course, it is very hard to consider that there is no production on sector Scientific research and development (M72) or Advertising and market research (M73), among other sectors, at the national level. Nevertheless, we are bounded by data availability.

The next region in the program is the Province of Antwerp. The Province of Antwerp lies in the north-west Belgium in Flanders and its capital is the city of Antwerp, which is also the second largest city in Belgium after Brussels. According to the Statistical Office of Belgium, the harbor of Antwerp is the second largest trading port in Europe, while Antwerp is a commercial hub for many wholesale and retail handlers, especially for furs and diamonds.

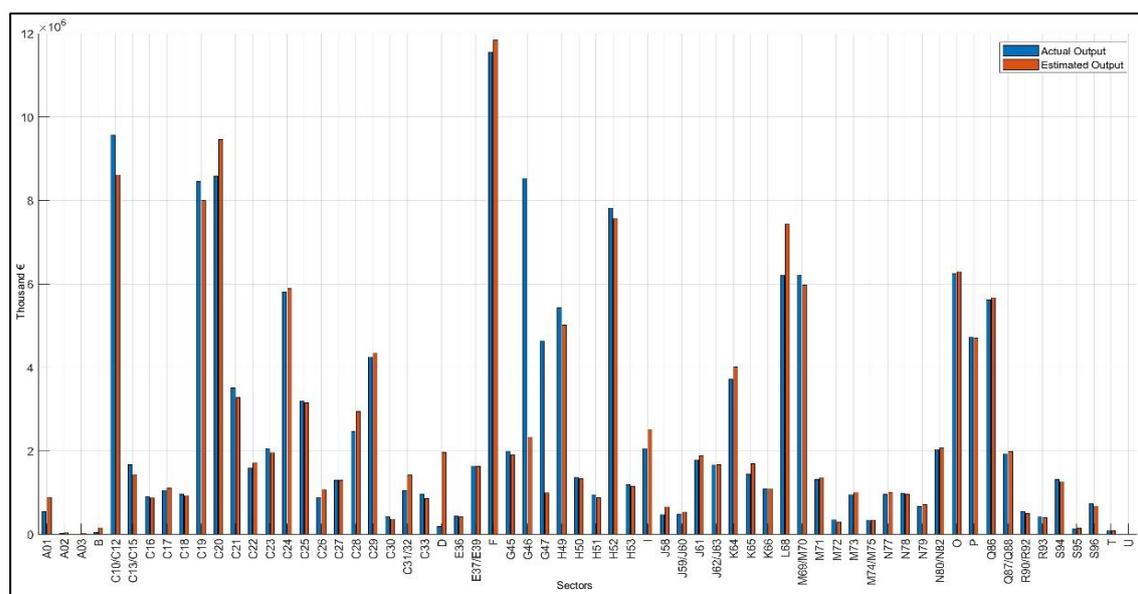
The regionalization process is based on regional sectoral production ratios, constructed from data retrieved from the database of the Belgian Statistical Office. We compile sectoral regional turnovers for the Province of Antwerp and compare them with the respective sectoral turnovers of the entire Belgian economy. The data are aggregated in a classification system in 13 production sectors for the period 2005-2014. In order to regionalize our national data, we match the available classification system to our 64 sectors using a bridge matrix. The bridge matrix links the two classification systems based on similarity in economic activity, reported in Table 5. The CPI is compiled from the database of the Belgian Statistical Office. We consider CPI and price indices to be constant across regions, so we use their national values. Regarding disposable income, the Belgian Statistical Office provides detailed data of the regional distribution of disposable income as it is reflected in tax statistics on income. Given that the ratios and the disposable income are available for the period 2005-2014, we extrapolate our data backwards based on OLS models.

Naturally, the bridge matrix that matches the two classification systems could be avoided, in the presence of detailed sectoral data. Nevertheless, in the absence of this information, we believe that our approach is a viable alternative, that simulates the actual regional data.

**Table 5: Sectoral classification for the Province of Antwerp as reported from the Belgian statistical office**

No	ESA 2010 Correspondence	StatBel Acronym	Sectoral Description
1	A01,A02,A03,B	B	Mining and quarrying
2	C10_12, C13_15, C16, C17, C18, C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31_32,C33	C	Manufacturing
3	D	D	Electricity, gas, steam and air conditioning supply
4	E36, E37_39	E	Water supply/ sewerage, waste management and remediation activities
5	F	F	Construction
6	G45, G46, G47	G	Wholesale and retail trade/ repair of motor vehicles and motorcycles
7	H49,H50,H51,H52,H53	H	Transportation and storage
8	I	I	Accommodation and food service activities
9	J58,J59_60,J61,J62_63	J	Information and communication
10	K64,K65,K66,L68,M69_70,M71,M72,M73,M74_75	K	Professional, scientific and technical activities
11	N77,N78,N79,N80_82,O,P,Q86,Q87_88	N	Administrative and support service activities
12	R90_92	R	Arts, entertainment and recreation
13	R93,S94,S95,S96,T,U	S	Other service activities

After the estimation of all coefficients for the econometric part of the model, we proceed in estimating the baseline scenario based on the EC-IO model, where we assume no exogenous shock (macroeconomic, environmental, technological, government policy etc.) on the regional economy. In Figure 10, we depict the estimated and the actual sectoral production for year 2010.



**Figure 10: Estimated and actual sectoral output for the Province of Antwerp at 2010.**

As we observe, construction (F), food production (C10/C12) and wholesales (G46) are the sectors with the largest regional output in the Province of Antwerp. Also significant are the production of refined petroleum products (C19) and the production of chemicals (C20). The large discrepancies observed in the actual and the estimated output for sectors G46 (wholesales) and G47 (retail sales) stem from data availability. The Belgian Statistical Office aggregates the demand for commodities in wholesales (G46) and retail sales (G47) of the Use table, reporting a total demand under sector G46 for both sectors. In contrast, in the Supply table reports separate sectoral turnovers for each sector, but only for the period 2009-2014. Given that it is not feasible that there is no output in the retail sales sector, we extrapolate the retail sale turnover for the period 2000-2008 and subtract it from the corresponding values of sector G46 (wholesales) on the Supply Table for the entire period. Then, based on the ratio between the two sectors' turnover, we segregate the reported demand of sector G46 in the Use table to create sectoral demand for sectors G46 and G47. Of course, this is a pure approximation of the demand for commodities for whole sales and retail sale with the remaining 62 sectors of the Use table, resulting in deviations in the estimation of total turnovers for sectors G46 and G47.

Cork is the third pilot city in the project. Within Cork, Cork City is the largest urban area in the County, as well as the second largest city in Ireland. Cork is located in the province of Munster, which is the largest of the four provinces in Ireland and is home to many pharmaceutical companies as well as high-tech industries. In this section we tailor our EC-IO model on the regional economic data of Cork.

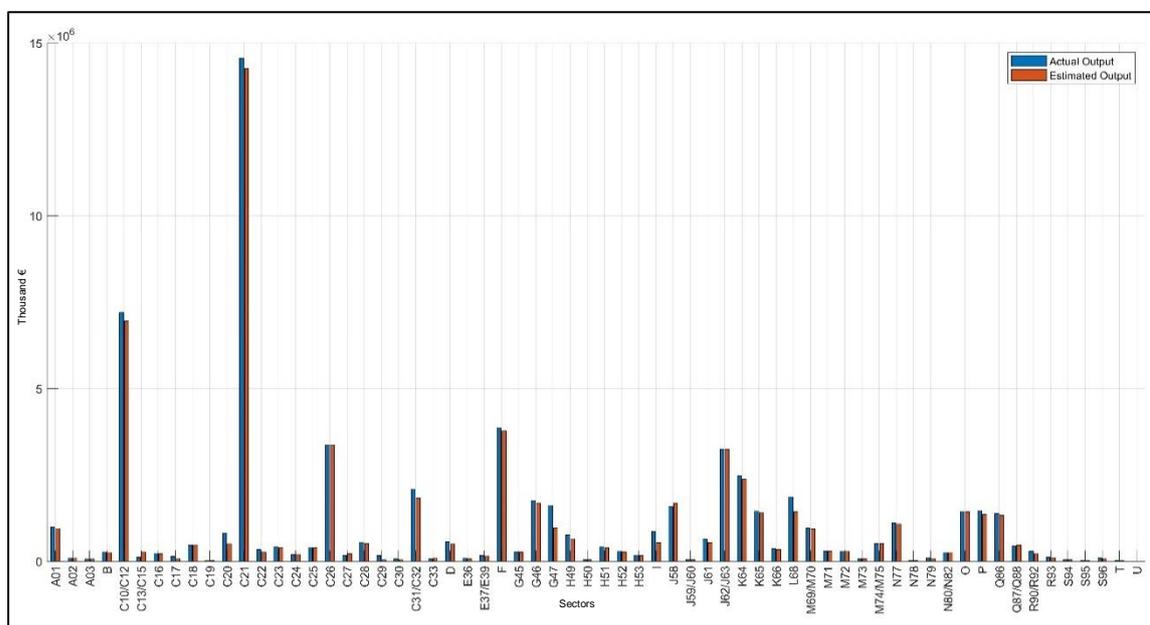
The main source of data is the WIOD project and specifically its 2016 release. From there, we compile data on Use and Supply tables, as well as additional datasets regarding wage rates, employment, capital stock formation, input and output commodity price indices. The CPI and the disposable income are compiled from the Central Statistics Office of Ireland. In fact, the disposable income is readily available at a regional level (Cork County), so we do not need to make any assumptions as in the other pilot cities. The regional CPI and price indices are assumed to follow national values. In order to regionalize all other variables, we compile regional sectoral production ratios from the Central Statistics Office database, but on an aggregate classification in 3 general sectors: "Agriculture, Forestry and Fishing", "Manufacturing, Building and Construction" and "Market and Non-Market Services". Thus, we match the

existing classification system with our 64 sector classification system through a bridge matrix, reported in Table 6.

**Table 6: Sectoral classification for the Cork County as reported from the Central Statistics Office**

No	ESA 2010 Correspondence	TurkStat Acronyms	Sectoral Description
1	A01,A02,A03,B	A	Agriculture, Forestry and Fishing
2	C10/C12, C13/C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31/C32	C	Manufacturing, Building and Construction
3	C33, D, E36, E37/E39, F, G45, G46, G47, H49, H50, H51, H52, H53, I, J58, J59/J60, J61, J62/J63, K64, K65, K66, L68, M69/M70, M71, M72, M73, M74/M75, N77, N78, N79, N80/N82 ,O, P, Q86, Q87/Q88, R90/R92, R93, S94, S95, S96, T, U	S	Market and Non-Market Services

After regionalizing all data according to the sectoral regional production ratios, we estimate the baseline scenario. Due to model stability reason, sectoral employment is considered as an exogenous variable for (a) Manufacture of other non-metallic mineral products, (b) Manufacture of motor vehicles, trailers and semi-trailers, (c) Repair and installation of machinery and equipment, (d) Human health activities, (e) Activities of membership organizations and (f) Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use. Such stability issues are expected given the lack of precise data of sectoral production levels. In Figure 11 we depict the estimated and actual sectoral output for the Cork County at 2010.



**Figure 11: Estimated and actual sectoral output for the Cork County at 2010.**

The sector with the highest regional output is Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21) followed by Manufacture of food products, beverages and tobacco products (C10/C12) and Construction (F).

The city of Thessaloniki is the last pilot city in the program. Thessaloniki is the second largest city in Greece and the capital of the region of Central Macedonia. The city has

the second largest port in the Balkan area, while it is a significant cultural, trade and economic center in Greece.

The main source of data is the WIOD 2016 release for the Use and Supply tables and the additional variables per sector (wage rates, employment, input and output prices) at the national level. We compile CPI and disposable income from the Hellenic Statistical Authority for the period 2000-2014, as with the WIOD data. The disposable income is provided at a regional level, regional CPI and price indices are considered in their national values. In the regionalization process of the Use and Supply tables we follow a different approach than the one we used in the other three pilots.

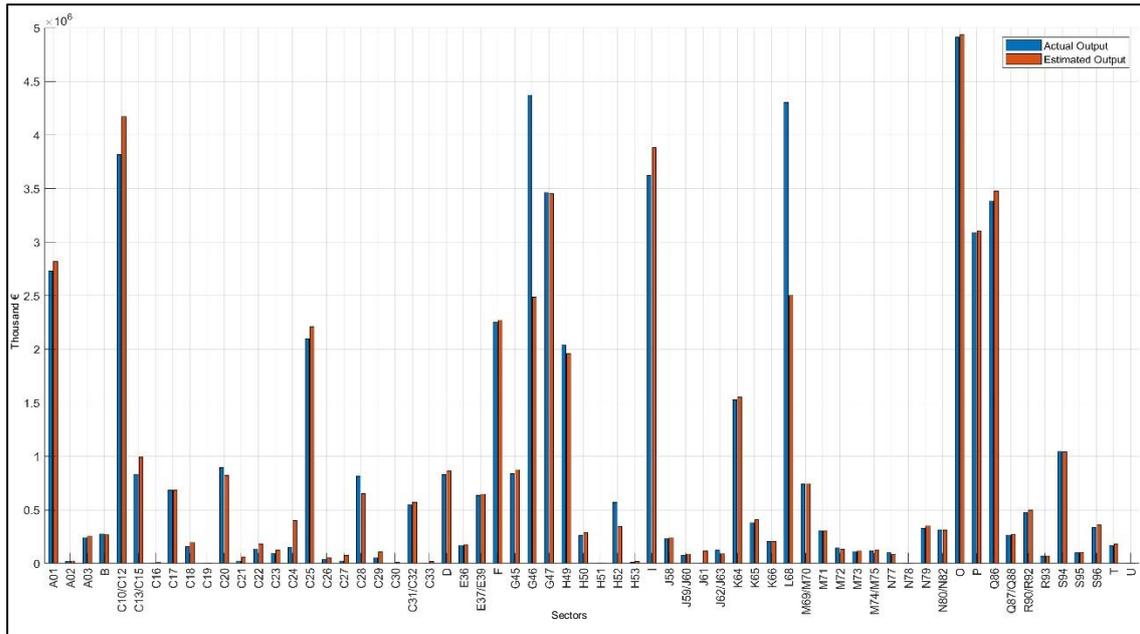
Under a specific research permission from the Hellenic Statistical Authority, we are granted access to the Structural Business Statistics survey that spans the period 2008-2014. The sample consists of 298 firms classified in 8 aggregate categories: (a) Industry, (b) Real Estate services, (c) Trade, (d) Construction, (e) Information Services, (f) Warehousing services, (g) Water transportation and (h) Tourist services. Moreover, the survey classifies firms according to their production activity in the most detail version of the NACE ver. 2 classification, e.g. in 100 sectors. In this way we create a bridge matrix that matches the 100-sector classification to the 64-sector classification system. The bridge matrix is depicted in Table 7.

**Table 7: Sectoral classification for the Central Macedonia region as reported by the Hellenic Statistical Authority**

No	HelStat Acronyms	ESA 2010 Acronyms	Sectoral Description
1	1	A01	Crop and animal production, hunting and related service activities
2	2	A02	Forestry and logging
3	3	A03	Fishing and aquaculture
4	5/6/7/8/9	B	Mining and quarrying
5	10/11/12	C10_12	Manufacture of food products, beverages and tobacco products
6	13/14/15	C13_15	Manufacture of textiles, wearing apparel and leather products
7	16	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
8	17	C17	Manufacture of paper and paper products
9	18	C18	Printing and reproduction of recorded media
10	19	C19	Manufacture of coke and refined petroleum products
11	20	C20	Manufacture of chemicals and chemical products
12	21	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
13	22	C22	Manufacture of rubber and plastic products
14	23	C23	Manufacture of other non-metallic mineral products
15	24	C24	Manufacture of basic metals
16	25	C25	Manufacture of fabricated metal products, except machinery and equipment
17	26	C26	Manufacture of computer, electronic and optical products
18	27	C27	Manufacture of electrical equipment
19	28	C28	Manufacture of machinery and equipment n.e.c.
20	29	C29	Manufacture of motor vehicles, trailers and semi-trailers
21	30	C30	Manufacture of other transport equipment
22	31/32	C31_32	Manufacture of furniture; other manufacturing
23	33	C33	Repair and installation of machinery and equipment
24	35	D	Electricity, gas, steam and air conditioning supply
25	36	E36	Water collection, treatment and supply
26	37/38/39	E37_39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
27	41/42/43	F	Construction
28	45	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
29	46	G46	Wholesale trade, except of motor vehicles and motorcycles
30	47	G47	Retail trade, except of motor vehicles and motorcycles
31	49	H49	Land transport and transport via pipelines
32	50	H50	Water transport
33	51	H51	Air transport
34	52	H52	Warehousing and support activities for transportation
35	53	H53	Postal and courier activities
36	55/56	I	Accommodation and food service activities
37	58	J58	Publishing activities
38	59/60	J59_60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
39	61	J61	Telecommunications
40	62/63	J62_63	Computer programming, consultancy and related activities; information service activities
41	64	K64	Financial service activities, except insurance and pension funding
42	65	K65	Insurance, reinsurance and pension funding, except compulsory social security
43	66	K66	Activities auxiliary to financial services and insurance activities
44	68	L68	Real estate activities without imputed rents

45	69/70	M69_70	Legal and accounting activities; activities of head offices; management consultancy activities
46	71	M71	Architectural and engineering activities; technical testing and analysis
47	72	M72	Scientific research and development
48	73	M73	Advertising and market research
49	74	M74_75	Other professional, scientific and technical activities; veterinary activities
50	77	N77	Rental and leasing activities
51	78	N78	Employment activities
52	79	N79	Travel agency, tour operator reservation service and related activities
53	80/81/82	N80_82	Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support activities
54	84	O	Public administration and defence; compulsory social security
55	85	P	Education
56	86	Q86	Human health activities
57	87/88	Q87_88	Social work activities
58	90/91/92	R90_92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities
59	93	R93	Sports activities and amusement and recreation activities
60	94	S94	Activities of membership organisations
61	95	S95	Repair of computers and personal and household goods
62	96	S96	Other personal service activities
63	97 /98	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
64	99	U	Activities of extra-territorial organisations and bodies

Due to the disaggregation level of provided data, we are able to regionalize the Use and Supply tables with adequate accuracy, given that we are able to create sectoral regional ratios of production avoiding assumptions of similarity in the economic activity between sectors. We extrapolate all data according to an OLS regression model to simulate regional sectoral production ratios for the period 2000-2007. During the estimation of the EC-IO model, we assume that sectoral employment is exogenously determined in (a) Mining and quarrying, (b) Manufacture of motor vehicles, trailers and semi-trailers, (c) Repair and installation of machinery and equipment, (d) Telecommunications, (e) Employment activities and (f) Manufacture of textiles, wearing apparel and leather products. In Figure 12, we depict the estimated and the actual sectoral output for Central Macedonia at 2010.



**Figure 12: Estimated and actual sectoral output for Central Macedonia at 2010.**

As we observe, Public administration and defense, compulsory social security (O), Real estate activities without imputed rents (L68) and Wholesale trade, except of motor vehicles and motorcycles (G46) are the sectors with the largest sectoral production in the region.

1.1.1.6 Policy-oriented scenarios

As mentioned earlier, the main advantage of our EC-IO model is the ability to study the economic impact of policy-oriented scenarios to the regional level. In order to demonstrate the versatility of our model, we consider a number of scenarios based on environmental, administrative or other interventions to the economic activity of each region and measure the economic impact of the interventions. The following scenarios are simple examples where the EC-IO model is implemented to measure the economic impact, without direct focus on the scope of each pilot city in CUTLER. We emphasize on the expected scopes of CUTLER as reported in D9.1 in section 2 of this report.

Starting from Antalya, we develop a scenario where the final demand for the services of sector Land transport and transport via pipelines (H49) is increased, and we measure the spillovers in the local economy. Although the full flexibility of the scenarios is developed in a regional-tailored dashboard described in a different section of this report, in Table 8 we report the spillovers of the scenario in the region based on the EC-IO model, assuming a 10% increase in the demand for the services of the respective sector.

**Table 8: Accumulated impact for the scenario in Antalya**

Simulation end: 2029	Percentage change between baseline and selected scenario 10% increase in land transportation turnover
Capital Stock	0.18
Total Regional Production	0.56
Wage rate (expense)	0.18
Employment	0.20
Demand for Investments	0.27
Aggregate Consumption	0.19
Disposable Income	0.01
Regional GDP	0.08

Note: all values are percentages

As we observe from Table 8, a 10% increase in land transportation increases regional production by 0.56%, employment by 0.20% and regional GDP by 0.08%. These numbers represent the economy of the entire province and not just an increase in a sector. Of course, the model is fully expandable, examining shocks in the region from political, economic, environmental or other sources, leading to measurable economic impacts on the local economy.

We examine 2 different scenarios for the city of Antwerp. We assume that due to environmental damages in manufacturing facilities, the manufacturing production is reduced. In order to measure the economic impact of this shock, we assume a decrease in the output of sectors “manufacture of textiles, wearing apparel and leather products”, “manufacture of wood and of products of wood and cork, except furniture”, “manufacture of articles of straw and plaiting materials”, “manufacture of paper and paper products” and “Printing and reproduction of recorded media “ (sectors C13-15 to sector C18). In Table 9 we report the percentage change for economic variables, assuming a 10% decrease in manufacturing production. On the second scenario, we assume a decrease in the turnover of the wholesales sector (G46) in the region as a result of an increase in taxes.

**Table 9: Accumulated impact for the scenarios in Antwerp**

Simulation end: 2029	Percentage change between baseline and selected scenario	
	10% decrease in manufacture output	10% decrease in wholesales output
Capital Stock	-0.21	-0.14
Total Regional Production	-4.95	-0.35
Wage rate (expense)	-0.08	-0.41
Employment	-0.08	-0.27
Demand for Investments	-0.82	-0.94
Aggregate Consumption	-0.28	-0.59
Disposable Income	-0.02	-0.03
Regional GDP	-0.04	-0.12

Note: all values are percentages

As we observe from Table 9, a decrease in manufacturing output will cause a 4.95% decrease in the total production in the region, coupled with a 0.82% decrease in the aggregate demand for investments and a 0.28% decrease in the aggregate private consumption. The impact from a decrease in wholesales reports a 0.35% reduction in the aggregate production, 0.94% decrease in demand for investments and 0.59% decrease in consumption. Overall, a decrease of similar magnitude between the two scenarios has different impacts on the regional economy, suggesting that the manufacturing sector possesses a considerable economic role in the Province of Antwerp.

Moving to Cork, we measure the economic impact of an increase in the number of visitors that results an increase in the retail sales sector. Moreover, we assume an investment on the infrastructure of Cork harbor that increases transportation of raw material through sea to the regional facilities and results to an increase in the output of sector Water transportation (H50).

In Table 10 we report the economic impacts of the two scenarios to the regional economy. Moreover, we also report the Residential Dwelling Property Price change due to the importance of this variable to the local economy.

**Table 10: Accumulated impact for the scenario in Cork**

Simulation end: 2029	Percentage change between baseline and selected scenario	
	10% increase in retail sales turnover	10% increase in water transportation turnover

Capital Stock	0.05	0.09
Total Regional Production	0.74	0.43
Wage rate (expense)	0.13	0.35
Employment	0.47	0.38
Demand for Investments	0.23	0.33
Aggregate Consumption	2.19	0.61
Disposable Income	0.14	0.04
Regional GDP	0.20	0.05
Residential Dwelling Property Prices	0.27	0.08

Note: all values are percentages

As we observe, a 10% increase in retail sales increases aggregate consumption by 2.19% and total regional production by 0.74%. In contrast, an increase in water transportation causes a 0.61% increase in aggregate consumption and a 0.43% increase in total regional production. All other variables exhibit very small positive responses to the exogenous shocks.

Finally, we examine three scenarios for the city of Thessaloniki. In the first scenario, the organization of a festival is expected to increase the number of visitors that choose to visit the region, increasing the turnover of the sector Accommodation and food services (I). The second scenario examines an increase in retail sales (G47) as a result of visitors for the festival spend a portion of their budget to shopping. Finally, we consider an investment in the region with the construction of a new sports center, that boosts the revenues of the Construction sector (F). All scenarios assume a 10% increase in the final demand (and thus production) of the respective sector. In Table 11 we report the accumulated impacts of the scenarios, as compared to the baseline scenario, in percentage points.

**Table 11: Accumulated impact for the scenarios in Thessaloniki**

Simulation end: 2029	Percentage change between baseline and selected scenario		
	10% increase in accommodation and food services turnover	10% increase in retail sales turnover	10% increase in construction turnover
Capital Stock	0.08	0.09	0.06
Total Regional Production	1.60	1.77	1.05
Wage rate (expense)	0.01	0.14	0.06
Employment	1.14	1.23	0.70
Demand for Investments	2.07	2.31	1.40
Aggregate Consumption	0.30	1.36	0.45
Disposable Income	0.02	0.09	0.03
Regional GDP	0.14	0.70	0.26

Note: all values are percentages

A 10% increase in retail sales causes an increase of 2.31% in the regional demand for investments, 1.77% increase in total regional production (across all sectors), 1.23% in regional employment and 1.36% in aggregate consumption. The 10% increase in accommodation and food services causes a regional increase of 1.60% in total regional production, 1.14% in employment and 2.07% in the demand for new investments. The scenario in the construction sector exhibits modest spillovers to the local economy, with a 1.40% increase in the demand for investments and a 1.05% increase in total regional production.

Overall, our EC-IO model can provide quantitative answers on the impact of shocks on sectoral production, providing comparable answers in all possible scenarios posed by policy makers to potential interventions to the local economy.

### 1.1.1.7 Support Vector Regression

Within the CUTLER project, Cork and Thessaloniki posed a number of specific goals that concern a more disaggregated level from the one handled by the EC-IO model. These goals involve the expected revenues of the new parking system in Thessaloniki and the expected revenues and number of visitors to Camden Fort Meagher in Cork. The examination of these city-dependent goals is not possible with the EC-IO model, in order to meet these demands, we develop Support Vector models as auxiliary analysis tools.

The Support Vector Regression (SVR) methodology that we will use in forecasting economic variables is a direct extension of the classic Support Vector Machine algorithm. The SVR algorithm has gained popularity due to its flexibility, the lack of initial assumptions regarding the data and its superiority in fitting economic phenomena. The SVR methodology was initially proposed by Vapnik *et al.* (1992), later extended in Cortes and Vapnik (1995) and belongs to the broader category of statistical learning techniques. In that, a model is built arbitrarily and its coherence to a phenomenon is gradually improved through a train and error procedure; the introduction of new data (observations) improves the adherence of the model to the phenomenon. When it comes to regression, the basic idea is to find a function that has at most a predetermined deviation from the actual values of the dataset. In other words, errors are not of interest if they don't violate a predefined threshold  $\varepsilon$ , only errors higher than  $\varepsilon$  are penalized. The vectors that define the "error tolerance band" are identified through a minimization procedure and are called the Support Vectors (SV); this is where the method gained its name.

One of the main advantages of SVR in comparison to other techniques is that it yields a convex minimization problem with a unique global minimum, avoiding local minima. In order to avoid local minima, the model is built in two stages; a training and a validation step. In the first step, a part of the available data is used to determine model's coefficients and provide initial estimations on the model's coherence with the data. Typically, cross-validation and other bootstrapping techniques are used to pinpoint the Support Vectors. In the next step, the ability to forecast the data left aside during the training phase is evaluated. In this, the "unknown" data are fed to the model and the accuracy on the validation data is measured. Discrepancies in the training and validation accuracy are an indication of a local minima and the procedure is repeated with alternative configurations to achieve a consistent universal performance to the entire sample.

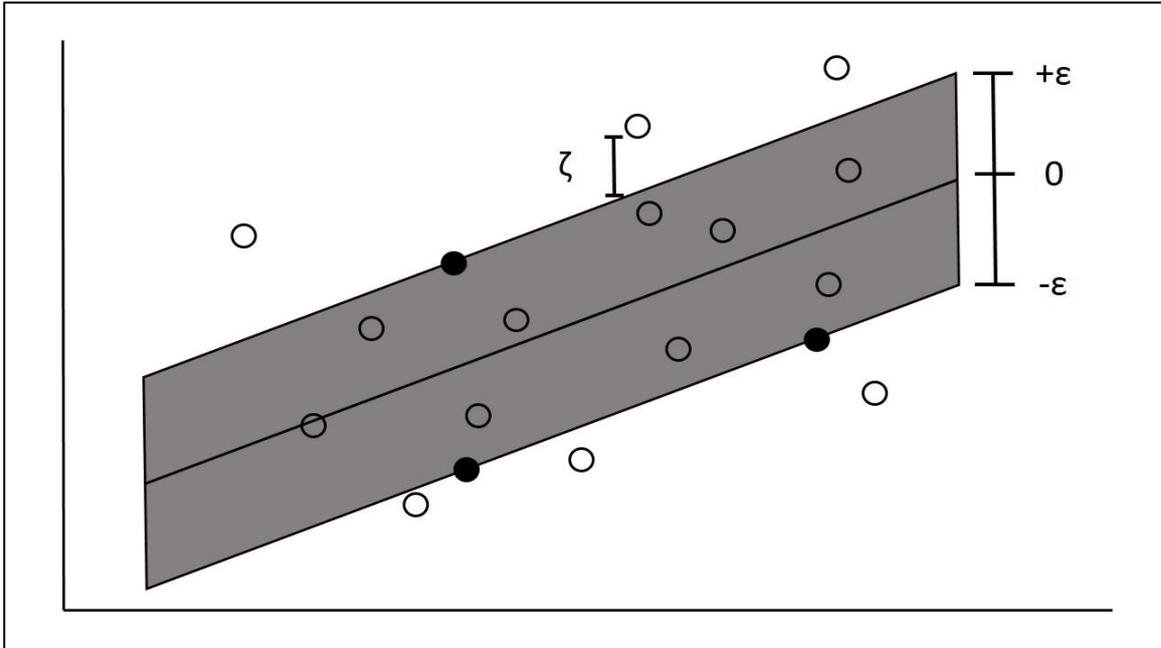
For a training dataset  $D = [(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)]$ ,  $x_i \in \mathbb{R}^m$ ,  $y_i \in \mathbb{R}$ ,  $i = 1, 2, \dots, n$ , where  $x_i$  is a vector of independent variables and  $y_i$  is the dependent variable, the linear regression function takes the form of  $y = f(x) = \mathbf{w}^T \mathbf{x} + b$ . This is achieved by solving:

$$\min \left( \frac{1}{2} \|\mathbf{w}\|^2 + C \sum_{i=1}^n (\zeta_i + \zeta_i^*) \right) \quad (19)$$

$$\text{subject to } \begin{cases} y_i - (\mathbf{w}\mathbf{x}_i + b) \leq \varepsilon + \zeta_i \\ (\mathbf{w}\mathbf{x}_i + b) - y_i \leq \varepsilon + \zeta_i^* \\ \zeta_i, \zeta_i^* \geq 0 \end{cases}$$

where  $\varepsilon$  defines the width of the tolerance band, and  $\zeta_i, \zeta_i^*$  are slack variables controlled through a penalty parameter C (see Figure 13). All the points inside the tolerance band have  $\zeta_i, \zeta_i^* = 0$ . The asterisk denotes observations that lie below the error-tolerance band. System (19) describes a convex quadratic optimization problem with linear constraints with a unique solution. The first part of the objective function controls the width of the band, by imposing the "flatness" of the model controlled through the Euclidean norm  $\|\mathbf{w}\|$ . The second part of the objective function controls the regression fit

to the training data (by increasing  $C$  we penalize any point outside the tolerance band with a bigger weight i.e. with  $\zeta_i \geq 0$  or  $\zeta_i^* \geq 0$ ). The key element in the SVR concept is to find the balance between the two parts in the objective function controlled by the  $\varepsilon$  and  $C$  parameters.



**Figure 13: Upper and lower threshold on error tolerance indicated with letter  $\varepsilon$ . The boundaries of the error tolerance band are defined by the Support Vectors (SVs) denoted with the black filled points. Forecasted values greater than  $\varepsilon$ , get a penalty  $\zeta$  according to their distance from the tolerance accepted band.**

Using the Lagrange multipliers in System (19) the solution is given by:

$$\mathbf{w} = \sum_{i=1}^n (a_i - a_i^*) \mathbf{x}_i \quad (20)$$

$$\text{and} \quad \mathbf{y} = \sum_{i=1}^n (a_i - a_i^*) \mathbf{x}_i^T \mathbf{x} \quad (21)$$

with the coefficient  $a_i$ ,  $a_i^* = 0$  for all non-SVs. Thus, the SVR model is defined solely by its SVs.

Nevertheless, the aforementioned process is linear in nature, while real-life phenomena are rarely linear. In order to tackle with this drawback, the SVR methodology is coupled with a kernel function to provide a nonlinear derivation of the process. The so-called “kernel trick” follows the projection idea while ensuring minimum computational cost. In cases of nonlinear phenomena, the dataset is projected in a higher dimensional space where a linear function can adhere to the dataset. Then, after the derivation of the model, the data set is re-projected to its initial dimensional space. This mapping is performed using only dot products instead of explicitly computing the mapping of each data point and thus is computationally efficient. When the kernel function is nonlinear, the produced SVR model is nonlinear as well. In our empirical estimations we employed two alternative kernels: the linear and the radial basis function (RBF), with the latter being a purely nonlinear kernel. The mathematical representation of each kernel is:

$$\text{Linear} \quad K_1(\mathbf{x}_1, \mathbf{x}_2) = \mathbf{x}_1^T \mathbf{x}_2 \quad (22)$$

$$\text{RBF} \quad K_2(\mathbf{x}_1, \mathbf{x}_2) = e^{-\gamma \|\mathbf{x}_1 - \mathbf{x}_2\|^2} \quad (23)$$

with factor  $\gamma$  representing a kernel parameter.

### 1.1.2 Model's software

#### Econometric Model/SVR Model - Technical requirements / Characteristics

The results of the aforementioned models (EC-IO and SVR) are accessible to the user through a custom dashboard, deployed on an Ubuntu 16.04 LTS Server with Apache2 Webserver installed and cgi-mod enabled. A Python 2.7 CGI (Common Gateway Interface) script and several python libraries undertake the coordination between the service components.

Given that both models are utilized in *Matlab*, we provide *Matlab* executables under the MathWorks MATLAB R2018a (9.4) Runtime. Moreover, in order to provide the user with a user-friendly interface, several web development libraries/frameworks are used. Table 12 reports the technical requirements of the custom econometric dashboard.

**Table 12: Econometric model technical requirements/characteristics**

<b>Server OS</b>	Ubuntu 16.04 LTS
<b>Web server</b>	Apache2 Web server – cgi-mod enabled
<b>Python CGI Script</b>	Python 2.7, Python Pandas, Python Numpy
<b>Web development</b>	HTML 5, Bootstrap 3 CSS and JavaScript, jQuery 3.3.1
<b>Econometric models</b>	MathWorks MATLAB R2018a (9.4) Runtime

All models (*Matlab* executables), user dashboard codes as well as instructions regarding setting up the service can be found at the official CUTLER-H2020 repository (link: [https://github.com/CUTLER-H2020/econometric\\_svr\\_models](https://github.com/CUTLER-H2020/econometric_svr_models)).

## 1.2 The architecture of the visualization widget

Big data analytics for sensing the economic activity (WP4) consists of two different implementations. On one part, a *kibana* dashboard regarding all the relevant information to support the decision-making process for each pilot city, including visualization widgets and data crawled from different sources, is developed. The second part refers to a custom dashboard that reports the information of the econometric analysis and also allows for interaction with the economic models.

### 1.2.1 Kibana Visualization Widgets

In order to create the economic visualization widgets for every pilot, we use the *elasticsearch* and *kibana* as described in D8.1. The data used on *elasticsearch* and *kibana* visualizations/dashboards are crawled from different sources by the crawlers described in D3.2. Moreover, some new crawlers are developed since new requirements/features are added.

The developed crawlers (MAPS.ME Crawler - not included in D3.2) compile data on points of interest regarding five categories from the popular mobile application maps.me (Maps.me, 2019) that provides offline maps using OpenStreetMap (OpenStreetMap, 2019) data. The selected categories are points of attractions, entertainment, food, lodging and shops, further segregated in subcategories. Table 13 presents the five categories along with their subcategories.

**Table 13: Maps.me selected point of interest categories and subcategories**

Maps.me Categories (Sections)	Maps.me Subcategories (Types)
Attractions	Attractions, Castel, Church, Memorial, Monument, Mosque, Museum, Synagogue, Temple, Tomb, Viewpoint, Wayside Shrine
Entertainment	Athletics, Basketball Pitch, Casino, Cinema, Fitness Centre, Football Pitch, Library, Multi-sport Pitch, Nightclub, Park, Pier, Sauna, Stadium, Swimming Pool, Theatre, Water Park, Zoo
Food	Bar, Cafe, Fast Food, Pub, Restaurant
Lodging	Apartments, Camping, Hotel, Guest House, Hostel, Motel
Shops	Bakery, Beauty Shop, Bookstore, Butcher's, Chemist Shop, Clothes Shop, Computer Store, Department Store, Florist's, Furniture Store, Gift Shop, Hardware Store, Jewellery, Kiosk, Liquor Store, Mall, Marketplace, Pet shop, Photo Shop, Shoe Store, Sports Goods, Supermarket, Sweets, Ticket Shop, Toy Store, Wine Shop

In Table 14, we present the fields that the crawler compiles for each point of interest.

**Table 14: Maps.me crawler selected fields**

Field on maps.me	Field on crawler	Description
Category	poi_category	Point of interest category (Table 13)
Subcategory	poi_subcategory	Point of interest subcategory (Table 13)
GPS coordination	poi_geo_point	The given GPS coordination (latitude and longitude) for each point of interest
Date	date	The date (format: yyyy-mm) the crawler downloaded the data

The MAPS.ME webpage used as our data source locates points of interest based on GPS coordinates and not on city sections or postal codes. Thus, all points of interest are located on a map based on GPS coordinates, making difficult to implement custom search queries for point of interest per street or section of the city. The crawler should be executed on an annual base, in order to provide a time element in the data and create a timeseries. The MAPS.ME Crawler can be found in the official CUTLER-H2020 repository (link: <https://github.com/CUTLER-H2020/DataCrawlers>).

Additionally to the points of interest, in the case of Antwerp we compile rents and sales prices on properties that are also presented on the devoted to the city *kibana* dashboard. The source of the data is a new crawler (IMMOSCOOP.BE Crawler - not included in D3.2), which draws data from immoscoop.be (IMMOSCOOP, 2019), a popular Belgian real estate website. The IMMOSCOOP Crawler compiles data for several property categories reported in Table 15.

**Table 15: immoscoop.be crawler selected fields**

Field on immoscoop.be	Field on crawler	Description
Category	poi_desc_category	Property category
Postal code	poi_desc_postalcode	Property postal code
Address	poi_desc_address	Property address (if applicable)
Property purpose	purpose	Either property for sale or property for rent
Price per m <sup>2</sup>	poi_price_per_sm	Property price per square meter
Construction year	poi_construction_year	The year the property was built
date	date	The date (format: yyyy-mm) the crawler downloaded the data

All data are categorized according to the postal code of the property in Antwerp, while this crawler should also be annually to develop to a timeseries database. The

IMMOSCOOP.BE Crawler can be found in the official CUTLER-H2020 repository (link: <https://github.com/CUTLER-H2020/DataCrawlers>).

As in Antwerp, we compile rent and sales prices on properties in Thessaloniki, which are presented on the devoted to the city *kibana* dashboard. This crawler was also not described in D3.2. All data are compiled from Spitogatos.gr, a popular real estate website, with more than 750,000 listed properties in Greece and Cyprus, available to over 1.5 million visitors and 54 million page views per month. Table 16 presents the collected categories and subcategories from SPITOGATOS Crawler.

**Table 16: Spitogatos.gr selected property categories and subcategories**

Spitogatos.gr Property Categories	Spitogatos.gr Property Subcategories
Residential	Apartment, Studio, Maisonette, Detach House, Villa, Loft, Bungalow, Building, Apartment Complex, Farm, Houseboat, Other Categories
Commercial	Office, Store, Warehouse, Industrial Space, Craft Space, Hotel, Business Building, Hall, Showroom, Other Categories
Land	Land Plot, Parcels, Island, Other Categories
Other Properties	Parking, Business, Prefabricated, Detachable, Air, Other

In Table 17 we report the selected files for each listed property in the website source.

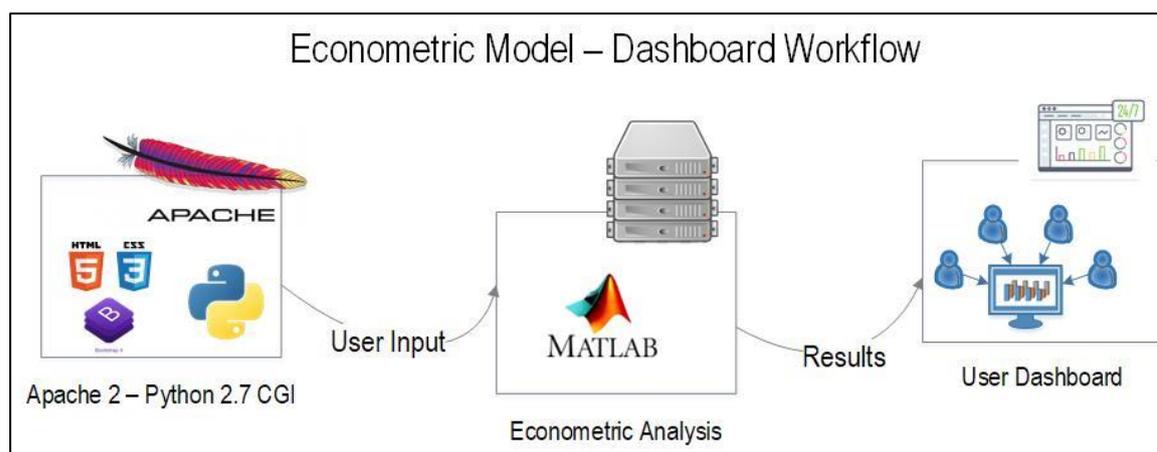
**Table 17: Spitogatos.gr crawler selected fields**

Field on spitogatos.gr	Field on crawler	Description
Category	category	Property category (Table 16)
Subcategory	Τύπος (type)	Property subcategory (Table 16)
Location	Περιοχή (Location)	Property location within Thessaloniki municipality
Property for	purpose	Either property for sale or property for rent
Price per m <sup>2</sup>	Τιμή ανά τ.μ. (Price per m <sup>2</sup> )	Property price per square meter
Construction year	Έτος κατασκευής (Construction year)	The year the property was built
date	date	The date (format: yyyy-mm) the crawler downloaded the data

All data are located on the dashboard according to their GPS coordinates, while the crawler should be executed annually to create a timeseries database. The SPITOGATOS.GR Crawler can be accessed at the official CUTLER-H2020 repository (link: <https://github.com/CUTLER-H2020/DataCrawlers>).

### 1.2.2. Econometric models – User Dashboard

Econometric analysis with an interactive user interface is not supported at the *elasticsearch* and *kibana* tools, thus a custom user dashboard is developed. The dashboard interacts with the user, handles user input, performs the econometric analysis and presents the results of the analysis to the user. In figure 14 we depict the workflow of the back-end procedures of the dashboard. The user is able to perform econometric analysis through the dashboard both with the EC-IO and the SVR model.



**Figure 14: Econometric Model / Dashboard Workflow**

The econometric dashboard workflow works in three stages:

In a **first stage**, an HTML input form, consisted of two select lists, is presented to the user (Figure 15), where the user selects the pilot city and the economic scenario under examination.

The CUTLER economic web tool allows simulating illustrative policy interventions. It gives users the opportunity to assess whether a policy intervention has a positive impact on the city's economy. Results are also disentangled by production sector.

**Run the model with values for policy shocks**

Please provide values for the simulation. For example, to simulate the effect of a 1% increase in the output of the manufacturing sector, fill in 1 in the box below. The range of valid values is: [-10, +10]

**Please select city:**

City ▼

**Please select a policy scenario:**

Please choose from above ▼

**Run the model** **Reset**

*Figure 15: Available Scenarios per city*

After the selection of the pilot city of her preference, a small paragraph appears, describing briefly the possible economic scenarios, in order to help the user select the desired scenario (Figure 16). The entire span of available scenarios is reported in Figure 17.

Run the model with values for policy shocks

Please provide values for the simulation. For example, to simulate the effect of a 1% increase in the output of the manufacturing sector, fill in 1 in the box below. The range of valid values is: [-10, +10]

**Please select city:**

Antwerp
▼

Floods affect economic activity through disruption of the industry production (manufacturing sector) or through disruption of harbor companies' activities as Antwerp's harbor is one of Europe's largest harbor.

**Please select a policy scenario:**

Change in manufacture production
▼

**Change in manufacture production:**

5

⚙️ Run the model

↺ Reset



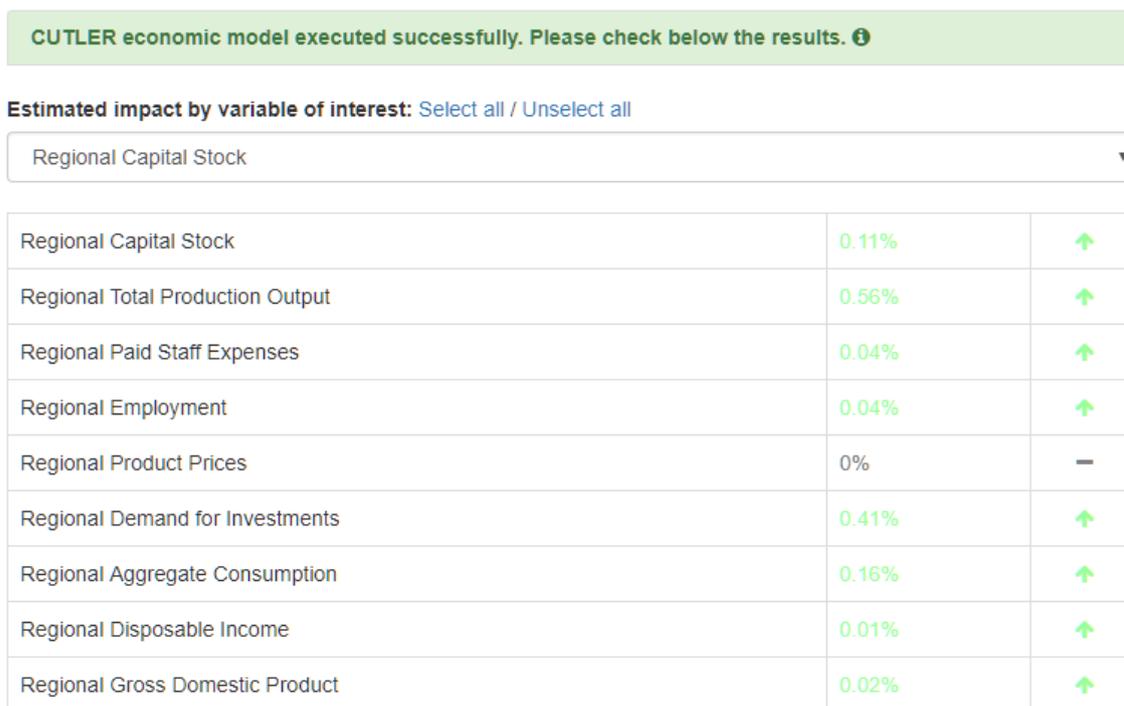
*Figure 16: Econometric model Dashboard, HTML input form (Stage 1)*

<p><b>Antalya - Scenarios:</b></p> <ul style="list-style-type: none"> <li>Tourism revenues</li> <li>Retail sales</li> <li>Transportation Revenues</li> </ul>
<p><b>Antwerp - Scenarios:</b></p> <ul style="list-style-type: none"> <li>Wholesales</li> <li>Changes in manufacture production</li> <li>Harbor activities revenues</li> </ul>
<p><b>Cork - Scenarios:</b></p> <ul style="list-style-type: none"> <li>Retails sales</li> <li>Water transportation services</li> <li>Tourism revenues</li> </ul>
<p><b>Thessaloniki - Scenarios:</b></p> <ul style="list-style-type: none"> <li>Construction sales</li> <li>Retail sales</li> <li>Tourism revenues</li> </ul>

*Figure 17: Available Scenarios per city*

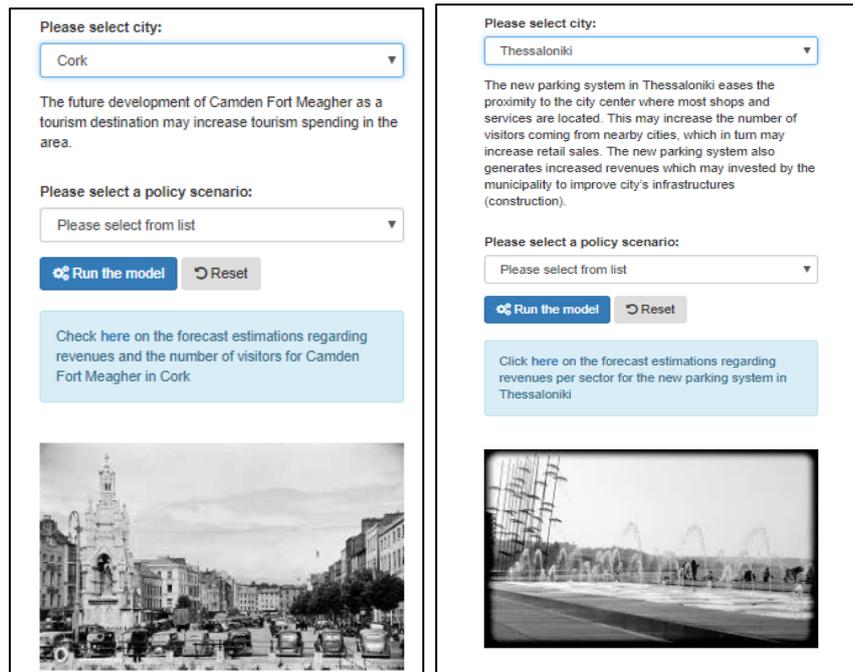
The “Run the model” button (**stage two**) executes the econometric part, based on a Python CGI Script that feeds the inputs of the HTML input form to the EC-IO model, deployed in *Matlab* executables. Every user session is accompanied by a unique 9-digits session ID, ensuring that every user input file is unique and used for the specific session.

After the successful execution of the econometric model (**third stage**), all outputs are reported on the dashboard (Figure 18) with the help of a Python CGI Script. The user has the ability to select the variables presented and add/remove economic variables of her interest.



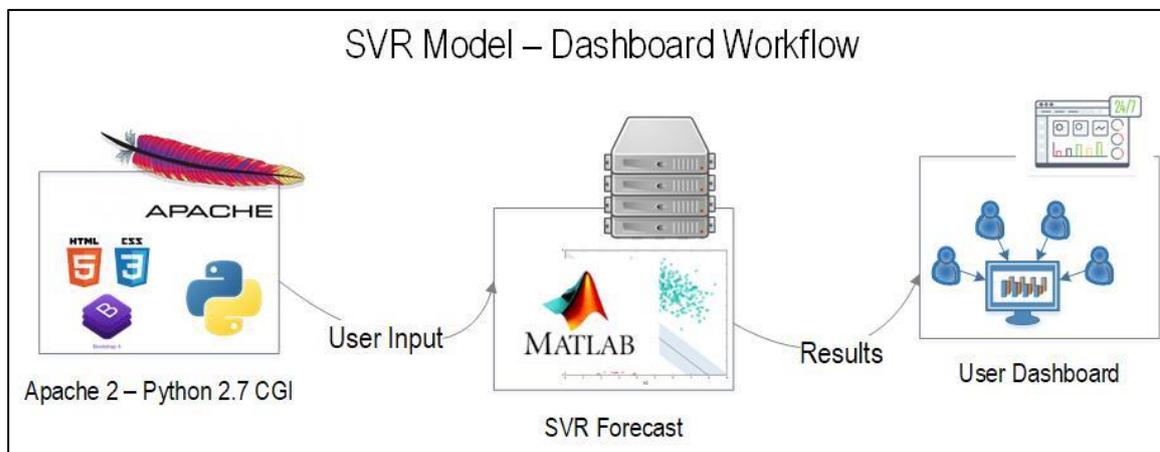
**Figure 18: Econometric model Dashboard results (Stage 3). From the selection list the user can add/remove variables**

Regarding the estimations on the expected sectoral revenues on the new parking system in Thessaloniki and the expected revenues and the number of visitors for Camden Fort Meagher, a dedicated dashboard is created with a link to the general econometric dashboard above (figure 15), only when Cork or Thessaloniki are selected (Figure 19).



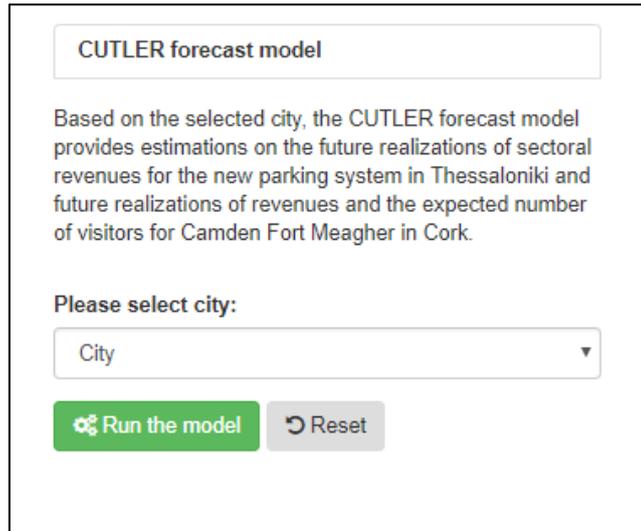
**Figure 19: The link for Cork (left) and Thessaloniki (right) of the general dashboard to the project specific dashboard. We also observe the paragraph that describes the special goals of each pilot city to the program.**

In Figure 20, we depict the workflow of the project-specific dashboard.



**Figure 20: SVR Model / Dashboard Workflow**

As with the EC-IO model section of the dashboard, an HTML input form with a single select list is presented to the user, where she can choose the pilot city of her interest (Figure 21).



**CUTLER forecast model**

Based on the selected city, the CUTLER forecast model provides estimations on the future realizations of sectoral revenues for the new parking system in Thessaloniki and future realizations of revenues and the expected number of visitors for Camden Fort Meagher in Cork.

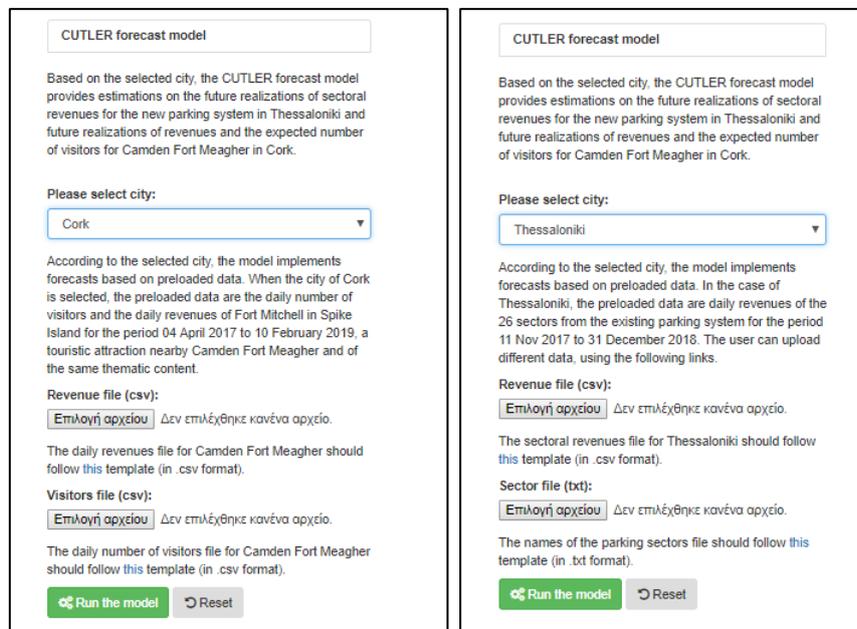
Please select city:

City

Run the model Reset

**Figure 21: SVR Dashboard**

After the selection of the city of interest, the user access information on the existing (default) data that can be used to access estimations on the future realizations on sectoral revenues for the new parking system in Thessaloniki and the future revenues and the expected number of visitors for Camden Fort Meagher. Moreover, the user has the ability to upload her own data and train the models to produce estimations that are based on alternative datasets. This feature is extremely useful for updating the training models. In order to do so, the user is provided with templates she must use to upload her data in a format exploitable by the dashboard (Figure 22). A point of interest, though, is that while the results presented for the default data are pre-computed and thus reported with no time delay, retraining the SVR models is a computationally demanding and time-consuming process that may take hours to execute.



**CUTLER forecast model**

Based on the selected city, the CUTLER forecast model provides estimations on the future realizations of sectoral revenues for the new parking system in Thessaloniki and future realizations of revenues and the expected number of visitors for Camden Fort Meagher in Cork.

Please select city:

Cork

According to the selected city, the model implements forecasts based on preloaded data. When the city of Cork is selected, the preloaded data are the daily number of visitors and the daily revenues of Fort Mitchell in Spike Island for the period 04 April 2017 to 10 February 2019, a touristic attraction nearby Camden Fort Meagher and of the same thematic content.

Revenue file (csv):

Επιλογή αρχείου Δεν επιλέχθηκε κανένα αρχείο.

The daily revenues file for Camden Fort Meagher should follow [this template](#) (in .csv format).

Visitors file (csv):

Επιλογή αρχείου Δεν επιλέχθηκε κανένα αρχείο.

The daily number of visitors file for Camden Fort Meagher should follow [this template](#) (in .csv format).

Run the model Reset

**CUTLER forecast model**

Based on the selected city, the CUTLER forecast model provides estimations on the future realizations of sectoral revenues for the new parking system in Thessaloniki and future realizations of revenues and the expected number of visitors for Camden Fort Meagher in Cork.

Please select city:

Thessaloniki

According to the selected city, the model implements forecasts based on preloaded data. In the case of Thessaloniki, the preloaded data are daily revenues of the 26 sectors from the existing parking system for the period 11 Nov 2017 to 31 December 2018. The user can upload different data, using the following links.

Revenue file (csv):

Επιλογή αρχείου Δεν επιλέχθηκε κανένα αρχείο.

The sectoral revenues file for Thessaloniki should follow [this template](#) (in .csv format).

Sector file (txt):

Επιλογή αρχείου Δεν επιλέχθηκε κανένα αρχείο.

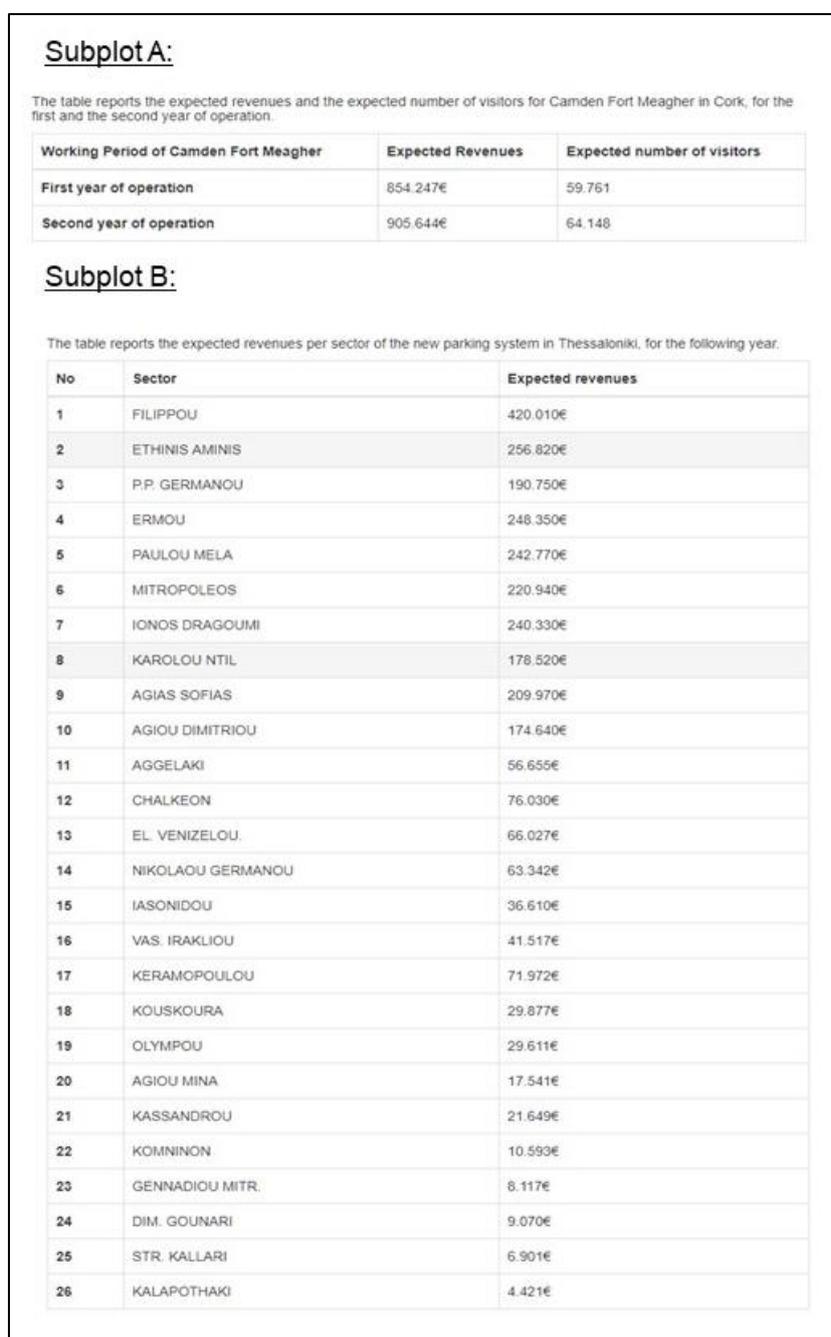
The names of the parking sectors file should follow [this template](#) (in .txt format).

Run the model Reset

**Figure 22: Details on the default data and instructions to upload new data for Cork (left) and Thessaloniki (right) of the project specific dashboard**

The “Run the model” button executes a Python CGI Script that feeds *Matlab* executables and train the SVR models, producing estimations on future realizations according to the

selection on the HTML input form by the user. Every user session is accompanied by a unique 9-digits session ID, ensuring that every input file is unique and used for the specific session. On the successful completion of training the SVR model, the output of the analysis is presented through a Python CGI Script to the dashboard (Figure 23).



**Figure 23: Reported results for Cork (Subplot A) and Thessaloniki (Subplot B) based on the default data**

## 2. Visualization widgets for each pilot city

### 2.1 Antalya

The city of Antalya is crossed by Düden Brook, which is a natural stretch of water that falls into the Mediterranean Sea (Figure 24). There are two waterfalls on Düden Brook, which are important tourist attraction points. One of them is in the north, at the beginning of the river and is considered as both a natural and archeological protection zone. The other waterfall is at the end of the river and falls into the Mediterranean Sea.



*Figure 24: Düden Brook and Düden Waterfalls in Antalya (source: D9.1)*

The Municipality of Antalya intends to use the CUTLER platform as a tool to design policy that will optimize the management of the area of the first Düden Waterfall, in order to increase the number of visitors in the area. In this regard, we exploit the capabilities of the EC-IO model in order to estimate the expected economic impact from this renovation to the regional economy and provide quantitative evidence that supports the decision-making process of the Municipality of Antalya.

### 2.1.1 Data models

The region of Antalya has over 11 million visitors per year, while Düden Waterfall had 450,000 visitors in 2018 (Table 18).



**Figure 25: First Düden Waterfall (source D9.1)**

**Table 18: Visitor numbers for Düden Waterfall in 2018**

Month	Visitors
January	9,007
February	19,631
March	30,134
April	49,427
May	43,912
June	67,611
July	59,551
August	73,940
September	61,924
November	18,000
<b>Sum</b>	<b>433,137</b>

Note: Source D9.1

The renovation of the Düden Brooks waterfalls is expected to increase the number of visitors to the Province of Antalya and specifically to the city of Antalya. This increase is expected to have two economic effects to the region:

1. The renovation of the Düden Brook waterfall will **increase the number of visitors** arriving from the surrounding areas to visit the new waterfall system,

increasing the turnover of sector **Accommodation and food service activities (I)**, with economic spillovers to the regional economy. The specific assumption refers mainly to tourists and visitors that will stay at least overnight in order to visit the Düden Brook area.

2. The increased number of visitors in the Düden Brook area is expected to increase the turnover of sector **Retail trade, except of motor vehicles and motorcycles (G47)**. Every visitor that visits the area is expected to dedicate a part of his budget on shopping. Thus, we measure the economic impact produced not only by visitors that stay overnight but contemporaneously of visitors in daily trips. Moreover, visitors that stay overnight are also expected to spend a part of their budget in shopping to the area.

Combining the two aforementioned assumptions, we report the regional economic impact calculated by our EC-IO model in Table 19. We assume that the increase in the Accommodation and food service activities (I) is coupled with a smaller increase in the sector Retail trade, except of motor vehicles and motorcycles (G47). We consider three possible scenarios, a pessimistic scenario that assumes a 3% increase in accommodation and food services and a 1.5% increase in retail sales turnover, a mainstream scenario of 5% and 2.5% increase and an optimistic scenario of 10% and 5% increase, respectively. The quantitative aspect of our scenarios is based on the existing literature (see among others the special report on Turkey by the International Monetary Fund (IMF, 2017, p. 40), in order to use shocks that are feasible and of high likelihood of appearance.

**Table 19: Accumulated impact response for the scenarios of Antalya**

Simulation end: 2029	Percentage change between a baseline (do-nothing) and a selected scenario based on an increase in the accommodation and food services and retail sales turnover.		
	Pessimistic	Mainstream	Optimistic
	3% / 1.5%	5% / 2.5%	10% / 5%
Capital Stock	0.09	0.15	0.29
Total Regional Production	0.21	0.34	0.69
Wage rate (expense)	0.13	0.18	0.21
Employment	0.10	0.17	0.37
Demand for Investments	0.15	0.24	0.48
Aggregate Consumption	0.98	1.63	3.24
Disposable Income	0.06	0.10	0.20
Regional GDP	0.47	0.78	1.56

Note: all values are percentages

As we observe, in the optimistic scenario, the increase of 10% in food and accommodation and 5% in retail sales produces a 3.24% increase in aggregate consumption to the region, a significant 1.56% increase in regional GDP and a 0.20% increase in disposable income. This effect will also cause a 0.69% increase in total regional production and a 0.37% increase in employment. If we assume that a 10% is a very optimistic scenario, the mainstream scenario has a positive effect of 0.78% in the regional GDP, 1.63% in the regional aggregate consumption, 0.17% in employment and 0.34% in the regional production. The pessimistic scenario reports a 0.47% increase in the local GDP, 0.98% increase in the regional aggregate consumption and a 0.21% increase in the total regional production. Thus, **the expected increase in the numbers of visitors from the renovation of the Düden waterfalls is expected to cause significant economic spillovers to the local economy** in terms of the creation of new employment spots, increases in economic activity and the overall output of the local economy.

## 2.1.2 User interfaces

The analysis of the econometric model is presented in a user-friendly interface in a *kibana* dashboard. In doing so, we create an index named “antalya\_ec\_scenario\_data” that includes the results of the scenarios discussed in Section 2.1.1. The details of the “antalya\_ec\_scenario\_data” index are presented in Table 20.

**Table 20: Fields of the “antalya\_ec\_scenario\_data” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each Kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
Accommodation and food Services	number	Yes	Yes	Econometric variables
Aggregate Consumption	number	Yes	Yes	Econometric variables
Capital Stock	number	Yes	Yes	Econometric variables
Demand for Investments	number	Yes	Yes	Econometric variables
Disposable Income	number	Yes	Yes	Econometric variables
Employment	number	Yes	Yes	Econometric variables
GDP	number	Yes	Yes	Econometric variables
Paid Staff Expenses	number	Yes	Yes	Econometric variables
Retail Sales	number	Yes	Yes	Econometric variables
Total Production Output	number	Yes	Yes	Econometric variables

The data used to create the visualization widgets are extracted from Antalya’s econometric model in ndjson format. Figure 26 depicts the Antalya’s format for the econometric model.

```
{
  "index": {"_id": "0"}
  {"Accommodation and food Services": 1.0, "Retail Sales": 0.5, "Capital Stock": 0.03, "Total Production Output": 0.07, "Paid Staff Expenses": 0.05, "Employment": 0.03, "Demand for Investments": 0.05, "Aggregate Consumption": 0.33, "Disposable Income": 0.02, "GDP": 0.16}

  {"index": {"_id": "1"}
  {"Accommodation and food Services": 2.0, "Retail Sales": 0.5, "Capital Stock": 0.06, "Total Production Output": 0.14, "Paid Staff Expenses": 0.09, "Employment": 0.06, "Demand for Investments": 0.10, "Aggregate Consumption": 0.65, "Disposable Income": 0.04, "GDP": 0.31}

  {"index": {"_id": "2"}
  {"Accommodation and food Services": 3.0, "Retail Sales": 1.5, "Capital Stock": 0.09, "Total Production Output": 0.21, "Paid Staff Expenses": 0.13, "Employment": 0.10, "Demand for Investments": 0.15, "Aggregate Consumption": 0.98, "Disposable Income": 0.06, "GDP": 0.47}

  {"index": {"_id": "3"}
  {"Accommodation and food Services": 4.0, "Retail Sales": 2.0, "Capital Stock": 0.12, "Total Production Output": 0.28, "Paid Staff Expenses": 0.16, "Employment": 0.13, "Demand for Investments": 0.20, "Aggregate Consumption": 1.30, "Disposable Income": 0.08, "GDP": 0.63}

  {"index": {"_id": "4"}
  {"Accommodation and food Services": 5.0, "Retail Sales": 2.5, "Capital Stock": 0.15, "Total Production Output": 0.34, "Paid Staff Expenses": 0.18, "Employment": 0.17, "Demand for Investments": 0.24, "Aggregate Consumption": 1.63, "Disposable Income": 0.10, "GDP": 0.78}
```

**Figure 26: Antalya - The selected format for econometric model data presentation**

In Figure 27, we depict the visualization widget regarding the econometric analysis for the dashboard of Antalya.

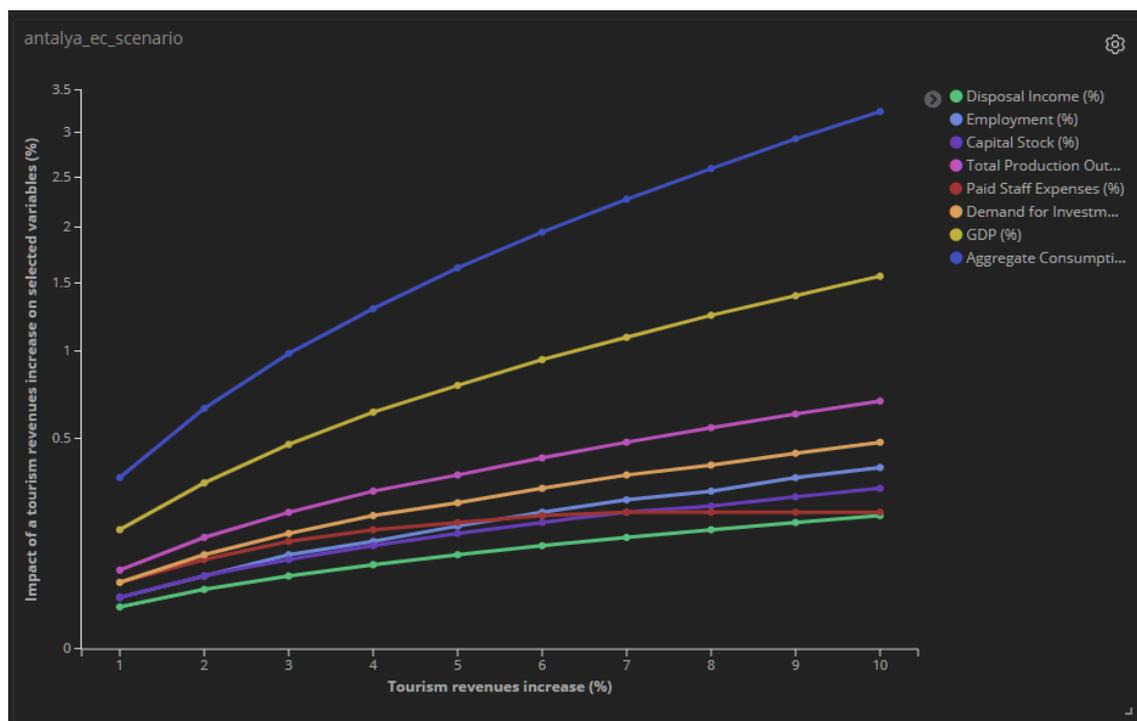


Figure 27: Antalya dashboard – Econometric model results

The line charts depict the economic spillovers to the local economy produced by the expected increase in tourism revenues.

Another point of interest is the maps.me crawler data, regarding a general overview of the city's supported amenities. In order to import the data of the crawler to the kibana dashboard, we create an index named “antalya-mapsme-dashboard”, presented in Table 21.

Table 21: Fields of the “antalya-mapsme-dashboard” index

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
date	date	Yes	Yes	The date (format: yyyy-mm) the crawler downloaded the data
poi_category	string	Yes	Yes	Point of interest category
poi_subcategory	string	Yes	Yes	Point of interest sub-category
poi_geo_point	geo_point	Yes	Yes	The given GPS coordination (latitude and longitude) for each point of interest

In Figure 28, we depict the format of the maps.me data used in Antalya.

```

{"index":{"_id":0}}
{"poi_category": "lodging", "date": "2019-2", "poi_subcategory": "Hotels", "poi_geo_point": " 36.8819,30.7096"}

{"index":{"_id":1}}
{"poi_category": "food", "date": "2019-2", "poi_subcategory": "Fast Food", "poi_geo_point": " 36.8931,30.7055"}

{"index":{"_id":2}}
{"poi_category": "attractions", "date": "2019-2", "poi_subcategory": "Mosque", "poi_geo_point": " 36.9071,30.7071"}

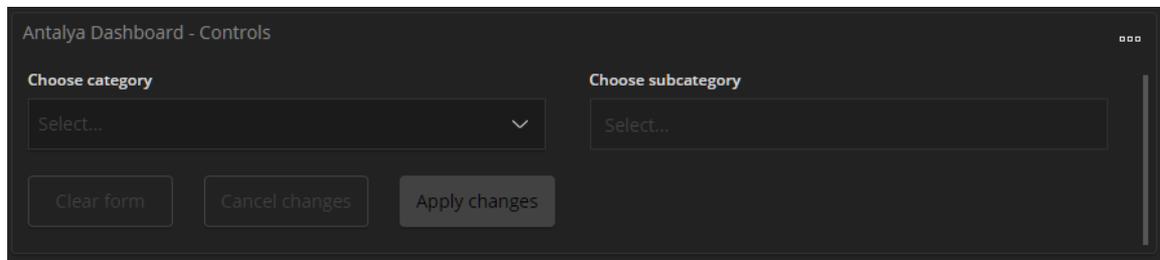
{"index":{"_id":3}}
{"poi_category": "attractions", "date": "2019-2", "poi_subcategory": "Monument", "poi_geo_point": " 36.8505,30.8178"}

{"index":{"_id":4}}
{"poi_category": "shop", "date": "2019-2", "poi_subcategory": "Supermarkets", "poi_geo_point": " 36.7308,30.5621"}

```

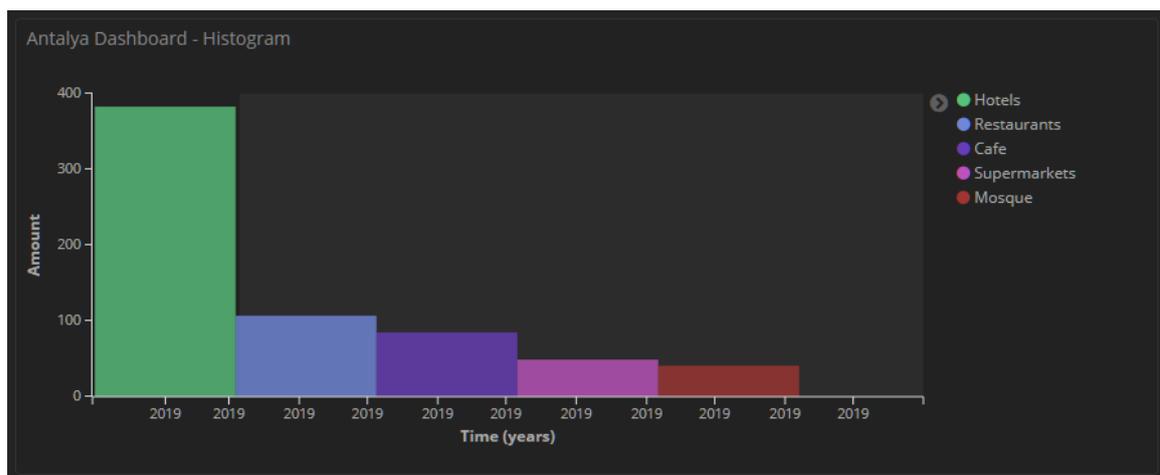
**Figure 28: Antalya - The selected format for MAPS.ME data**

From the aforementioned procedure, we produce data visualizations in the *kibana* dashboard. Figure 29 presents dashboard controls for maps.me data, where the user can select the points of interest, categories and subcategories she wants to present.



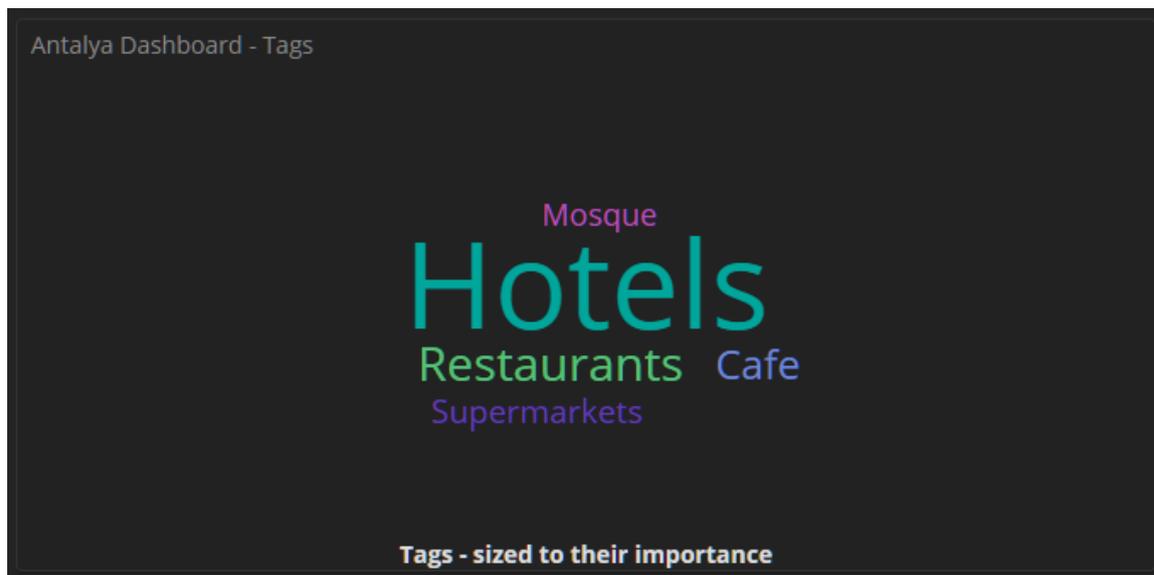
**Figure 29: Antalya dashboard – Maps.me data control**

In Figure 30, we present the top-5 categories based on the number of point of interest amount displayed on the dashboard. The X-axis, measures time in years while the Y-axis reports the number of the points of interest. At the current version of the dashboard, only data for 2019 are included



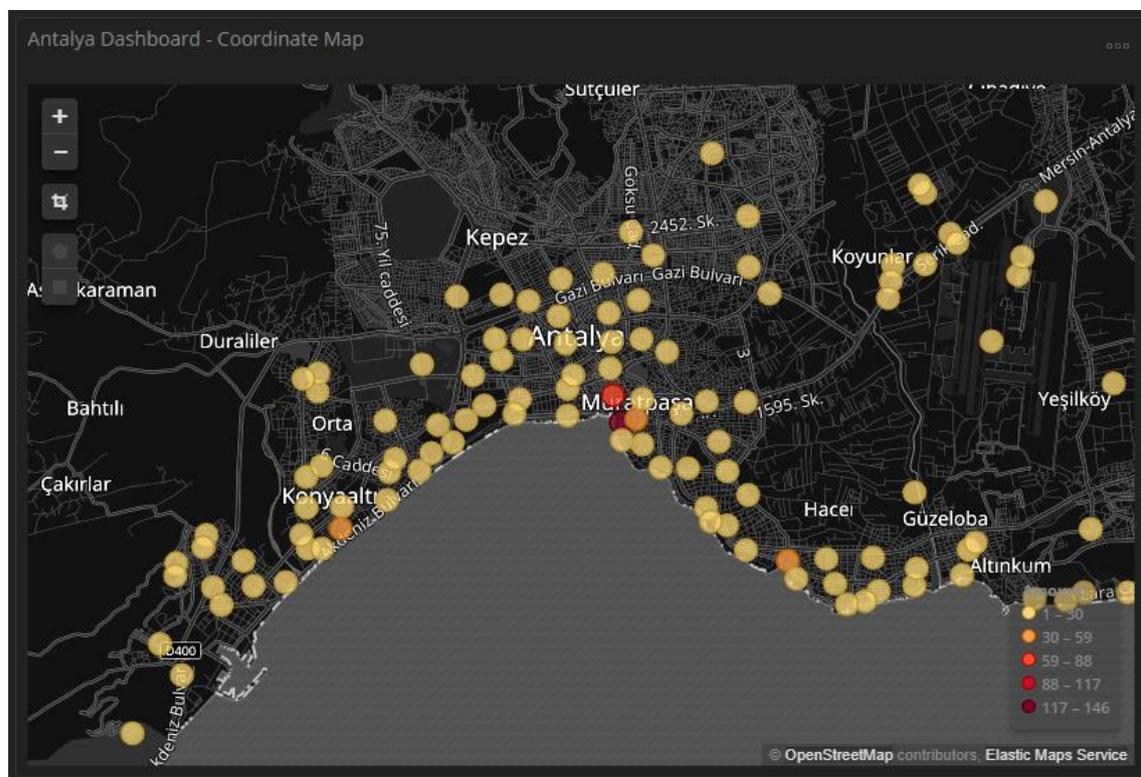
**Figure 30: Antalya dashboard – Maps.me top-5 subcategories (yearly)**

In Figure 31, we present the top 5 categories according to their quantity. The font size of the text provides a qualitative perspective to the number of point of interest per subcategory.



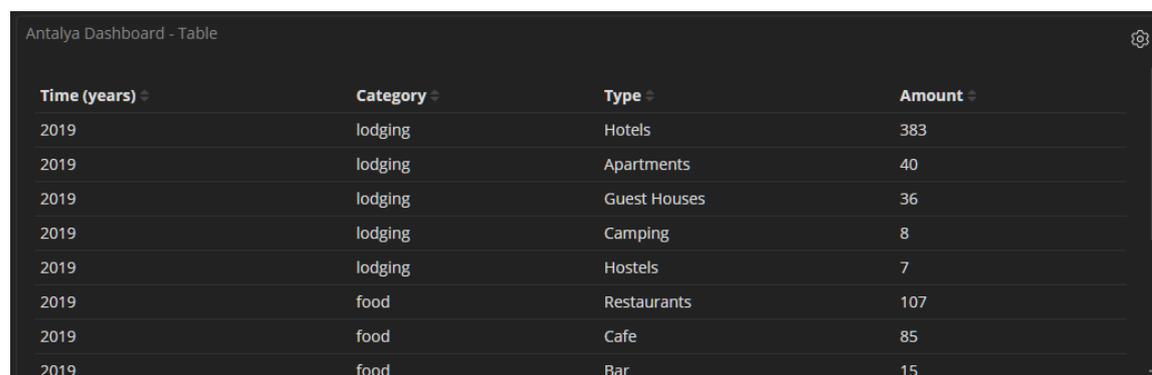
**Figure 31: Antalya dashboard – Maps.me subcategories tags sized to their importance**

The coordinate map in Figure 32 depicts the location of each point of interest on a map of Antalya. The red dots on the map represent high concentration of points of interest in particular areas and accordingly areas of high economic importance.



**Figure 32: Antalya dashboard – Maps.me coordinate map with points of interest**

In Figure 33, we gather the maps.me data in a table form. Each row reports the number of points of interest based on categories, subcategories (type) and the year these data are compiled.



Time (years)	Category	Type	Amount
2019	lodging	Hotels	383
2019	lodging	Apartments	40
2019	lodging	Guest Houses	36
2019	lodging	Camping	8
2019	lodging	Hostels	7
2019	food	Restaurants	107
2019	food	Cafe	85
2019	food	Bar	15

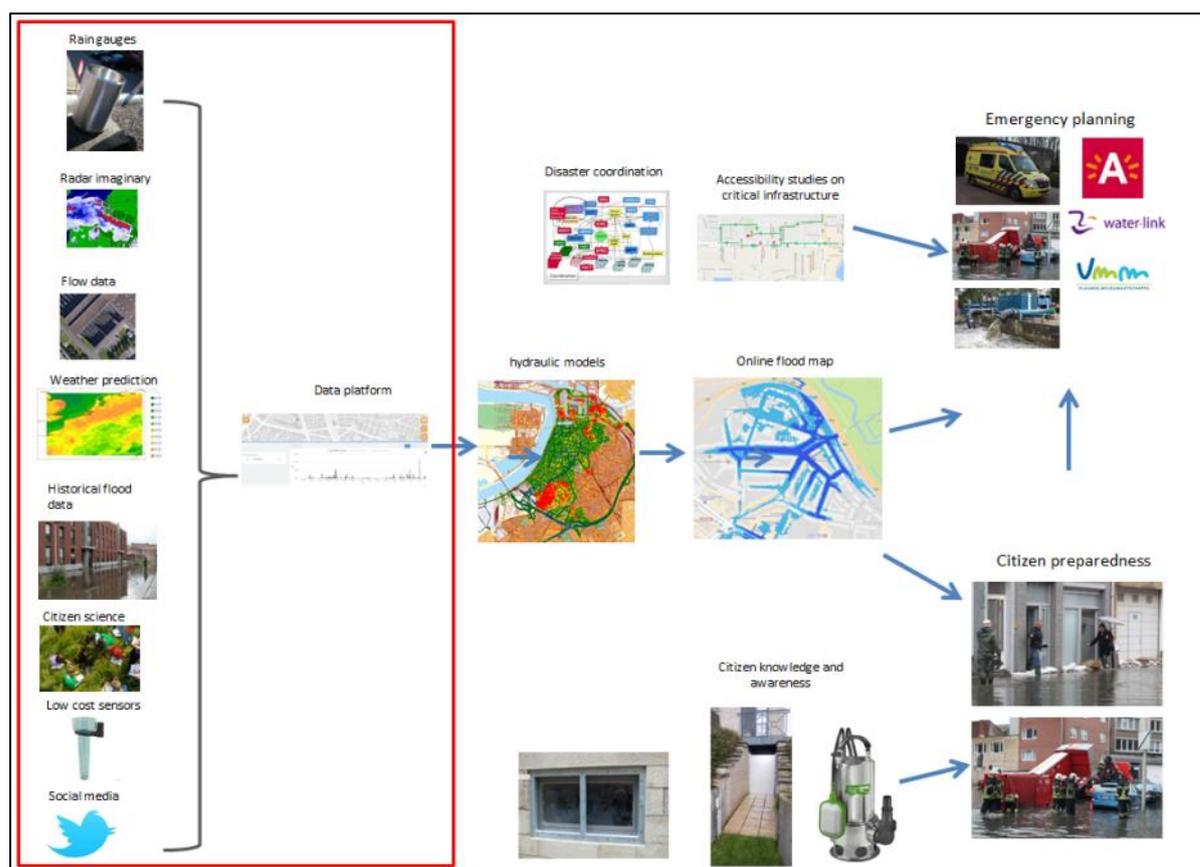
**Figure 33: Antalya dashboard – Maps.me table**

After a close inspection of the maps.me data, we decided not to include the specific information to the dashboard. This decision is taken due to the fact that the coverage of the actual points of interest from maps.me for Antalya is very small, leading to misleading conclusions. Nevertheless, given the full functionality of the crawler, we believe that as the data in maps.me will become richer, the certain crawler will be of significant value and this presentation is confined to a future version of the dashboard.

## 2.2 Antwerp

The city of Antwerp is the second (in alphabetical order) pilot city in the program. The city is faced with serious threats from climate change regarding rain water level (increased flood risk) and the level of ground water (increased drought risk). In order to counter the effects of climate change and the phenomenon of floods in the area, the City of Antwerp is working on a **strategic Urban Water Plan** covering the whole city (Figure 34). The plan focuses on the actions that the city and the city's stakeholders (such as citizens and businesses) need to take to protect themselves from the effects of climate change and floods in particular.

Regarding the economic widget of the CUTLER program, the city of Antwerp aims at measuring the economic impact of the increased size and frequency of floods to the local economy, both direct as destructions to floods, as well as indirect from the slowdown in economic activity, decrease in production turnover and difficulties in transportation of goods. We provide evidence towards this end.

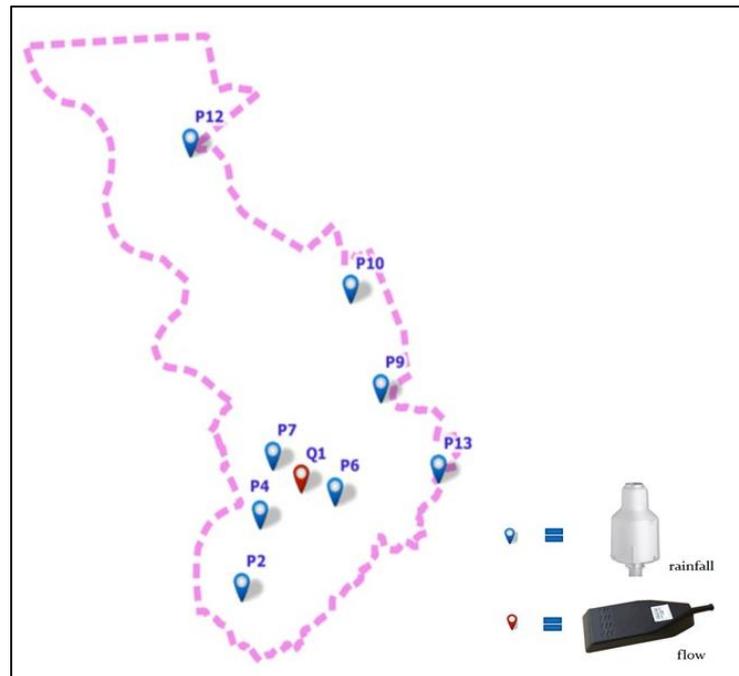


**Figure 34: The Urban Water Plan of the city of Antwerp (source D9.1)**

### 2.2.1 Data models

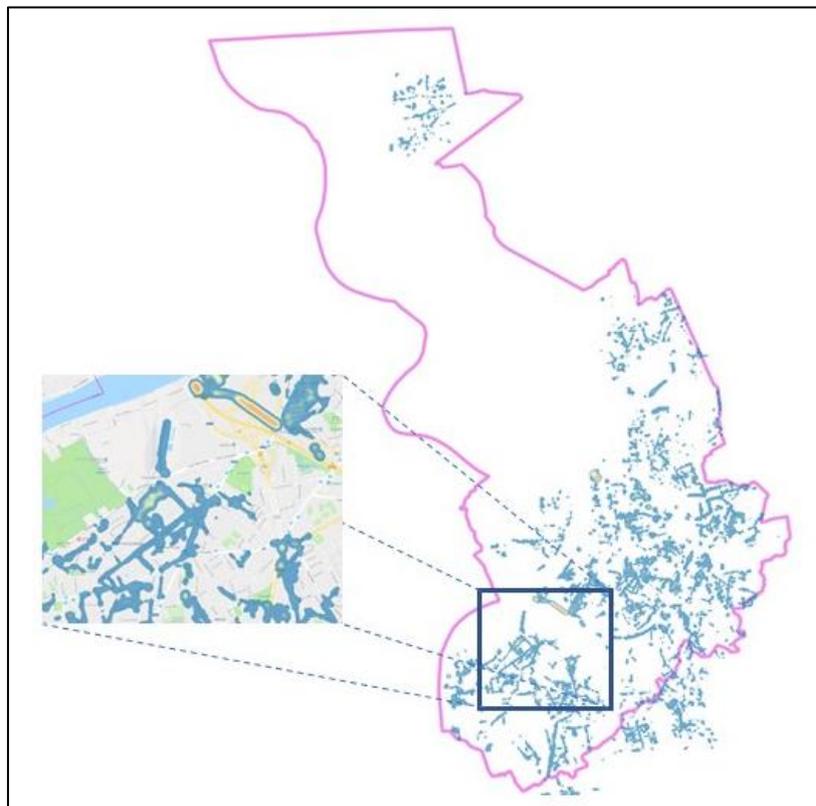
The lack of historical datasets regarding the economic impact of floods confides policy-making to intuition and experience. In contrast, the depiction of datasets in an easy-to-use dashboard could help the City of Antwerp to move towards evidence-based policy making and policy evaluation. Moreover, it could create a business process model that can help investors and other stakeholders in the local economy to measure the potential risk from floods in quantitative terms.

Within the scope of the CUTLER program and those of the city of Antwerp, a large number of sensors is deployed in the city that measure the main sources of floods, sewer flow and rainfall, depicted in Figure 35. These sensor data provide an initial source of data that can be used to access the potential economic impact of floods.



**Figure 35: Overview of locations where rainfall and sewer flow are measured in Antwerp.**

Based on the dataset provided by the existing network of sensors, the City of Antwerp has developed a **Flood Risk Map** that measures the potential economic damages in Euros per square meter ( $\text{€}/\text{m}^2$ ) according to the water level after a rainfall. In Figure 36 we depict a flood risk map that measures the potential economic damages for a specific region in Antwerp.



**Figure 36: Flood Risk Map of Antwerp (source D9.1).**

According to the data provided by the city of Antwerp, the economic damages from floods with the current climate conditions are estimated up to **5.4 million € per year** and include:

- Direct damages of houses (max. 600 to 2000 €/m<sup>2</sup>), household effects (30% of house price) and gardens (max. 1€/m<sup>2</sup>)
- Direct damages on industrial infrastructure (max. 100 to 700 €/m<sup>2</sup>) and installations/stocks (max. 100 €/m<sup>2</sup>)
- Direct damages on recreation facilities (max. 0.03 €/m<sup>2</sup>), agriculture (depending on the culture 0.2 to 2 €/m<sup>2</sup> max) and meadow (0.008 €/m<sup>2</sup>).
- Direct damages on roads, railroads (50 to 1000 €/m<sup>2</sup> max).
- Direct damages on point elements (museums, hospitals, tank stations, ...)
- Indirect damages (cleaning up, etc.) measured as percentage of the direct damages, irrelevant to economic activity.

Nevertheless, floods also cause indirect economic damages that are not included in the aforementioned estimation. These losses could be attributed to the slowdown of the economic activity, as a result of reduced manufacturing production, difficulties in the transportation of goods and raw materials and the reduced functionality of the harbor of Antwerp. These indirect damage measurement is exactly what we provide with our economic module of the CUTLER program, providing a definitive quantitative answer on the indirect effects of floods in Antwerp, not included in the direct estimation performed by the City of Antwerp. Direct damages on manufacturing production are already included in the direct part of the estimation and thus we focus only on the indirect transportation ones.

We assume that floods will affect the functionality of the harbor of Antwerp and of all other transportation activities in the area. In Table 22 we report the effect of floods in percentage changes on aggregate economic variables, comparing a baseline scenario of economic damages from floods with the event of floods. We examine three scenarios, a pessimistic one that assumes a 10% decrease in transportation activities, a mainstream scenario that assumes a 5% decrease and an optimistic scenario of only 2% decrease in transportation activities.

**Table 22: Accumulated impact for the scenarios of Antwerp**

Simulation end: 2029	Percentage changes between the baseline and the selected scenario of a decrease in transportation activities		
	Pessimistic	Mainstream	Optimistic
	-10%	-5%	-2%
Capital Stock	-0.16	-0.08	-0.03
Total Regional Production	-0.10	-0.05	-0.02
Wage rate (expense)	-0.05	-0.02	-0.01
Employment	-0.12	-0.06	-0.02
Demand for Investments	-0.14	-0.07	-0.03
Aggregate Consumption	-0.25	-0.13	-0.05
Disposable Income	-0.02	-0.01	0.00
Regional GDP	-0.04	-0.02	-0.01

Note: all values are percentages

As we observe from Table 22, according to the pessimistic scenario, a decrease in transportation activities turnover by 10% causes a 0.25% decrease in the aggregate consumption in the region, a 0.10% decrease in the total regional production and 0.12% in the regional employment. The decrease in the regional GDP corresponds to 0.04% or **3.53 million € per year** for the City of Antwerp. So, by adding the direct and the indirect economic damages, we conclude that the maximum economic damages in the local economy due to environmental reasons are up to **8.93 million € per year**. In the

mainstream scenario, the measured effects drop to **7.16 million € per year** and in the optimistic scenario reach up to **6.11 million € per year**.

Changes on the impact of floods for the different scenarios are more discrete in the other economic variables, where we observe a decrease of 0.12%, 0.06% and 0.02% for the pessimistic, mainstream and optimistic scenarios in the aggregate employment, respectively. Moreover, we observe small decreases in the total regional production.

Based on the different exposure of certain areas of Antwerp to economic damages, as reported in the Flood Risk Map, it is interesting to examine whether this element is apparent to the behavior of citizens and businesses of Antwerp and the indirect economic impact stemming for the differentiation in rent prices between city areas according to their exposure to floods. In doing so, we measure the correlation between the average economic damages per square meter (€/m<sup>2</sup>) and the average rent prices per square meter (€/m<sup>2</sup>) for 13 areas in Antwerp. The selected areas are compiled according to their postal code from **Immoscoop.be**. A positive correlation suggests that a tenant is willing to pay more as the risk of economic damages increases, while a negative value suggests that tenants are willing to pay less to compensate for the higher exposure to economic damages. If correlation equals zero, there is no linear relationship between the two variables. We should note that correlation is by no means a measure of causality. In other words, a correlation value different from zero does not mean that changes in one variable induces changes to the other. In contrast, correlation is a measure of co-movement of the two variables, in similar or opposite paths. In Table 23 we report the values for average rent price per square meter and the average economic damages per square meter for the 13 areas. The average rent price per square meter is the mean of rent prices for apartments, commercial use, garages, homes and industrial use rents reported in **Immoscoop.be**.

**Table 23: Average rent prices and economic damages for Antwerp**

No	Area	Postal code	Average rent price (€/m <sup>2</sup> )	Average economic damages (€/m <sup>2</sup> )
1	Antwerpen Zuid	2018	49.474	0.095
2	Antwerpen Centrum	2000	26.637	0.030
3	Antwerpen Kiel	2020	9.615	0.005
4	Haven Antwerpen	2030	43.000	0.002
5	Antwerpen Linkeroever	2050	23.770	0.001
6	Antwerpen Noord	2060	17.500	0.066
7	Berchem	2600	44.755	0.043
8	Borgerhout	2140	14.500	0.035
9	Deurne	2100	23.625	0.018
10	Ekeren	2180	19.952	0.002
11	Hoboken	2660	2.857	0.565
12	Merksem	2170	12.472	0.007
13	Wilrijk	2610	20.355	0.003
<b>Pearson's Correlation Coefficient</b>			<b>-0.36</b>	

As expected, the reported correlation for the two variables is -0.36, meaning that as the risk of economic damages from floods increases, the average rent that the potential tenant is willing to pay decreases. While this result is expected, our analysis provides a quantitative measure of the propensity of stakeholders to pay for renting a space with as a function to economic exposure. For instance, moving from an area of 0.01 €/m<sup>2</sup> risk of economic damages to an area of 0.02 €/m<sup>2</sup>, the potential tenant is willing to pay on average 0.0036 €/m<sup>2</sup> less.

## 2.2.2 User interfaces

The econometric analysis is imported in a *kibana* dashboard based on an index named “antwerp\_ec\_scenario\_data”, measuring the effects of the scenario discussed in Section 2.2.1 (decrease in transportation activities). Moreover, index “antwerp\_correlation\_scenario\_data” presents the correlation analysis results between average economic damages and average rent price, for each postal code. In Table 24 we present the fields of “antwerp\_ec\_scenario\_data” index.

**Table 24: Fields of the “antwerp\_ec\_scenario\_data” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
Transportation revenues	number	Yes	Yes	Econometric variables
Aggregate Consumption	number	Yes	Yes	Econometric variables
Capital Stock	number	Yes	Yes	Econometric variables
Demand for Investments	number	Yes	Yes	Econometric variables
Disposable Income	number	Yes	Yes	Econometric variables
Employment	number	Yes	Yes	Econometric variables
GDP	number	Yes	Yes	Econometric variables
Paid Staff Expenses	number	Yes	Yes	Econometric variables
Total Production Output	number	Yes	Yes	Econometric variables
GDP loss (in mil Euros)	number	Yes	Yes	Econometric variables
Fixed damages (mil Euros)	number	Yes	Yes	Econometric variables
Direct and Indirect damages (mil Euros)	number	Yes	Yes	Econometric variables

The data used to create the visualization widgets, are extracted from Antwerp’s econometric model in ndjson format. Figure 37 depicts the format of the econometric analysis.

```
{
  "index": {"_id": "0"}
  {
    "Transportation revenues": -10.0,
    "Capital Stock": -0.16,
    "Total Production Output": -0.10,
    "Paid Staff Expenses": -0.05,
    "Employment": -0.12,
    "Demand for Investments": -0.14,
    "Aggregate Consumption": -0.25,
    "Disposable Income": -0.02,
    "GDP": -0.04,
    "GDP loss (in mil Euros)": 3.53,
    "Fixed damages (mil Euros)": 5.4,
    "Direct and Indirect damages (mil Euros)": 8.93
  }

  {"index": {"_id": "1"}}
  {"Transportation revenues": -9.0, "Capital Stock": -0.14, "Total Production Output": -0.09, "Paid Staff Expenses": -0.04, "Employment": -0.11, "Demand for Investments": -0.13, "Aggregate Consumption": -0.23, "Disposable Income": -0.02, "GDP": -0.04, "GDP loss (in mil Euros)": 3.18, "Fixed damages (mil Euros)": 5.4, "Direct and Indirect damages (mil Euros)": 8.58}

  {"index": {"_id": "2"}}
  {"Transportation revenues": -8.0, "Capital Stock": -0.13, "Total Production Output": -0.08, "Paid Staff Expenses": -0.04, "Employment": -0.10, "Demand for Investments": -0.11, "Aggregate Consumption": -0.20, "Disposable Income": -0.01, "GDP": -0.04, "GDP loss (in mil Euros)": 2.82, "Fixed damages (mil Euros)": 5.4, "Direct and Indirect damages (mil Euros)": 8.22}
```

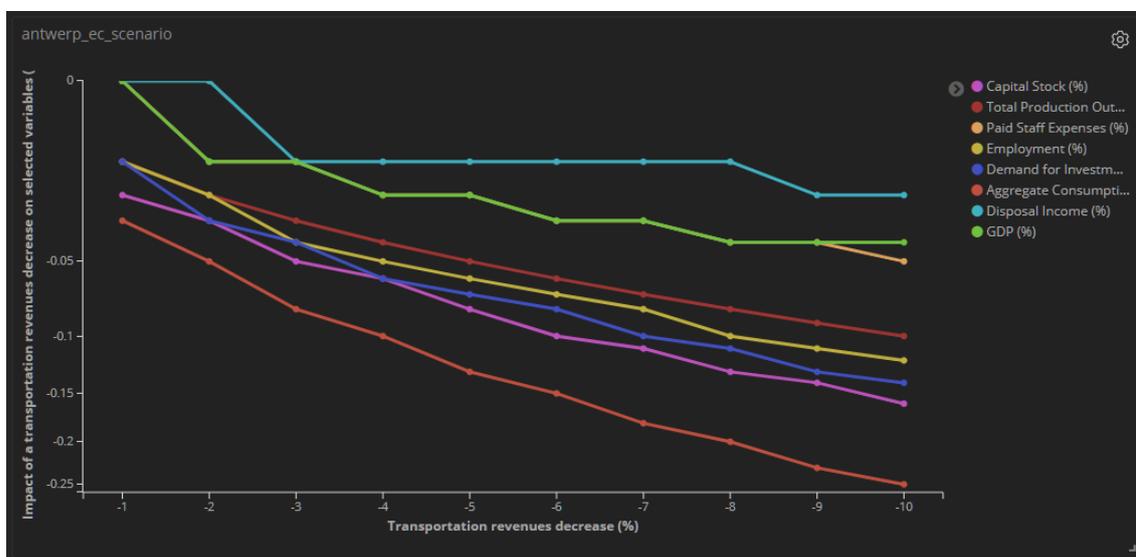
```

{"index":{"_id":3}}
{"Transportation revenues": -7.0, "Capital Stock": -0.11, "Total Production Output": -0.07, "Paid Staff Expenses": -0.03,
"Employment": -0.08, "Demand for Investments": -0.10, "Aggregate Consumption": -0.18, "Disposable Income": -0.01,
"GDP": -0.03, "GDP loss (in mil Euros)": 2.47, "Fixed damages (mil Euros)": 5.4, "Direct and Indirect damages (mil
Euros)": 7.87}

{"index":{"_id":4}}
{"Transportation revenues": -6.0, "Capital Stock": -0.10, "Total Production Output": -0.06, "Paid Staff Expenses": -0.03,
"Employment": -0.07, "Demand for Investments": -0.08, "Aggregate Consumption": -0.15, "Disposable Income": -0.01,
"GDP": -0.03, "GDP loss (in mil Euros)": 2.12, "Fixed damages (mil Euros)": 5.4, "Direct and Indirect damages (mil
Euros)": 7.52}
    
```

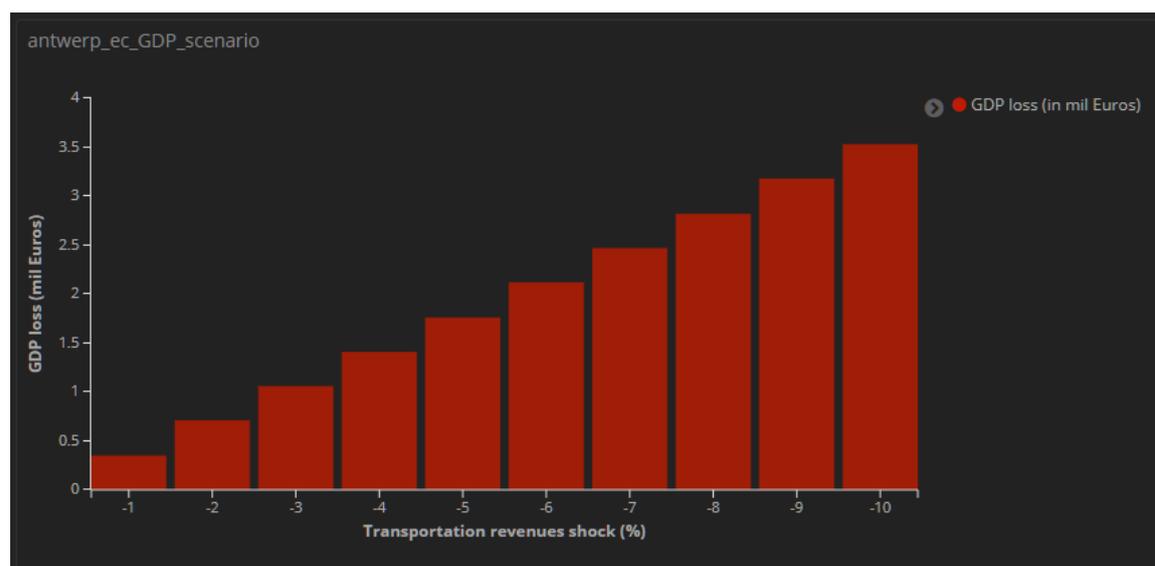
**Figure 37: Antwerp - The selected format for econometric model data**

The visualization widgets regarding the econometric analysis are depicted in the following figures. The line charts in Figure 38 depicts the economic impact by a decrease in Transportation Revenues.



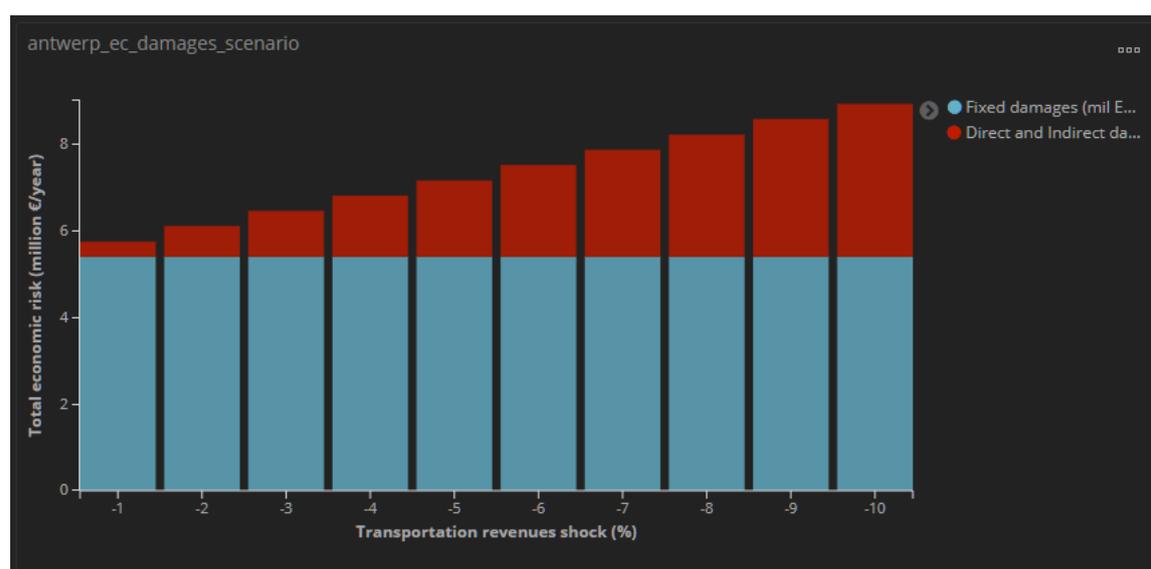
**Figure 38: Antwerp dashboard – Econometric model results**

In Figure 39 we depict the GDP losses measured in millions of Euros due to a decrease in transportation activity. This information is crucial to create a complete picture on total economic damages in Antwerp.



**Figure 39: Antwerp dashboard – Econometric model GDP loss in million euros**

Combining direct (fixed) and indirect damages in a stacked bar diagram of Figure 40, we quantify the potential total economic damages in Antwerp.



**Figure 40: Antwerp dashboard – Econometric model fixed damages and direct/indirect damages in million euros**

Apart from measuring economic losses, as reported in D9.1, one of the uses of the CUTLER platform for Antwerp is to depict all economic data in a comprehensible and easily accessible manner, in order to aid the decision-making process. In doing so, we utilize data from immoscoop.be (described in section 1.2) and create an index named “antwerp-immoscoop”. Table 25 reports the fields of “antwerp-immoscoop” index.

**Table 25: Fields of the “antwerp-immoscoop” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
date	date	Yes	Yes	The date (format: yyyy-mm) the crawler downloaded the data
address	string	Yes	No	Property address (if applicable)
category	string	Yes	Yes	Property category
postcode	string	Yes	Yes	Property postal code
price_per_sqr_met	Number	Yes	Yes	Property price per square meter (if applicable)
Purpose	String	Yes	Yes	Either property for sale or property for rent

The data used to create the visualization widgets, are downloaded in ndjson format from the IMMOSCOOP.BE crawler described in section 1.2. Figure 41 depicts the format of immoscoop.be data.

```
{
  "index": {"_id": "0"}
  {"construction_year": 1955, "price_per_sqr_met": 2179.4871794871797, "purpose": "Sale", "category": "home", "date": "2019-3", "address": "Vrijgeweide 40", "postcode": "borgerhout"}

  {"index": {"_id": "1"}
  {"construction_year": 0, "price_per_sqr_met": 1041.4583333333333, "purpose": "Sale", "category": "home", "date": "2019-3", "address": "Lange Lobroekstraat 121-123", "postcode": "antwerp-2060"}

  {"index": {"_id": "2"}
  {"construction_year": 1964, "price_per_sqr_met": 11155.0, "purpose": "Sale", "category": "apartment", "date": "2019-3", "address": "Rietschoorvelden 41", "postcode": "merksem"}

  {"index": {"_id": "3"}
  {"construction_year": 1935, "price_per_sqr_met": 0, "purpose": "Sale", "category": "apartment", "date": "2019-3", "address": "Gitschotellei 84", "postcode": "berchem"}
```

**Figure 41: Antwerp - The selected format for IMMOSCOOP.BE data**

In Figure 42, we report the average sales prices (€/m<sup>2</sup>) for five property categories, according to their postal codes. Obviously, office sale prices are higher in the city's centre (Antwerp-2018) while prices decrease in the suburbs of the city (Borgerhout).

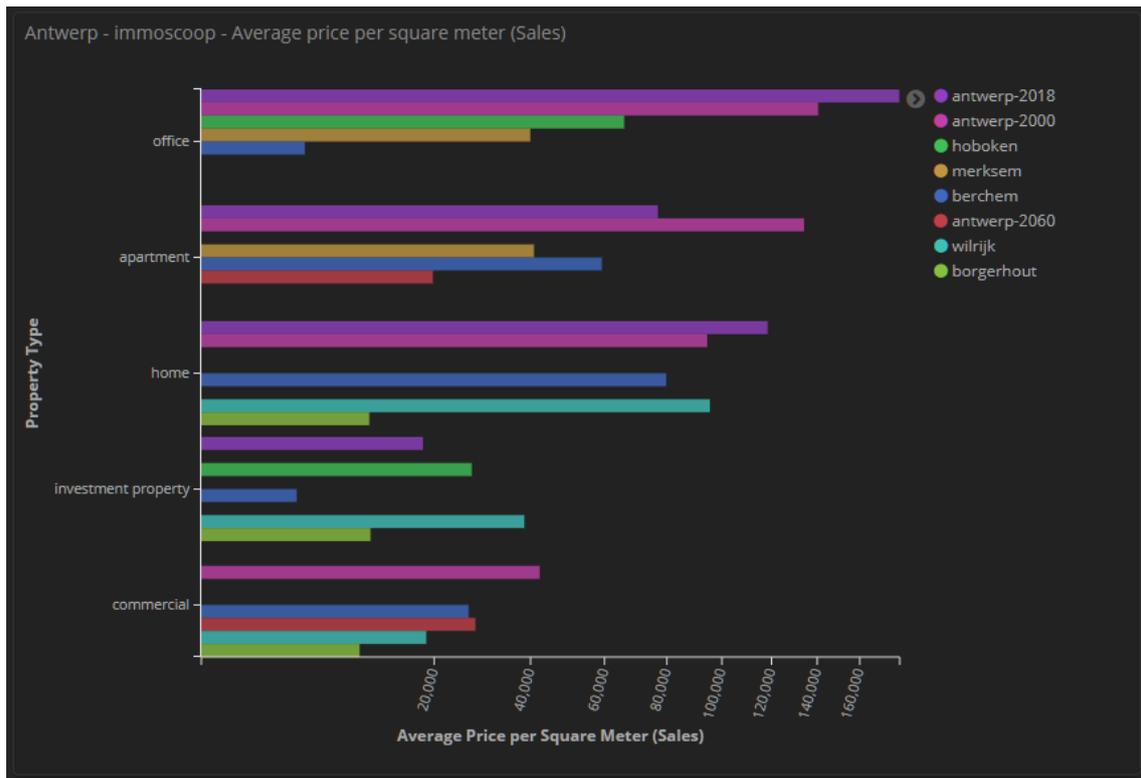


Figure 42: Antwerp dashboard – Immoscoop.be average sale price per square meter

In Figure 43, we present the average rent price (€/m<sup>2</sup>) for five property categories Antwerp, according to their postal codes. As expected, rent prices for commercial use in the city’s centre are higher than suburbs, while the opposite applies for homes and apartments.

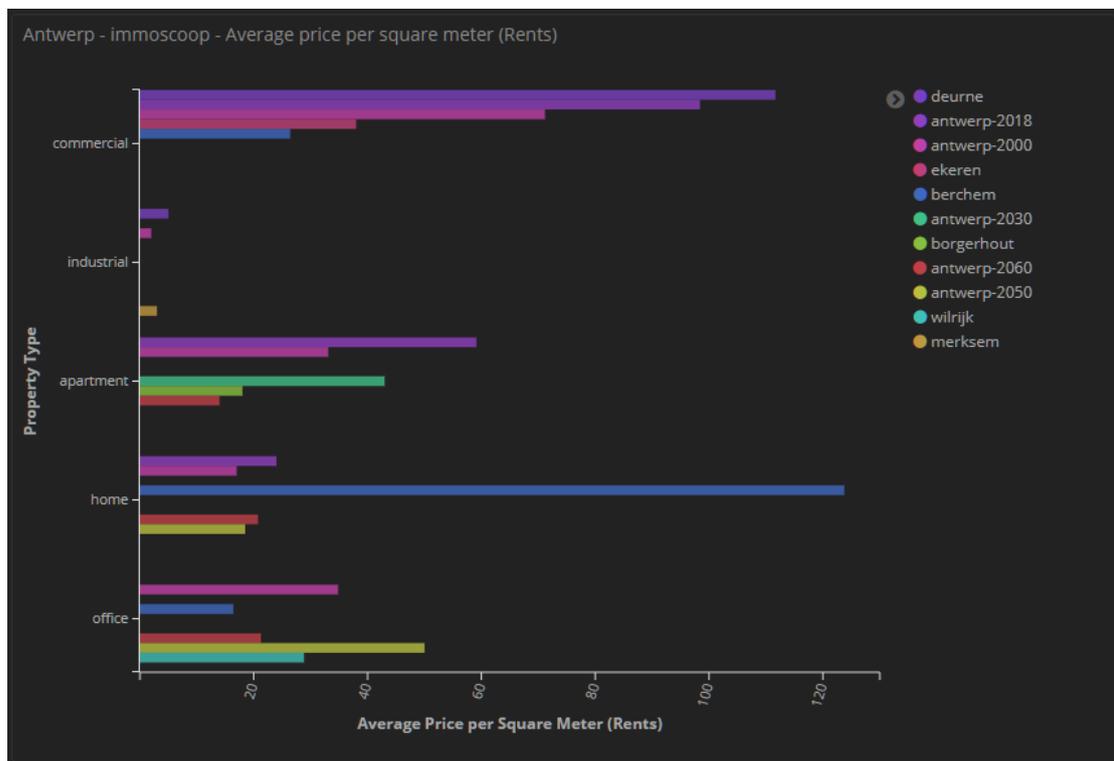


Figure 43: Antwerp dashboard – Immoscoop.be average rent price per square meter

We use the aforementioned information to measure the correlation between rent prices and the risk of economic damages and present this information to the dedicated to the city *kibana* dashboard. In Table 26 we report the fields of the “antwerp\_correlation\_scenario\_data” index.

**Table 26: Fields of the “antwerp\_correlation\_scenario\_data” index**

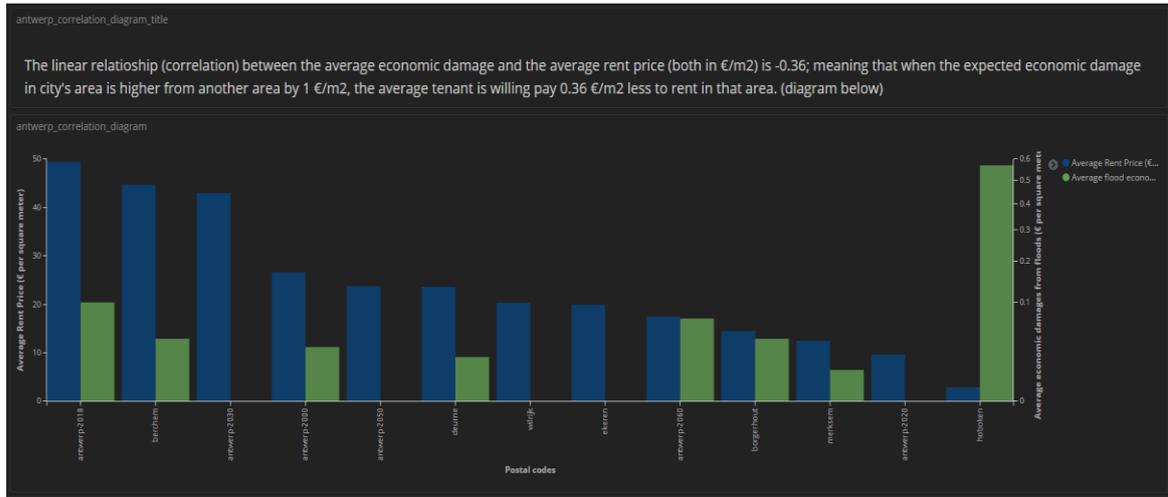
Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
postalcode	string	Yes	Yes	Antwerp’s postal codes
Average Rent Price	number	Yes	Yes	Average rent price per postal code
Average flood economic damages (E/m <sup>2</sup> )	number	Yes	Yes	Average flood economic damage per postal code

In Figure 44, we depict the format of the “antwerp\_correlation\_scenario\_data” index.

<pre>{   "index": {"_id": "0"},   "postalcode": "antwerp-2018",   "Average flood economic damages (E/m2)": 0.10,   "Average Rent Price": 49.47 }</pre>
<pre>{   "index": {"_id": "1"},   "postalcode": "antwerp-2000",   "Average flood economic damages (E/m2)": 0.03,   "Average Rent Price": 26.64 }</pre>
<pre>{   "index": {"_id": "2"},   "postalcode": "antwerp-2020",   "Average flood economic damages (E/m2)": 0.00,   "Average Rent Price": 9.62 }</pre>
<pre>{   "index": {"_id": "3"},   "postalcode": "antwerp-2030",   "Average flood economic damages (E/m2)": 0.00,   "Average Rent Price": 43.00 }</pre>
<pre>{   "index": {"_id": "4"},   "postalcode": "antwerp-2050",   "Average flood economic damages (E/m2)": 0.00,   "Average Rent Price": 23.77 }</pre>

**Figure 44: Antwerp - The selected data format for the “antwerp\_correlation\_scenario\_data” index**

In Figure 45, we present the comparison of average rent prices (€/m<sup>2</sup>) to average economic damages (€/m<sup>2</sup>) from the Flood Risk Map, for 13 areas of Antwerp. This comparison is a *prima facie* evidence on the interest of citizens and business on the risk of economic damages, while the dashboard provides the information in a user-friendly manner to all interest parties that wish to evaluate renting a building in an area.



**Figure 45: Antwerp dashboard – Average economic damages and rents per square meter**

Additionally, data from maps.me are introduced in the dashboard, based on the index named “anwerp-mapsme-dashboard”. Table 27 presents the fields of the “anwerp-mapsme-dashboard” index, that describe the main amenities provided in the city.

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
date	date	Yes	Yes	The date (format: yyyy-mm) the crawler downloaded the data
poi_category	string	Yes	Yes	Point of interest category
poi_subcategory	string	Yes	Yes	Point of interest sub-category
poi_geo_point	geo_point	Yes	Yes	The given GPS coordination (latitude and longitude) for each point of interest

In Figure 46, we depict the data format.

```

{"index":{"_id":0}}
{"poi_category": "lodging", "date": "2019-2", "poi_subcategory": "Hotels", "poi_geo_point": " 51.2184,4.3963"}

{"index":{"_id":1}}
{"poi_category": "food", "date": "2019-2", "poi_subcategory": "Restaurants", "poi_geo_point": " 51.2252,4.4048"}

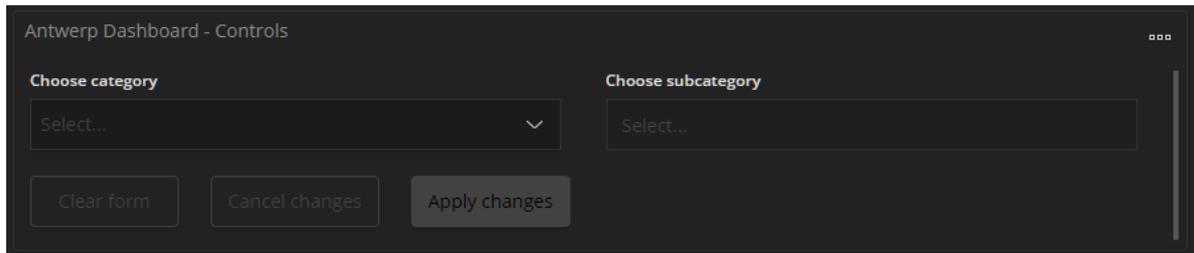
{"index":{"_id":2}}
{"poi_category": "lodging", "date": "2019-2", "poi_subcategory": "Guest Houses", "poi_geo_point": " 51.2205,4.4035"}

{"index":{"_id":3}}
{"poi_category": "food", "date": "2019-2", "poi_subcategory": "Cafe", "poi_geo_point": " 51.2258,4.4165"}

{"index":{"_id":4}}
{"poi_category": "food", "date": "2019-2", "poi_subcategory": "Fast Food", "poi_geo_point": " 51.2079,4.3891"}
    
```

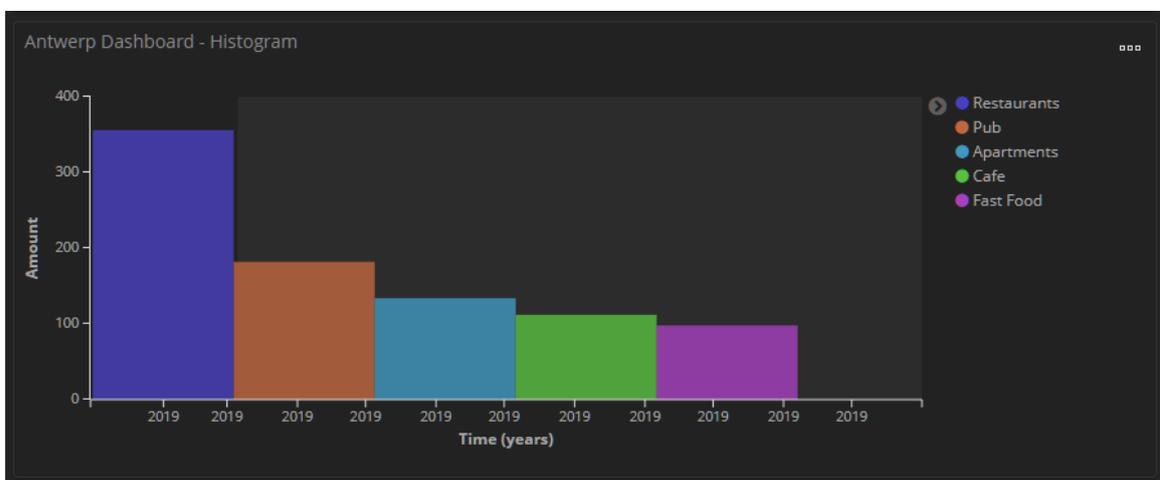
**Figure 46: Antwerp - The selected format for MAPS.ME data**

Moreover, in Figure 47 we present the control element of the dashboard for categories and subcategories.



**Figure 47: Antwerp dashboard – Maps.me data control**

In Figure 48, we present a histogram about the top-5 amenities, based on their quantity in maps.me. The X-axis measures time in years, while the Y-axis is the quantity of each point of interest including only 2019 data.



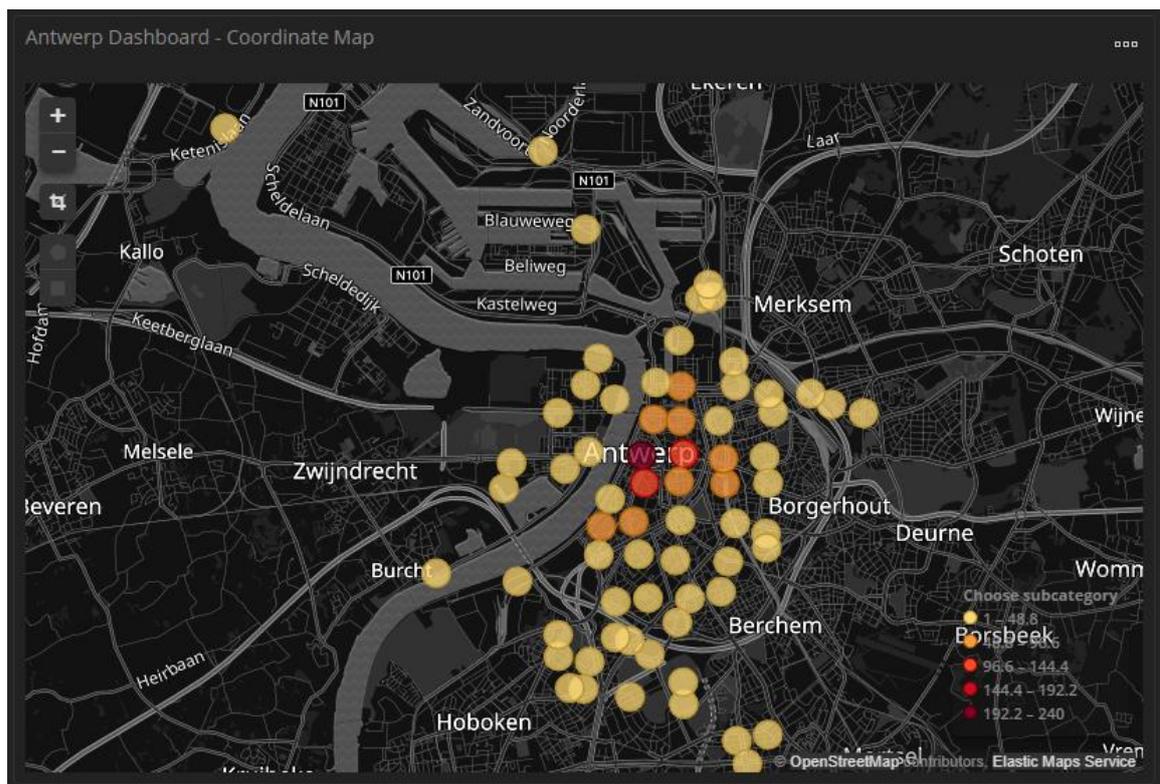
**Figure 48: Antwerp dashboard – Maps.me top-5 subcategories (yearly)**

The next item is a graphical representation of the quantity of each point of interest in a word cloud representation. The font size represents the number of the points of interest reported in maps.me.



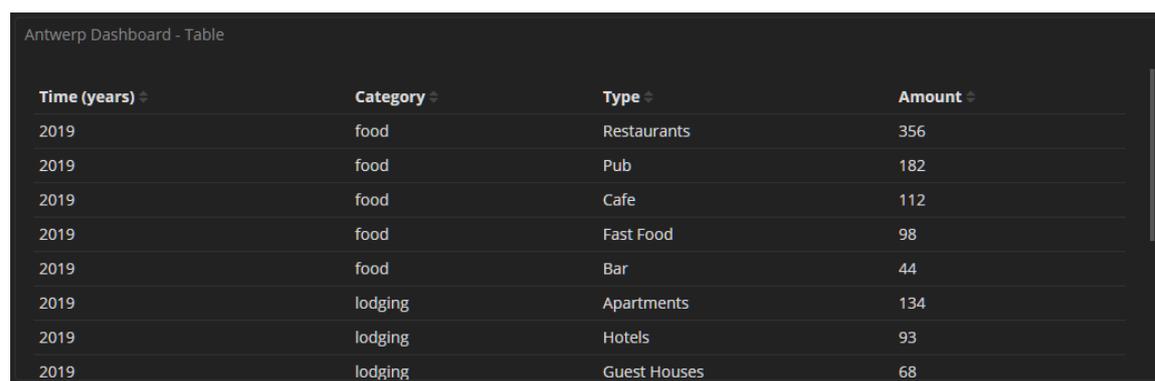
**Figure 49: Antwerp dashboard – Maps.me subcategories tags sized to their importance**

The coordinate map in Figure 50 depicts the location of all points of interest in Antwerp, where the red points on the map represent high concentration of points of interest in particular areas with significant economic interest.



**Figure 50: Antwerp dashboard – Maps.me coordinate map with points of interest**

Finally, in Figure 51 we concentrate all data from maps.me in a table format. Rows report the quantity of each point of interest based on category, while subcategory (type) and the year the data were downloaded are also presented.



Antwerp Dashboard - Table

Time (years)	Category	Type	Amount
2019	food	Restaurants	356
2019	food	Pub	182
2019	food	Cafe	112
2019	food	Fast Food	98
2019	food	Bar	44
2019	lodging	Apartments	134
2019	lodging	Hotels	93
2019	lodging	Guest Houses	68

**Figure 51: Antwerp dashboard – Maps.me table**

The data from Maps.me are a valuable source of information, however we believe that the sparsity of the provided data is misleading and so we decided not to include them to the final dashboard. Thus, as the coverage of the city in the database gets higher, the specific source will be of high value and will be available in a future version of the dashboard.

Overall, combining the aforementioned information, we create a *kibana* dashboard named “Antwerp Dashboard”, presented in Figure 52. The dashboard contains only the visualization widgets regarding the immoscoop.be data index and the econometric analysis.



Figure 52: Antwerp dashboard – Kibana dashboard

### 2.3 Cork

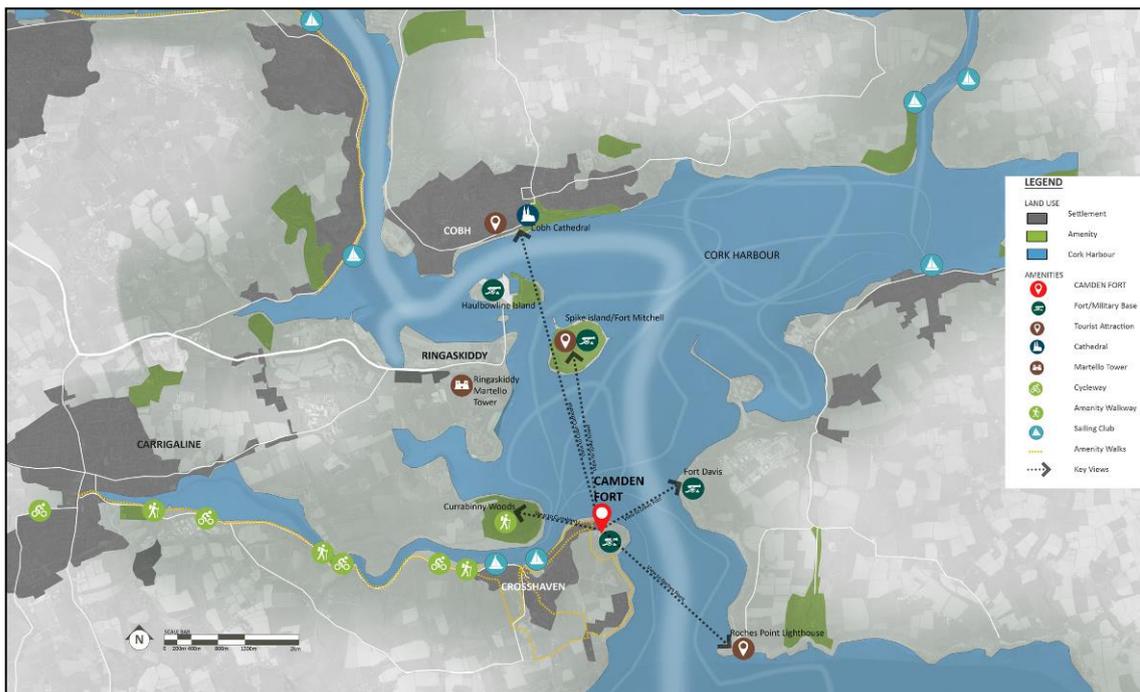
The motivation of Cork in using the CUTLER platform is to access the information included in the economic data in a easily interpretable manner, towards shaping policy interventions that will increase the number of visitors in Camden Fort Meagher (Figure 53) and establish it as a popular touristic destination. In order to progress the development of the Fort as a sustainable and viable addition to the touristic and cultural infrastructure of Cork, Cork County Council intends to renovate the entire area surrounding the Fort in order to create parking spaces, facilities surrounding the main

attraction as well as other amenities that will simplify the access to the Fort and increase the number of visitors.

Camden Fort Meagher is a coastal defense fortification originally built in the 16th Century to defend the mouth of Cork Harbour. The harbour is of high natural and landscape value, designated as a Special Area of Protection and an internationally important wetland site (Figure 54). Currently, the Camden Fort Meagher receives 18,000 visitors per year and is restricted to openings over the summer months, from May to September only. Access to the Fort is limited to one local road, which approaches the Fort from the west, while access by foot, from the nearby village (Crosshaven), is also problematic due to the characteristics of the road infrastructure (narrow roads, the absence of footpaths), and this has a potentially negative impact on the development of Camden Fort Meagher as a prosperous and viable tourist attraction. Furthermore, there is no sea access point in operation.

Another significant issue is the existing parking facilities, an on-site parking space at the Fort is currently limited to 30 spaces; and during times of peak demand, additional parking in the area is not available and therefore visitor vehicles often obstruct local roads and resident access. To overcome this issue the Cork County Council has proposed three individual site access possibilities, which are not mutually exclusive:

- Camden Fort Meagher additional on-site parking
- Camden Fort Meagher off-site parking
- Camden Fort Meagher access point by sea from another location



**Figure 53: Camden Fort Meagher location and surrounding amenities in Cork County (source D.9.1)**

Overall, as described in deliverable D9.1, the City of Cork has the following expectations from the economic widget:

- Monitor visitor numbers to the site in order to identify potential development policies for the Fort. In this we will provide a forecast on the expected number of visitors and future revenues to assist the financial planning process of the City of

Cork. This will justify or reject the renovation process comparing costs with potential revenues.

- Assist in the identification of possible future car parking locations on site. Following the above expectation, we will provide suggestions regarding the capability of the selected parking space, based on our economic analysis.
- Possible positive impacts in relation to increased tourist numbers as Camden Fort Meagher will attract visitors from other geographical locations e.g. Cobh and Spike Island. The analysis will measure the direct but also the indirect economic impact on the region.



**Figure 54: Landscape of the surrounding Cork Harbour area of Camden Fort Meagher.**

### 2.3.1 Data models

The primary policy question that Cork County Council will be exploring is the feasibility of future access and renovation infrastructure for Camden Fort Meagher by measuring the direct and indirect effects of a decision towards this end. **We measure the direct economic effects** by developing a Support Vector Regression forecasting model (SVR) from the field of machine learning that provides projections on possible future revenues and expected number of visitors after the renovation of the Fort. On the other hand, we measure the **indirect economic spillovers** from making the Camden Fort Meagher a popular tourist attraction using the EC-IO model.

Starting from the latter, in order to measure the economic impact of the spatial orientation and exploitation of the Owenabue River Catchment and Estuary region and specifically that of the Camden Fort Meagher, we measure the indirect economic spillovers to the local economy from the renovation of the Fort using our EC-IO model. The basic sectors influenced by this project are as follows:

- The restoration of the Camden Fort Meagher will **increase the number of foreign and national visitors**, increasing the final demand for **Accommodation and food service activities** (sector I). This element mainly refers to tourists and visitors that will stay overnight in Cork area.

- The increased number of visitors in Camden Fort Meagher is expected to affect **the turnover of the retail sales sector**. Several visitors are expected to use a part of their budget to shop in the area. Thus, we assume an increase in the final demand of the sector “Retail trade, except of motor vehicles and motorcycles (G47)”.

In Table 28 we report the economic impact from the two effects in a scenario, where we assume an increase in the turnover of accommodation and food services sectors coupled with an smaller increase in the retail sales sector. In doing so, we estimate three scenarios, a pessimistic scenario of 3% increase in accommodation and food services coupled with a 1.5% increase in retail sales, a mainstream scenario of 5% increase in accommodation and food services turnover and a 2.5% increase in retail sales and an optimistic scenario of 10% increase in accommodation and food services and a 5% increase in retail sales.

**Table 28: Accumulated impact responses for the scenarios of Cork**

Simulation end: 2029	Percentage change between the baseline (do-nothing) scenario and an increase in accommodation and food services turnover, coupled with a smaller (half) increase in retail sales turnover		
	Pessimistic	Mainstream	Optimistic
	3% and 1.5%	5% and 2.5%	10% and 5%
Capital Stock	0.08	0.13	0.26
Total Regional Production	0.17	0.22	0.14
Wage rate (expense)	0.10	0.17	0.33
Employment	0.16	0.27	0.54
Demand for Investment	0.04	0.07	0.13
Aggregate Consumption	0.44	0.73	1.44
Disposable Income	0.06	0.10	0.19
Regional GDP	0.08	0.13	0.26
Residential Dwelling Property Prices	0.11	0.18	0.36

Note: all values are percentages

In the pessimistic scenario, the renovation of Camden Fort Meagher creates a 0.44% increase in aggregate consumption, a 0.17% increase in the total regional production and a 0.16% increase in regional employment. The mainstream scenario reports a 0.73% increase in aggregate consumption, a 0.27% increase in employment and a 0.13% increase in the regional GDP. Finally, the optimistic concludes in a 1.44% increase in aggregate consumption, a 0.54% increase in employment and a 0.26% increase in regional GDP.

Another element of interest in the case of Cork is the indirect effect of the renovation of the Fort to the residential dwelling property prices. This element is of interest to the City of Cork, specifically posed as a demand from the City of Cork during the implementation of the economic model. In the pessimistic scenario, the increase in accommodation, food services and retail sales turnover leads to a 0.11% increase in property prices, while the mainstream scenario estimates a 0.18% increase. On the other hand, the optimistic scenario leads to a 0.36% increase in property prices in Cork County.

The aforementioned analysis is relevant to indirect economic effects of the restoration of the Camden Fort Meagher to the regional economy. Nevertheless, on a project administration level, we need to access the potential number of visitors on site as well as the estimated future revenues, that will justify the investment in the project. In doing so, we build a Support Vector Regression (SVR) model that exploits the existing information from a similar popular tourist attraction nearby; the Fort Mitchell in Spike Island. Fort Mitchell and Camden Fort Meagher belong to the same line of defense fortifications in the harbor of Cork, and so belong to the same thematic content. Thus, information from Fort Mitchell that is open around the year can be used as a proxy to the future evolution of visitors number and revenues of Camden Fort Meagher.

The City of Cork has provided a dataset regarding the operation of Fort Mitchell in Spike Island. The dataset spans the period 04 April 2017 to 10 February 2019 and includes the number of visitors per day and hour, daily revenues, number of items sold in site and the nationality of the visitors. In Table 29 we report the descriptive statistics of the visitors according to their country of origin.

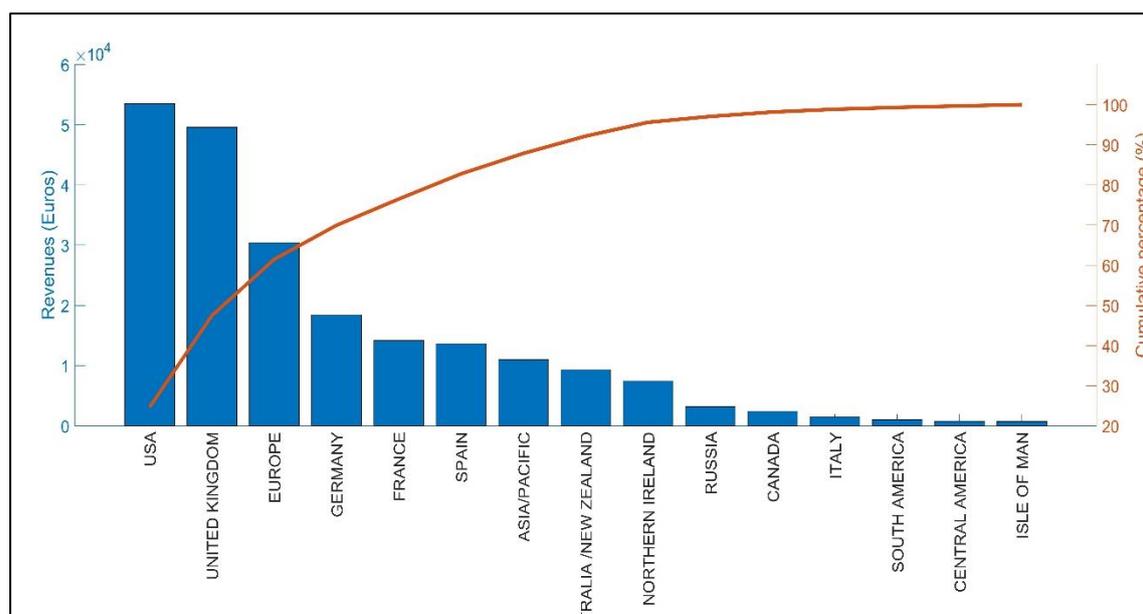
**Table 29: Descriptive Statistics according to the country of Origin**

No	Country	Visits	Visitors	Items Sold	Revenue
1	Asia	142	719	611	11,039
2	Australia – New Zealand	133	575	517	9,344
3	Canada	50	142	136	2,388
4	Central America	12	48	42	760
5	Europe	250	1,897	1,602	30,406
6	France	178	873	781	14,208
7	Germany	212	1,113	990	18,427
8	Isle of Man	7	44	41	733
9	Italy	31	101	72	1,493
10	Northern Ireland	98	496	387	7,458
11	Russia	39	212	156	3,178
12	South America	19	61	52	1,014
13	Spain	160	866	746	13,646
14	United Kingdom	290	3,100	2,631	49,584
15	United States	313	3,236	2,913	53,522
<b>Foreign Tourists</b>		<b>1,934</b>	<b>13,483</b>	<b>11,677</b>	<b>217,200</b>
16	Republic of Ireland	40	76,578	59,171	1,091,354
17	Not recorded	575	9,743	30,249	216,793
<b>Total</b>		<b>2,549</b>	<b>99,804</b>	<b>101,097</b>	<b>1,525,347</b>

Note: All values are in Euros. The category "Europe" includes all other European countries not explicitly stated in the table.

As we observe, the largest number of visitors originate from the Republic of Ireland, but they are mainly gathered in certain dates, given that they visited the Fort in only 40 days throughout the entire time period. The 71.55% of all revenues comes from national visitors. The second most common origin (apart from the non-recorded) are visitors from the U.S., followed by the U.K. and other European countries (reporting visitors from all countries not explicitly stated in the sample). If we split the data into yearly sums, we find that the total number of visitors in 2017 are 34,503, 64,827 in 2018 and 474 in 2019. Thus, most visitors in Spike Island are local or domestic visitors, while a much smaller number of foreign visitors travel to Fort Mitchell. **This finding could be used in an audience targeting analysis during the initial marketing campaign of the Camden Fort Meagher.** In other words, it would be much easier to attract domestic sightseeing that are expected to come and visit the Fort along with Fort Mitchell; thus, the **main effort should be focused on foreign tourists** that are an under-exploited pool of visitors and their number can increase exponentially. **Combining the two Forts** in an organized thematic visit (probably with a commonly shared ticket) could increase the interest of foreign visitors to visit both sites.

In Figure 55 we depict the revenues for the City of Cork according to the country of origin of visitors, but only for people outside Ireland.



**Figure 55: Revenues according to the country of origin. The category “Europe” includes all other European countries not explicitly stated in the table.**

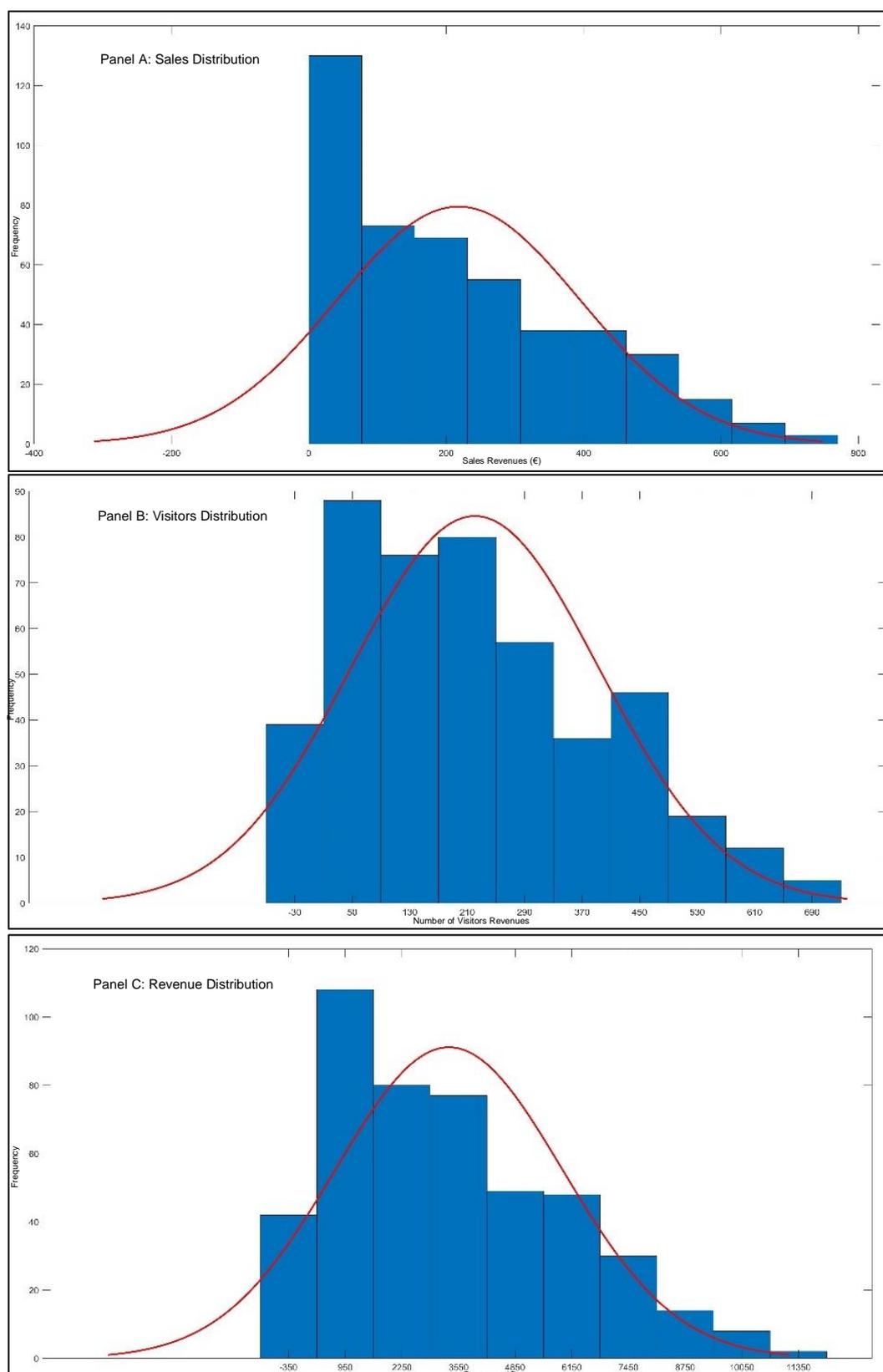
The largest revenues originate from U.S. tourists (53,522 €), followed by tourists from the U.K. (49,584 €) and tourists from all other European countries (30,406 €) not explicitly identified in the sample. In fact, tourists from the U.S. and the U.K. account for the 52.53% of all revenues originating from visitors outside Ireland. Focusing on the statistical features of the data, in Table 30 we report their descriptive statistics.

**Table 30: Descriptive Statistics of Fort Mitchell visitors**

	Statistic	Revenue	Items sold	Number of Visitors
1	Observations	457	457	411
2	Mean	3,330	220.71	211.89
3	Standard Deviation	2,606	172.76	177.13
4	Kurtosis	2.73	2.58	2.55
5	Skewness	0.71	0.65	0.66
6	Jaque-Bera test	39.55*	35.69*	37.41*
7	Augmented Dickey Fuller test	-4.31**	-4.83**	-4.26**

Note: \* denotes rejection of the null hypothesis that the data stem from a normal distribution at the 5% level of significance. \*\* denotes rejection of the null hypothesis that the series is non-stationary at the 5% level of significance.

All three series are stationary; they do not follow a stochastic linear trend. Thus, we could forecast the future evolution of the series based on an Ordinary Least Squares model. Nevertheless, the results from the Jarque-Bera test and the values of kurtosis and skewness suggest that no series originates for the family of normal distributions and they appear to have the mass of the distribution gathered around the left tail of the distribution. This finding violates the basic assumption of the OLS regression, suggesting the use of an alternative methodology; the SVR in our case. These findings are also obvious from Figure 56, where we depict the distributions of the 3 series.



**Figure 56: Histogram of Items sold (panel A), Number of Visitors (panel B) and revenues (panel C). The red line depicts the corresponding theoretical normal distribution.**

Another interesting finding from the data is the number of observations in the sample. The time period covering the data should be 677 days (observations), while in the data

we find only 457 observations for revenues and 411 for the number of visitors per day. If we exclude weekends from the time period under examination, we should observe 468 days, which is very close to the actual number of observations (accounting for weekends and holidays in Ireland).

Our forecasting exercise follows a mere autoregressive approach; the future values of the series under examination are forecasted based on their historical (previous) values. In doing so, we forecast each series separately. After training the initial model on the entire sample of 457 observations, we forecast dynamically the next 504 observations using the models' coefficients determined during the initial training phase. In this, each forecasted observation is considered as a new observation and its value is used in forecasting next period's value. Considering that each year has 252 working days (excluding weekends and holidays), our forecasting period accounts for approximately 2 years of operation.

In an alternative pure dynamic training approach, each forecast augments the initial sample and the model is re-trained recursively on the entire "new" span to produce next period's forecast. We repeat this dynamic retraining scheme for 504 observations. In either scheme (fixed or recursively determined coefficients) we examine up to 5 lags of data; that is using from one up to five past values each time as independent regressors and select the model with the highest forecasting accuracy.

In table 31 we report the estimated values in forecasting cumulative revenues and the cumulative number of visitors. We separate our forecasts in two periods: 1 to 252 days, and 253 to 504 days, given that after the renovation of the Fort the visitors' number should gain a different dynamic with time. Moreover, we measure the cumulative returns and the number of visitors for each period. We drop sale items forecasting, since it is modeled through revenues. In all models we use one lag, given that the increase in the forecasting accuracy with the addition of more lags is insignificant.

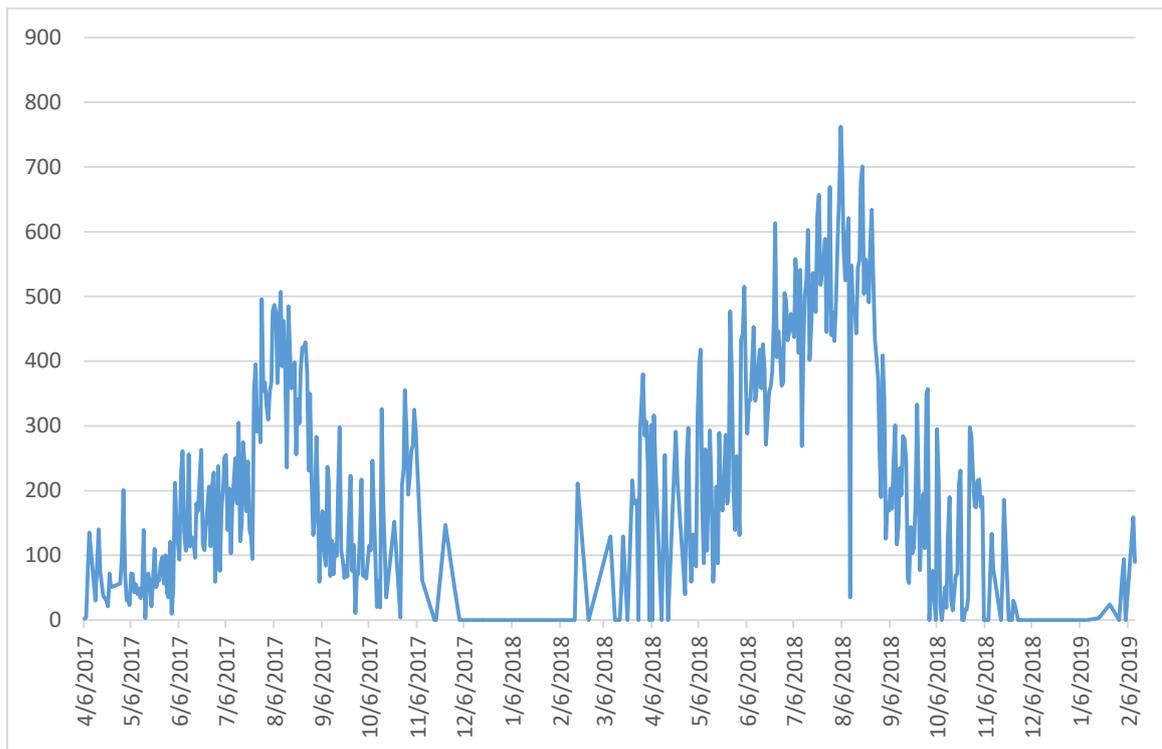
**Table 31: SVR forecasts for Fort Camden Meagher**

	Linear kernel				RBF kernel			
<i>Panel A: Fixed Coefficient Approach</i>								
	Visitors		Revenues		Visitors		Revenues	
Operation of the Fort	Period	Cumulative	Period	Cumulative	Period	Cumulative	Period	Cumulative
1-252 days / First year	59,761*	59,761	854,247*	854,247	34,454	34,454	497,999	497,999
253-504 days / Second year	64,148*	123,909	905,644*	1,759,891	34,641	69,095	503,866	1,001,865
<i>Panel B: Dynamic Retraining</i>								
1-252 days / First year	13,742	-	32,206.13	-	32,206	-	186,178.38	-
253-504 days / Second year	6,584	20,596	51,673.08	83,879.21	51,673	83,879	177,118.98	363,297.36

*Note: The table reports the forecasted revenues of the expected number of visitors and the expected revenues from the renovation of Camden Fort Meagher, based on two SVR model coupled with the linear and the linear kernel. We examine a forecasting methodology of training the models once and fixing the coefficients and an alternative approach of dynamically retraining each model, including the new forecasted values. The most accurate forecasts are denoted with an asterisk.*

The most accurate model is the SVR model that uses one lag of the data (previous working day data), coupled with the linear kernel and trained only once in the entire sample, keeping the coefficients fixed during forecasting. The dynamic retraining scheme fails significantly to even approach the historical values of the dataset. This was up to a certain degree expected, given that with the addition of new forecasts and the retraining scheme of the model (in order to re-tune model's coefficients) the model deviates from the original phenomenon, including increasing forecasting error (noise) in the training process. Thus, we find that the number of visitors and the **expected revenues in Camden Fort Meagher will match the number of visitors in Spike Island**. More specifically, in the first 457 days Fort Mitchell received 99,804 visitors and gathered 1,525,347 € in revenues, while Camden Fort Meagher is expected to receive **123,909 visitors and 1,759,891 € in its first 504 days of operation**. Thus, the renovation of Camden Fort Meagher is expected to double the revenues of the Cork County Council, during the first two years of operation of Camden Fort Meagher.

On a different perspective, the number of visitors to Spike Island is a crucial point in determining the desired capacity and thus the appropriate location of the new parking area in Camden Fort Meagher. Focusing on the historical values we are interested in the number of visitors that the Fort should serve in a regular visiting day. In Figure 57 we depict the daily number of visitors in Fort Mitchell. The maximum number of visitors in the Fort is 762 and was observed on the 5<sup>th</sup> August 2018. In contrast, during the winter the number of visitors in the Fort is smaller and for certain periods are zero.



**Figure 57: Daily number of visitors in Fort Mitchell, Spike Island.**

In Table 32, we report the percentiles of the observed number of visitors in Fort Mitchell.

**Table 32: Percentiles of the number of visitors**

Percentile	Observed in Fort Mitchell
10%	1
20%	56
30%	89
40%	131
50%	185
60%	234
70%	298
80%	386
90%	484

The distribution of the historical prices suggests that during normal working days, the median number of visitors is 185. Assuming that each car has 2 passengers and that the new parking space should be able to cover the 80% of all working days, **the area should provide 193 parking spaces. Taking into account that the existing on-site parking has a capacity of 30 parking spaces, the off-site location should fill the demand for the additional 163 spaces.** Of course, in extreme situations where the number of visitors increases (for instance special days of visitation like national holidays or large groups) there could be some congestion problem, but this needs more traffic data to be accurately estimated. A future line of research would be to measure the frequency of parked cars per hour in the parking amenities of Fort Mitchell. In this way we could estimate the exact number of parking places needed to fulfil the parking demand in Fort Mitchell and extend this estimation to Camden Fort Meagher.

### 2.3.2 User interfaces

The econometric analysis is presented in a devoted to Cork *kibana* dashboard. The results of the EC-IO model create the index “cork\_ec\_scenario\_data”, while the SVR analysis is presented in “cork\_tourist\_scenario\_data” index. Furthermore, the additional information of the descriptive statistics analysis is reported in indices “cork\_visitors\_percentiles\_data”, “cork\_visitors\_revenues\_data” and “cork\_svr\_forecast\_data”. In Table 33 we report the “cork\_ec\_scenario\_data” index.

**Table 33: Fields of the “cork\_ec\_scenario\_data” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
Transportation revenues	number	Yes	Yes	Econometric variables
Aggregate Consumption	number	Yes	Yes	Econometric variables
Capital Stock	number	Yes	Yes	Econometric variables
Demand for Investments	number	Yes	Yes	Econometric variables
Disposable Income	number	Yes	Yes	Econometric variables
Employment	number	Yes	Yes	Econometric variables
GDP	number	Yes	Yes	Econometric variables

Paid Staff Expenses	number	Yes	Yes	Econometric variables
Total Production Output	number	Yes	Yes	Econometric variables
Residential Dwellings Property Prices	number	Yes	Yes	Econometric variables

The data used to create the visualization widgets, are extracted from the econometric model in ndjson format. Figure 58 depicts the format of these data.

```

{"index":{"_id":0}}
{"Accommodation and food Services": 1.0, "Retail Sales": 0.5, "Capital Stock": 0.03, "Total Production Output": 0.07, "Paid Staff Expenses": 0.03, "Employment": 0.05, "Demand for Investments": 0.01, "Aggregate Consumption": 0.15, "Disposable Income": 0.02, "GDP": 0.03, "Residential Dwellings Property Prices": 0.04}

{"index":{"_id":1}}
{"Accommodation and food Services": 2.0, "Retail Sales": 0.5, "Capital Stock": 0.05, "Total Production Output": 0.13, "Paid Staff Expenses": 0.07, "Employment": 0.11, "Demand for Investments": 0.03, "Aggregate Consumption": 0.29, "Disposable Income": 0.04, "GDP": 0.05, "Residential Dwellings Property Prices": 0.07}

{"index":{"_id":2}}
{"Accommodation and food Services": 3.0, "Retail Sales": 1.5, "Capital Stock": 0.08, "Total Production Output": 0.17, "Paid Staff Expenses": 0.10, "Employment": 0.16, "Demand for Investments": 0.04, "Aggregate Consumption": 0.44, "Disposable Income": 0.06, "GDP": 0.08, "Residential Dwellings Property Prices": 0.11}

{"index":{"_id":3}}
{"Accommodation and food Services": 4.0, "Retail Sales": 2.0, "Capital Stock": 0.11, "Total Production Output": 0.20, "Paid Staff Expenses": 0.14, "Employment": 0.22, "Demand for Investments": 0.05, "Aggregate Consumption": 0.59, "Disposable Income": 0.08, "GDP": 0.11, "Residential Dwellings Property Prices": 0.15}

{"index":{"_id":4}}
{"Accommodation and food Services": 5.0, "Retail Sales": 2.5, "Capital Stock": 0.13, "Total Production Output": 0.22, "Paid Staff Expenses": 0.17, "Employment": 0.27, "Demand for Investments": 0.07, "Aggregate Consumption": 0.73, "Disposable Income": 0.10, "GDP": 0.13, "Residential Dwellings Property Prices": 0.18}
    
```

**Figure 58: Cork - The selected data format for “cork\_ec\_scenario\_data” index**

Table 34 reports the fields of “cork\_svr\_forecast\_data” index.

**Table 34: Fields of the “cork\_svr\_forecast\_data” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
Revenue number	number	Yes	Yes	Forecasted revenues number
Visitors number	number	Yes	Yes	Forecasted revenues number
Working Period of the Fort	string	Yes	Yes	Working periods of the fort

In Figure 59, we depict the format of the “cork\_svr\_forecast\_data” index.

```

{"index":{"_id":0}}
{"Working Period of the Fort": "1-252 days", "Visitors": 59761, "Revenue": 854247}
{"index":{"_id":1}}
{"Working Period of the Fort": "253-504 days", "Visitors": 64148, "Revenue": 905644}
{"index":{"_id":2}}
{"Working Period of the Fort": "505-600 days", "Visitors": 24594, "Revenue": 347223}
    
```

**Figure 59: Cork - The selected data format for “cork\_svr\_forecast\_data” index**

Table 35 presents the fields of “cork\_tourist\_scenario\_data” index.

**Table 35: Fields of the “cork\_tourist\_scenario\_data” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
Country	string	Yes	Yes	Country of origin
Revenue	number	Yes	Yes	Tourism revenues
Visitors	number	Yes	Yes	Number of visitors
Type_of_tourist	String	Yes	Yes	Either foreign or locals

In Figure 60, we depict the format of the “cork\_tourist\_scenario\_data” index.

```

{"index":{"_id":0}}
{"Country": "Asia", "Visitors": 719, "Revenue": 11039, "type_of_tourist": "Foreign Tourists"}

{"index":{"_id":1}}
{"Country": "Australia - New Zealand", "Visitors": 575, "Revenue": 9344, "type_of_tourist": "Foreign Tourists"}

{"index":{"_id":2}}
{"Country": "Canada", "Visitors": 142, "Revenue": 2388, "type_of_tourist": "Foreign Tourists"}

{"index":{"_id":3}}
{"Country": "Central America", "Visitors": 48, "Revenue": 760, "type_of_tourist": "Foreign Tourists"}

{"index":{"_id":4}}
{"Country": "Europe", "Visitors": 1897, "Revenue": 30406, "type_of_tourist": "Foreign Tourists"}

```

**Figure 60: Cork - The selected data format for “cork\_tourist\_scenario\_data” index**

In Table 36 we report the fields of “cork\_visitors\_percentiles\_data” index.

**Table 36: Fields of the “cork\_visitors\_percentiles\_data” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
Observed (Visitors) in Fort Mitchell number	number	Yes	Yes	Number of observed visitors in Fort Mitchell
Percentile	string	Yes	Yes	Visitors percentiles

In Figure 61, we depict the format of the “cork\_visitors\_percentiles\_data” index.

```

{"index":{"_id":0}}
{"Percentile": "10%", "Observed (Visitors) in Fort Mitchell": 1}

{"index":{"_id":1}}
{"Percentile": "20%", "Observed (Visitors) in Fort Mitchell": 56}

```

```
{
  "index": {"_id": "2"},
  "Percentile": "30%",
  "Observed (Visitors) in Fort Mitchell": 89
}

{
  "index": {"_id": "3"},
  "Percentile": "40%",
  "Observed (Visitors) in Fort Mitchell": 131
}

{
  "index": {"_id": "4"},
  "Percentile": "50%",
  "Observed (Visitors) in Fort Mitchell": 185
}
```

**Figure 61: Cork - The selected data format for “cork\_visitors\_percantiles\_data” index**

In Table 37 we report the fields of the “cork\_visitors\_revenues\_data” index.

**Table 37: Fields of the “cork\_visitors\_revenues\_data” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
Date	date	Yes	Yes	Date of visit
No of Visitors	number	Yes	Yes	Number of visitors
Revenues	number	Yes	Yes	Tourism revenues

In Figure 62, we depict the format of the “cork\_visitors\_revenues\_data” index.

```
{
  "index": {"_id": "0"},
  "Date": "2017-04-06",
  "No of Visitors": 2,
  "Revenues": 36
}

{
  "index": {"_id": "1"},
  "Date": "2017-04-07",
  "No of Visitors": 4,
  "Revenues": 70.15
}

{
  "index": {"_id": "2"},
  "Date": "2017-04-08",
  "No of Visitors": 72,
  "Revenues": 930.4
}

{
  "index": {"_id": "3"},
  "Date": "2017-04-09",
  "No of Visitors": 135,
  "Revenues": 1846
}

{
  "index": {"_id": "4"},
  "Date": "2017-04-13",
  "No of Visitors": 30,
  "Revenues": 442
}
```

**Figure 62: Cork - The selected data format for “cork\_visitors\_revenues\_data” index**

The following figures depict the visualization widgets of the dashboard. In Figure 63, the line chart depicts the economic impact of several scenarios regarding an increase in Tourism Revenues.

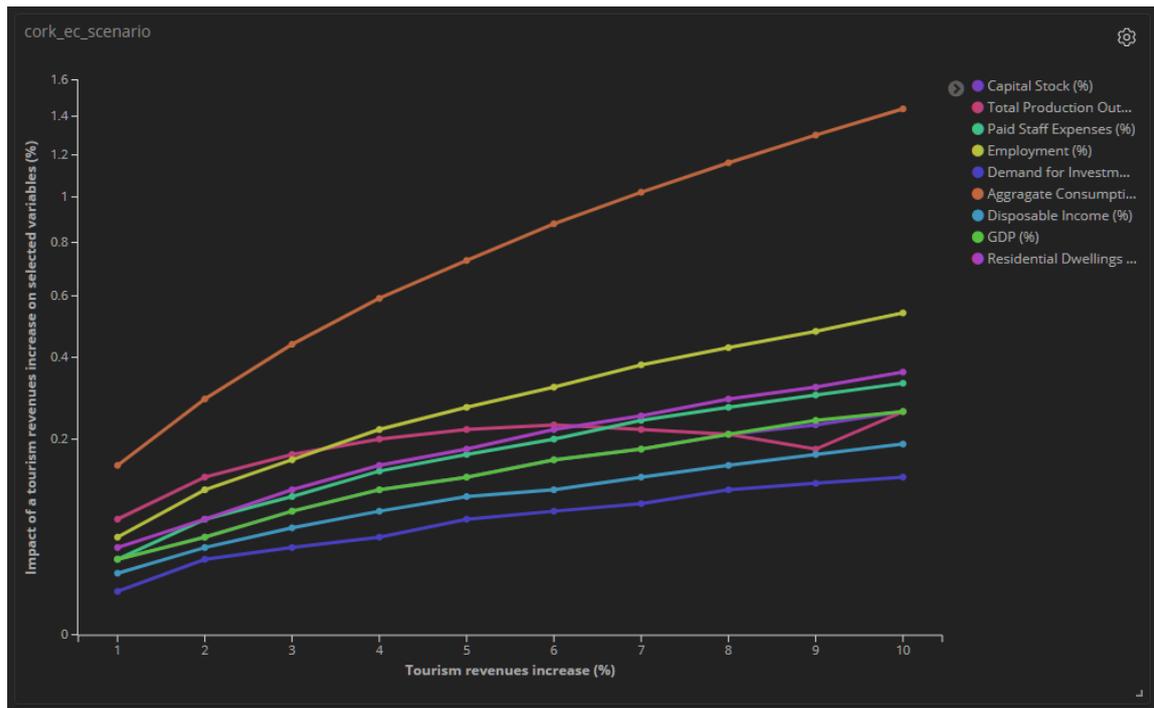


Figure 63: Cork dashboard – Econometric model results

The Pie char in Figure 64 shows the percentage of visitors to Fort Mitchell in Spike Island according to the country of origin. In this diagram both foreign and local tourists are included, while in Figure 65 we report only foreign visitors.

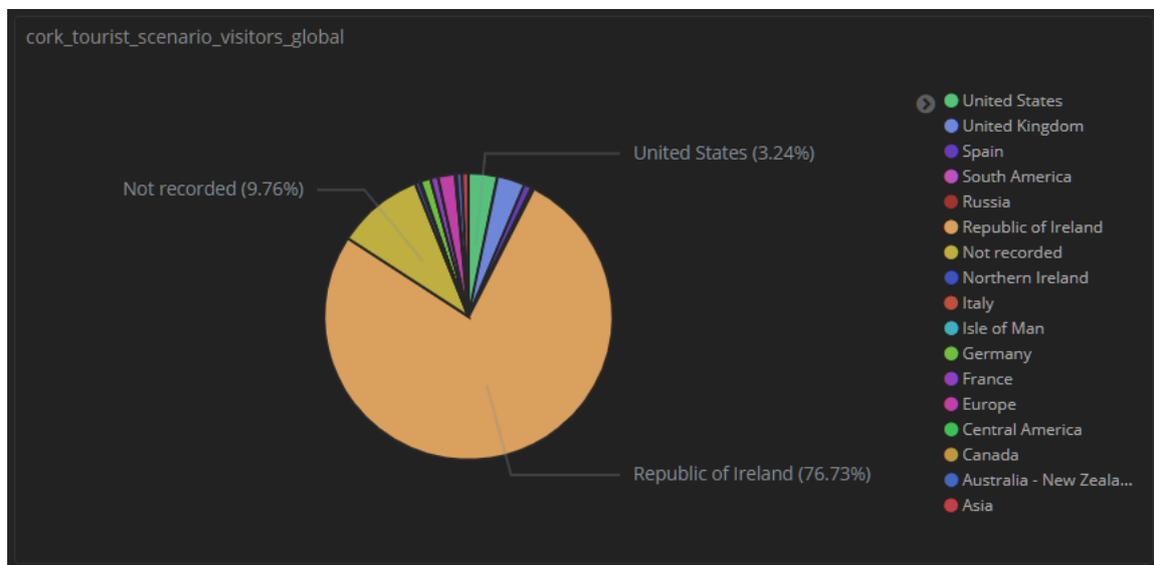


Figure 64: Cork dashboard – Number of global visitors in Fort Mitchell

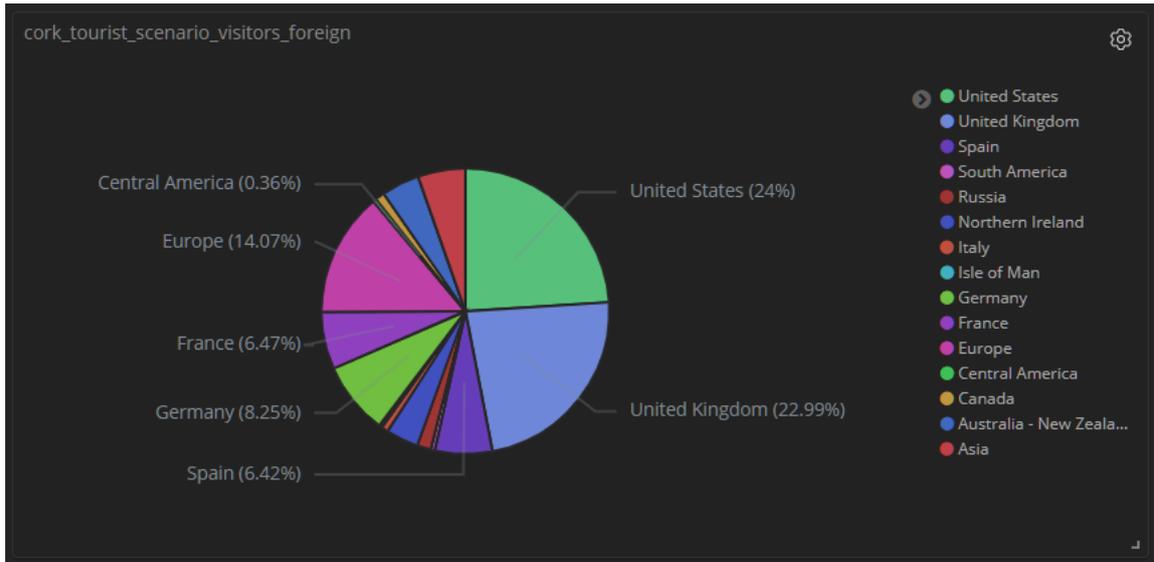


Figure 65: Cork dashboard – Amount of foreign visitors in Fort Mitchell

In Figure 66 the focus is on revenues according to the country of origin for foreign visitors.

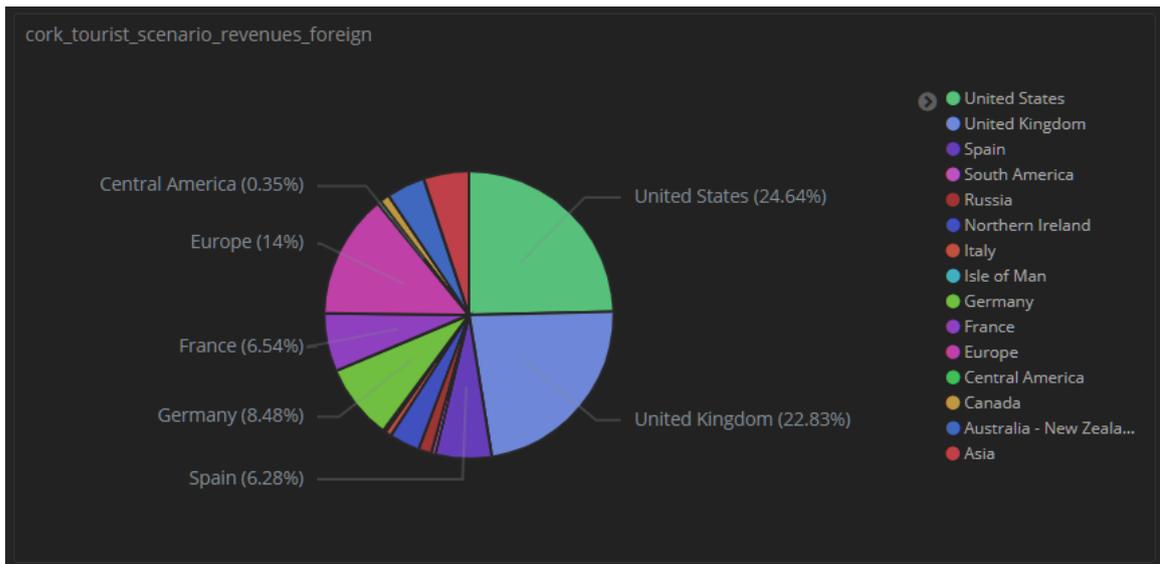


Figure 66: Cork dashboard – Tourism revenues in Fort Mitchell (foreign visitors)

Figure 67 presents the number of visitors in Fort Mitchell in Spike Island per year. Data are available from April 2017 to February 2019.

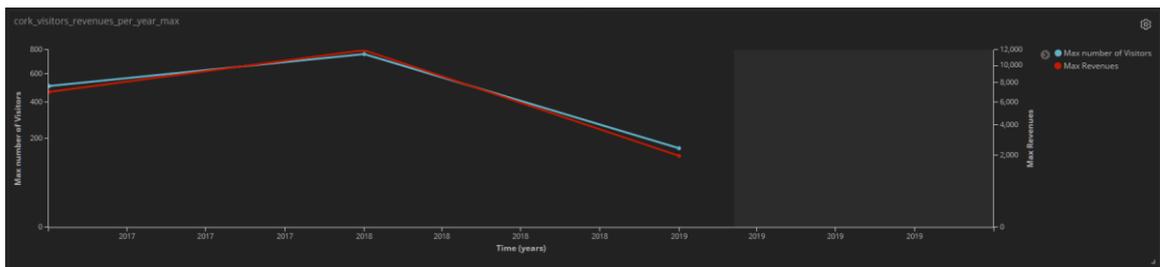
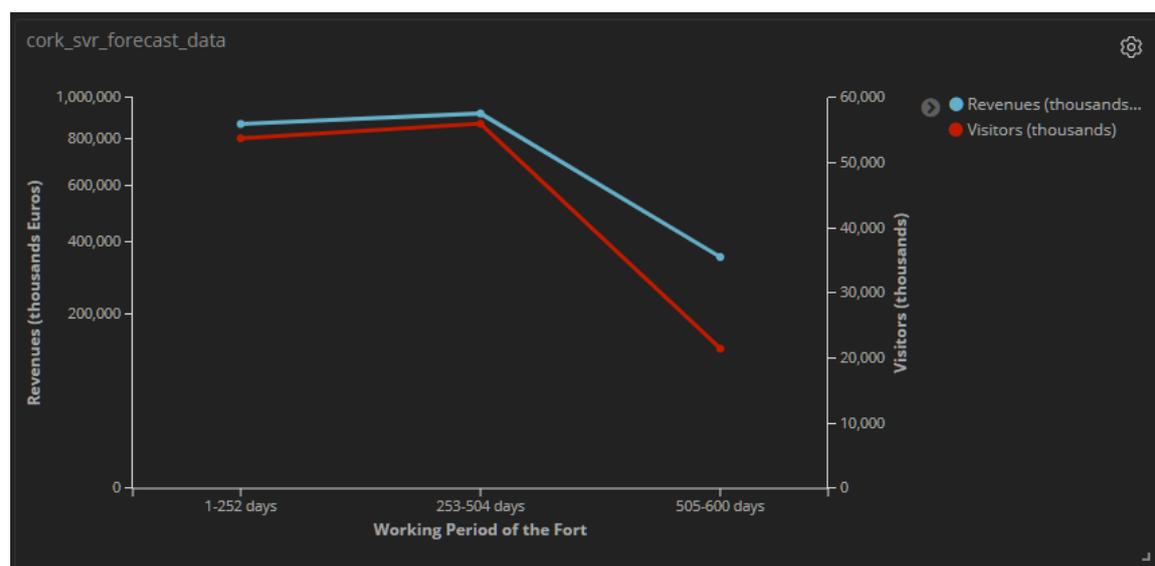


Figure 67: Cork dashboard –Visitor revenues per year

While the previous figure refers to historical data, the line chart in Figure 68 reports the estimated future number of visitors and revenues for Camden Fort Meagher.



**Figure 68: Cork dashboard – Forecasted visitors and revenues (SVR model)**

The percentiles on the past number of visitors for Fort Mitchell are depicted in Figure 69.

Percentile	Observed (Visitors) in Fort Mitchell
10%	1
20%	56
30%	89
40%	131
50%	185
60%	234
70%	298
80%	386
90%	484

**Figure 69: Cork dashboard – Observed visitors in Fort Mitchell (based on visitor's percentiles)**

An additional source of data for Cork are the point of interest compiled from maps.me, which are integrated in an index named “cork-mapsme-dashboard”. The maps.me data offer a general overview regarding the supported amenities in Cork. In Table 38, we report the fields of the “cork-mapsme-dashboard” index.

**Table 38: Fields of the “cork-mapsme-dashboard” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
date	date	Yes	Yes	The date (format: yyyy-mm) the crawler downloaded the data
poi_category	string	Yes	Yes	Point of interest category
poi_subcategory	string	Yes	Yes	Point of interest sub-category
poi_geo_point	geo_point	Yes	Yes	The given GPS coordination (latitude and longitude) for each point of interest

The data used to create the visualization widgets are downloaded in ndjson format via the MAPS.ME crawler described in section 1.2. Figure 70 depicts the format of the data from the crawler.

```

{"index":{"_id":0}}
{"poi_category": "food", "date": "2019-2", "poi_subcategory": "Restaurants", "poi_geo_point": " 51.9026,-8.4768"}

{"index":{"_id":1}}
{"poi_category": "lodging", "date": "2019-2", "poi_subcategory": "Hostels", "poi_geo_point": " 51.9026,-8.466"}

{"index":{"_id":2}}
{"poi_category": "food", "date": "2019-2", "poi_subcategory": "Bar", "poi_geo_point": " 51.8984,-8.4687"}

{"index":{"_id":3}}
{"poi_category": "shop", "date": "2019-2", "poi_subcategory": "Sports Goods", "poi_geo_point": " 51.8718,-8.4858"}

{"index":{"_id":4}}
{"poi_category": "attractions", "date": "2019-2", "poi_subcategory": "Church", "poi_geo_point": " 51.9132,-8.4278"}

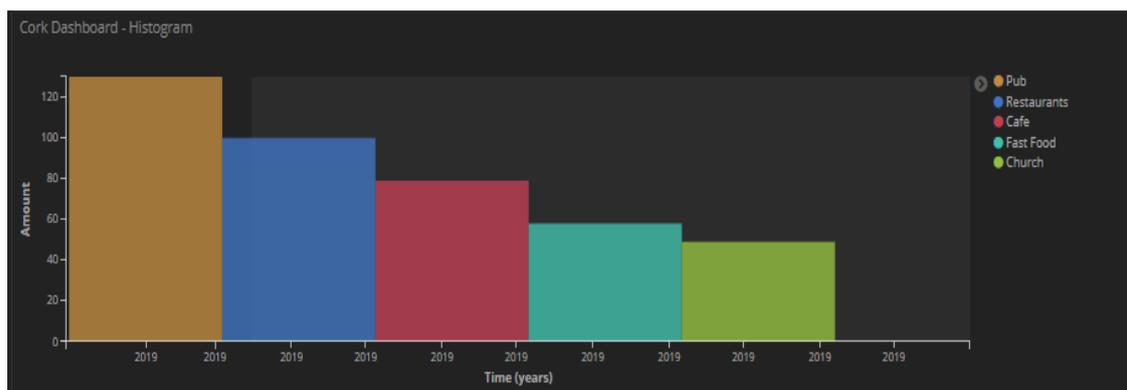
```

**Figure 70: Cork - The selected format for MAPS.ME data**

The following figures depict the visualization widgets regarding the maps.me data for Cork. In Figure 71, we present the selection options on categories and subcategories from the user.

**Figure 71: Cork dashboard – Maps.me data control**

Moving on, in the histogram of Figure 72 we present the top-5 subcategories based on the number of point of interest per category. The x-axis measures time in years while the y-axis measures the number of each point of interest, including only 2019 data.



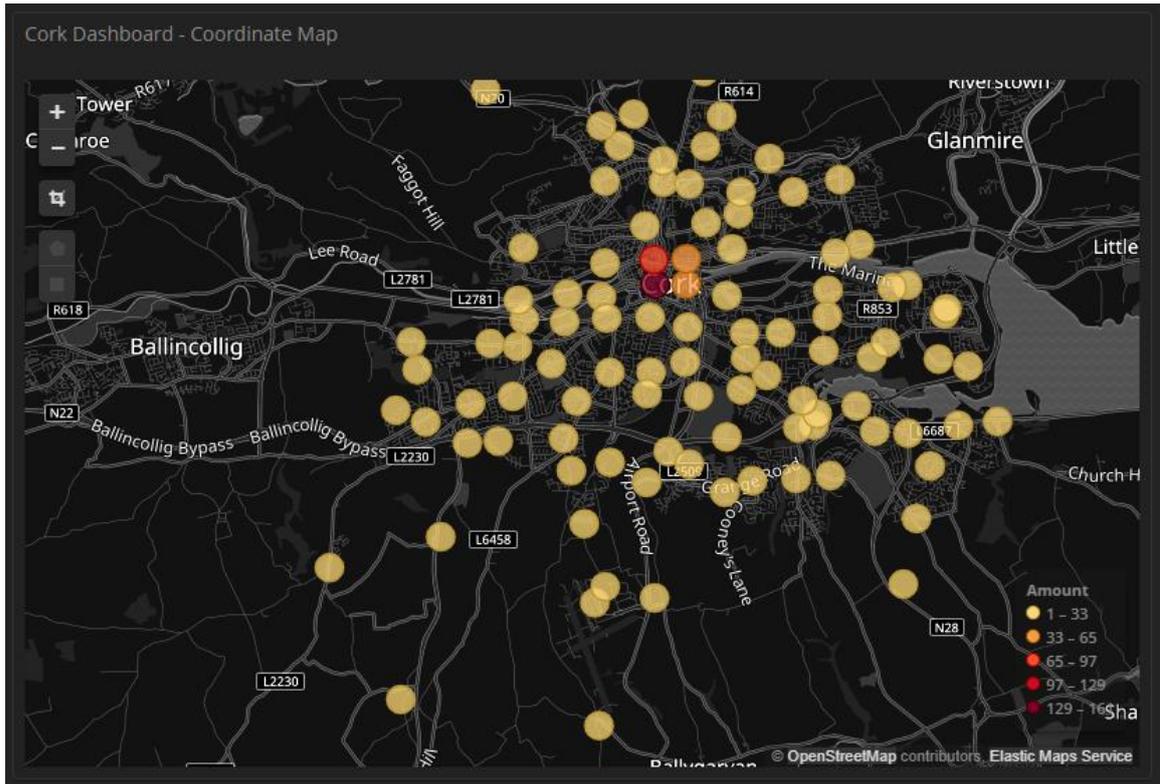
**Figure 72: Cork dashboard – Maps.me top-5 subcategories**

In Figure 73, the top 5 subcategories are depicted as a word cloud, where the font size signifies quantity.



**Figure 73: Cork dashboard – Maps.me subcategories tags sized to their importance**

In Figure 74, we present the location of each point of interest according to the data provided by maps.me. The red points represent areas of high concentration and thus of high economic significance. The specific dataset is mainly focused on Cork.



**Figure 74: Cork dashboard – Maps.me coordinate map with points of interest**

All the above information is gathered in a table, depicted in Figure 75.

Time (years)	Category	Type	Amount
2019	food	Pub	130
2019	food	Restaurants	100
2019	food	Cafe	79
2019	food	Fast Food	58
2019	food	Bar	22
2019	shop	Clothes Shop	28
2019	shop	Supermarkets	22
2019	shop	Beauty Shop	14

**Figure 75: Cork dashboard – Maps.me table**

Overall, we create a *kibana* dashboard named “Cork Dashboard” presented in Figure 76. The dashboard contains only the visualization widgets regarding the econometric model data indices. Again maps.me data are reserved for future use, when their coverage will be representative to the actual number of points of interest in Cork.

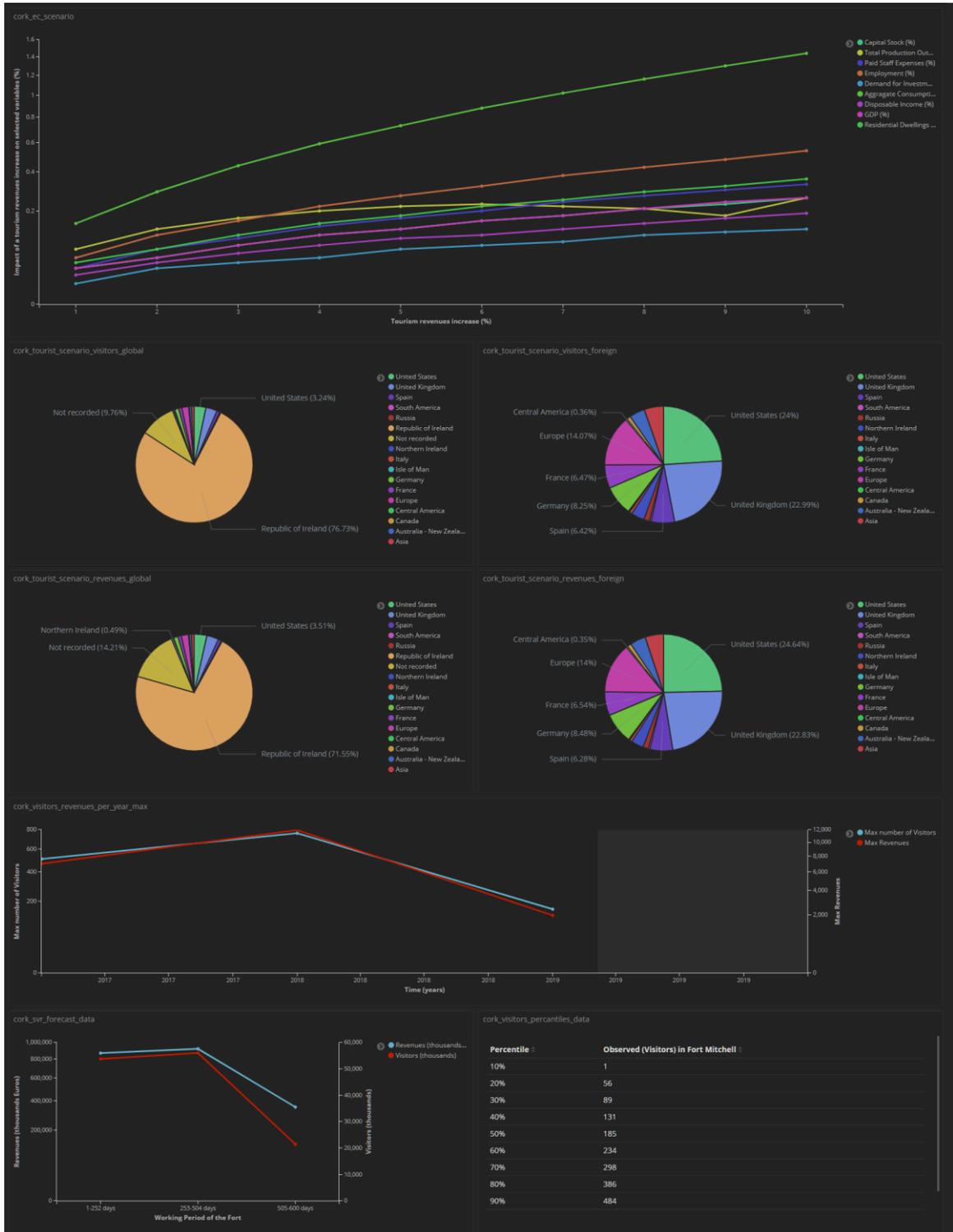


Figure 76: Cork dashboard – Kibana dashboard

## 2.4 Thessaloniki

The objective of Thessaloniki, the last (in alphabetical order) pilot city is to use the CUTLER platform to design, implement, monitor, and evaluate the new controlled parking system in the 1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> Municipal Districts (Figure 77). In doing so, the Municipality of Thessaloniki needs to evaluate the economic impact of the expansion of the existing parking system in new areas and the possibility for price differentiation and reallocation of existing parking spaces the existing parking system.

The available parking spaces are divided into white and blue spaces. The blue spaces are restricted to parking for permanent residents of the area, while the white spaces are destined for visitors. Each resident must go through an application process through which he will become a holder of a parking card that will allow him to park his vehicle in any spot of a blue space of his district. Permanent residents are not allowed to park in the blue spaces of another municipal district.

The ratio between blue and white spaces is 3 parking spaces for residents to 1 parking space for visitors in the entire Car Park System (CPS). Every visitor must pay a fee in order to park his vehicle in one of the white spots. The parking fee has been set to 1.70 € per hour from 8:00 to 21:00 from Monday to Friday and from 9:00 to 16:00 on Saturday. In the remaining time periods, any vehicle can occupy any white spot without charge. Parking on Sundays is free on all white spaces. In case a resident wishes to use one of the white spots, it is also compulsory to pay a fee during the time period of the operation of the system.

The system is supervised by the municipal police, which plays a crucial role in the establishment of the CPS. The Municipal Police is providing data coming from daily patrols and penalty notices. The platform will also be used by the Municipal Police to assist daily monitoring duties, e.g. redesigning patrol routes, setting goals, etc.

As described in D9.1, the Municipality of Thessaloniki aims to use the CUTLER platform as a policy design tool that will lead to the optimization of the functionality of the CPS. Focusing only on the economic aspect of the program, the Municipality of Thessaloniki is mainly focused on:

- Redistributing parking spots for visitors and residents, aiming to reduce the number of penalty notices and increase public satisfaction. We provide guidelines examining the characteristics of sectors and propose certain measures towards this end.
- Introduction of moderations in the financial policy aiming to increase profits. We provide sectoral revenue forecasts that help in shaping a financial program and goal setting, as well as changing the functionality of municipal police in order to increase public satisfaction.



**Figure 77: City of Thessaloniki and neighboring Municipalities. The City is divided in 6 Municipal Districts.<sup>2</sup>**

<sup>2</sup> Source: <https://opendata.thessaloniki.gr/en> [11]

### 2.4.1 Data models

The CPS is divided in 26 sectors, grouping individual parking spaces according to their proximity to main roads of the city's center. Moreover, there is an auxiliary group that includes all remote parking spaces that are not classified into specific sectors. The Municipality of Thessaloniki has provided data on the characteristics of each sector<sup>3</sup>, total revenues per sector in daily and monthly frequency, the daily frequency of occupied parking spaces per hour and the daily mean parking revenue per space for the entire CPS. The daily frequency of occupied parking spaces provides data at an aggregated level for the entire CPS and not sectoral frequencies. We organized and group the data into sectors in order to extract the necessary information that will assist the decision process. In Table 39 we depict the descriptive statistics of each sector according to the total revenues, the mean performance for each sector, the parking spaces available per sector and the parking tickets collected in each sector. The performance in the data provided is available on street level and not sectoral level, so we created a weighted performance index per sector, with the weight corresponding to the number of parking spaces per street within the sector. For 19 sectors the Municipality of Thessaloniki also provided data for the period 11-Nov-2017 to 31- Dec-2017, but in order to keep our analysis consistent across all sectors, we focus explicitly on 2018.

---

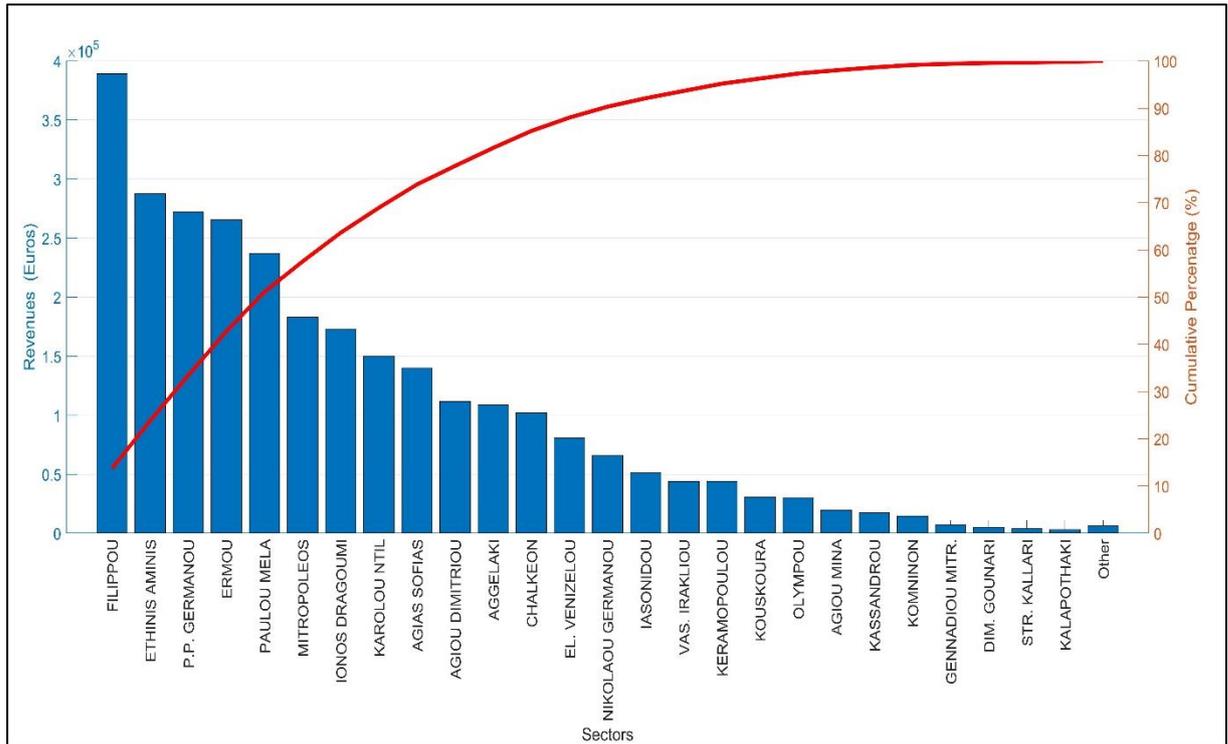
<sup>3</sup> number and names of roads included, number of parking spaces, mean daily revenues per parking space and performance per parking space

**Table 39: Descriptive Statistics of the CPS data**

	Sector ID	Total revenues	Sectoral Performance	Parking Spaces	Parking Tickets
1	FILIPPOU	389,181 €	0.23	249	134,070 €
2	ETHINIS AMINIS	287,596 €	0.19	224	92,770 €
3	P.P. GERMANOU	271,991 €	0.38	106	81,105 €
4	ERMOU	265,678 €	0.35	125	68,150 €
5	PAULOU MELA	236,786 €	0.37	94	73,280 €
6	MITROPOLEOS	183,106 €	0.42	65	105,770 €
7	IONOS DRAGOUMI	172,905 €	0.24	107	92,415 €
8	KAROLOU NTIL	150,003 €	0.32	70	47,770 €
9	AGIAS SOFIAS	139,931 €	0.28	74	60,550 €
10	AGIOU DIMITRIOU	111,596 €	0.08	204	46,505 €
11	AGGELAKI	108,484 €	0.22	74	34,255 €
12	CHALKEON	101,715 €	0.29	53	37,425 €
13	EL. VENIZELOU.	80,515 €	0.31	39	41,205 €
14	NIKOLAOU GERMANOU	65,566 €	0.12	84	19,650 €
15	IASONIDOU	50,824 €	0.20	38	22,615 €
16	VAS. IRAKLIYOU	44,039 €	0.33	20	15,000 €
17	KERAMOPOULOU	43,610 €	0.38	17	10,780 €
18	KOUSKOURA	30,811 €	0.46	10	6,170 €
19	OLYMPOU	30,125 €	0.15	29	75,440 €
20	AGIOU MINA	19,669 €	0.14	21	2,360 €
21	KASSANDROU	17,211 €	0.02	112	17,930 €
22	KOMNINON	14,661 €	0.17	13	18,890 €
23	GENNADIOU MITR.	6,961 €	0.13	8	120 €
24	DIM. GOUNARI	4,902 €	0.15	5	12,050 €
25	STR. KALLARI	3,730 €	0.11	5	23,790 €
26	KALAPOTHAKI	2,867 €	0.07	6	1,890 €
27	Other	6,018 €	0.23	249	134,070 €
<b>Total</b>		<b>2,840,481 €</b>	<b>-</b>	<b>2,101</b>	<b>1,276,025 €</b>

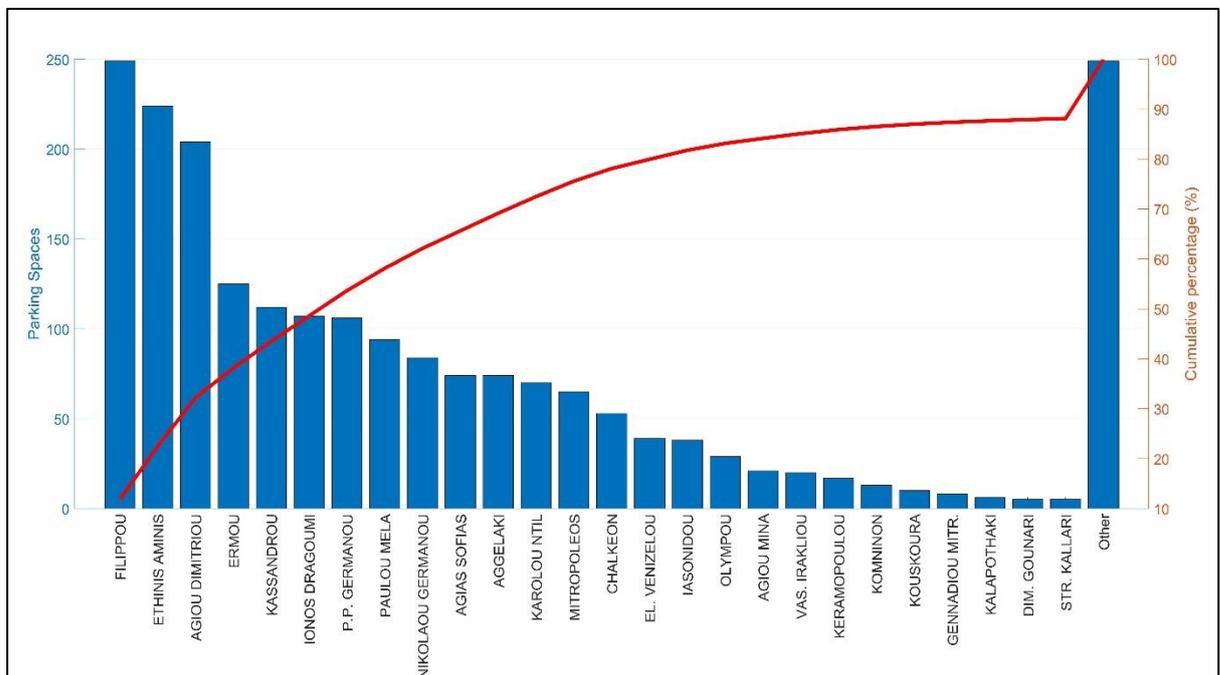
Note: The Table is sorted from the sector of the highest to the lowest revenues.

The sector with the highest revenues is sector “FILIPPOU”, followed by sector “ETHNIKIS AMINAS” and sector “P.P. GERMANOU”. In the Pareto chart of Figure 78, we depict these annual sectoral revenues.



**Figure 78: Sectoral revenues of the CPS system**

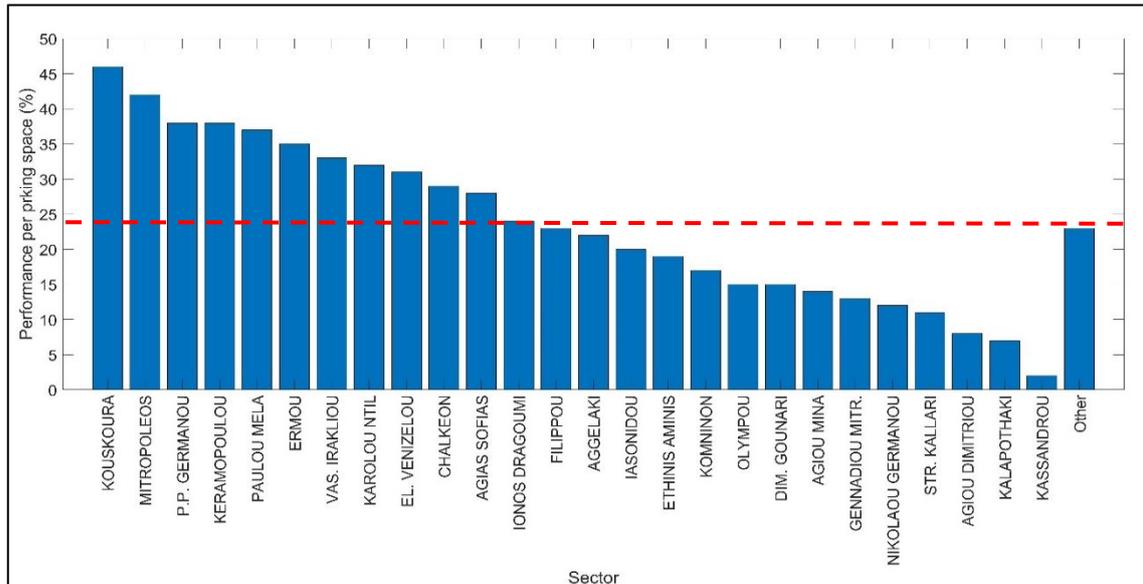
As we observe, the first 10 sectors account for approximately the 77% of the total revenues, while the first 14 sectors account for the 90% of total revenues. In Figure 79 we sort sectors according to the available parking spaces.



**Figure 79: Sectoral parking spaces of the CPS system**

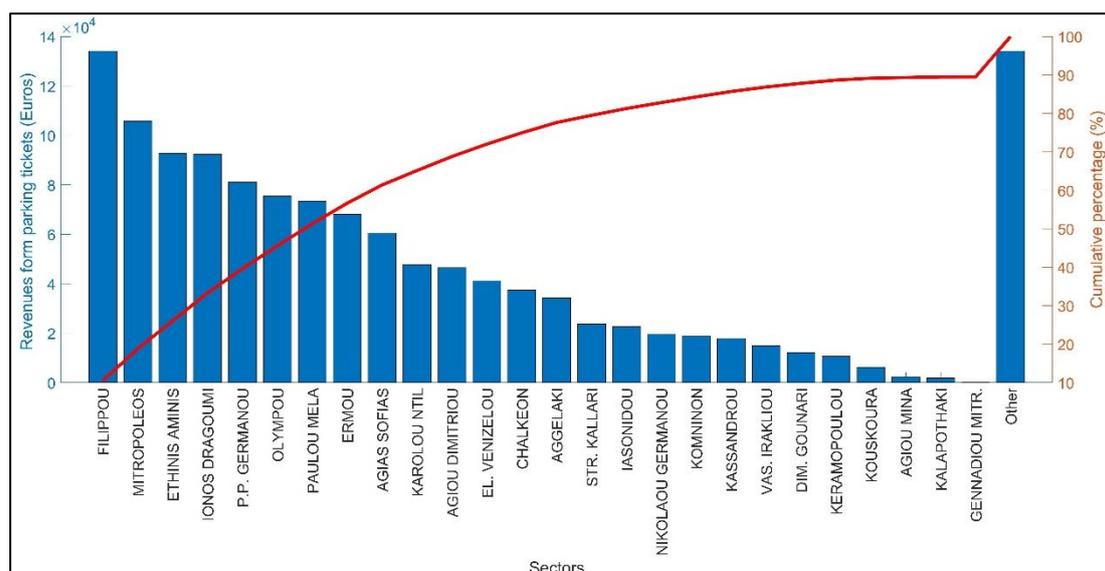
The first 10 sectors account for the 65% of the total parking spaces of the CPS, while the first 15 sectors reach to a total of 80% of the available parking spaces. As expected, **the correlation of total revenues with the number of parking spaces is 0.80**, which is expected given that more parking spaces provide higher potential revenues.

Combining the two figures we reach to some interesting results. Sectors “FILIPPOU” and “ETHNIKIS AMINAS” are the first and second in terms of parking spaces and total revenues, respectively. Sectors “P.P. GERMANOU”, “ERMOU”, “PAULOU MELA” and “IONOS DRAGOUMI” are within the first 10 sectors in terms of revenues and parking spaces, justifying that more parking spaces results in higher revenues. In contrast, sector “KASSANDROU” is fifth regarding the number of parking spaces with 112 parking spaces, but in place 21 in terms of revenues, while sector “MITROPOLEOS” with only 65 parking spaces is 6th in total revenues and “KAROLOU NTIL” with 70 parking spaces is 8th in terms of total revenues. In Figure 80 we sort sectors according to the performance per parking space. The mean performance of the CPS system is 24%.



**Figure 80: Sectoral performance of the CPS system. The average performance is depicted with the dotted line.**

In Figure 80 we observe that sector “KASSANDROU” with 112 parking places is at the last place with 2% sectoral performance and “AGIOU DIMITRIOU” with 204 parking spaces exhibits a disappointing 8% sectoral performance, sorted third from the end (excluding “Other” from counting). These two sectors call for policy-interventions, given their large number of parking spaces and their small performance. Thus, the Municipality of Thessaloniki could **differentiate price policy in sectors below the average performance of the CPS, lowering fees or decreasing the number of parking spaces for permanent residents** in order to increase performance and boost revenues. Again, as expected, the **correlation between revenues and performance is 0.42**, given that higher performance leads to higher revenues. Finally, in Figure 81 we depict the revenues from parking fines per sector.



**Figure 81: Parking fines per sector of the CPS system**

Once again, the first ten sectors in terms of revenues from parking tickets are the same with the ones with the highest revenues from parking tolls, apart from sector “OLYMOU” that is in the 19<sup>th</sup> place according to the total revenues from parking tolls, but appears at the 6<sup>th</sup> place according to parking tickets. Thus, most of the sector’s revenues come from parking tickets and not parking fees. This makes sector “**OLYMOU**” an excellent candidate for a differentiation in parking tolls, in order to lower parking tickets and increase public satisfaction. Moreover, the Municipality of Thessaloniki could alter the routes of the municipal police to decrease the number of parking tickets in sectors of unexpectedly high frequency of parking tickets in order to lower public dissatisfaction.

Another interesting issue that we wish to answer within the economic widget is the future evolution of CPS revenues, in order to provide the necessary data to the Municipality of Thessaloniki in drawing a future economic policy for the CPS. In doing so, we forecast the evolution of sectoral revenues based on an SVR model, coupled with the linear and the RBF kernel. All models are purely autoregressive in the sense that they use past (historical) information in forecasting future values. The lag structure of the model is selected to one observation, while we fix the coefficients after the initial estimation of the model during the forecasting phase, based on our experience from Cork. In Table 40 we report the estimated revenues per sector for 297 days ahead that correspond to one year of operation. We do not forecast the auxiliary category “OTHER”, given that those parking spaces do not correspond to a specific area and thus policy-intervention could not be consistent and targeted.

**Table 40: CPS sectoral Forecasts of the SVR model**

No	Sector	Actual	Forecasted	
			Linear kernel	RBF kernel
1	FILIPPOU	389,181 €	420,008 €*	91,453 €
2	ETHINIS AMINIS	287,596 €	256,820 €*	148,388 €
3	P.P. GERMANOU	271,991 €	190,754 €*	110,299 €
4	ERMOU	265,678 €	248,349 €*	143,722 €
5	PAULOU MELA	236,786 €	242,765 €*	127,815 €
6	MITROPOLEOS	183,106 €	220,939 €*	132,627 €
7	IONOS DRAGOUMI	172,905 €	240,325 €*	120,295 €
8	KAROLOU NTIL	150,003 €	178,517 €*	102,280 €
9	AGIAS SOFIAS	139,931 €	209,972 €*	104,942 €
10	AGIOU DIMITRIOU	111,596 €	174,636 €*	104,253 €
11	AGGELAKI	108,484 €	56,655 €*	29,785 €
12	CHALKEON	101,715 €	76,030 €*	40,012 €
13	EL. VENIZELOU.	80,515 €	118,185 €	66,027 €*
14	NIKOLAOU GERMANOU	65,566 €	63,342 €*	7,791 €
15	IASONIDOU	50,824 €	36,610 €*	21,770 €
16	VAS. IRAKLIOU	44,039 €	41,517 €*	23,710 €
17	KERAMOPOULOU	43,610 €	71,972 €*	42,043 €
18	KOUSKOURA	30,811 €	29,877 €*	17,962 €
19	OLYMPOU	30,125 €	29,611 €*	5,614 €
20	AGIOU MINA	19,669 €	17,541 €*	10,242 €
21	KASSANDROU	17,211 €	21,649 €*	12,919 €
22	KOMNINON	14,661 €	10,593 €*	6,287 €
23	GENNADIOU MITR.	6,961 €	8,117 €*	4,050 €
24	DIM. GOUNARI	4,902 €	9,070 €*	5,298 €
25	STR. KALLARI	3,730 €	6,901 €*	4,030 €
26	KALAPOTHAKI	2,867 €	4,421 €*	2,581 €

Note: The most accurate forecasts are denoted with an asterisk. All values are in Euros.

The SVR model with the highest forecast in the one coupled with the linear kernel, apart for sector “EL. VENIZELOU”, where the RBF kernel exhibits higher forecasting accuracy. As we observe, certain sectors as “FILIPPOU”, “MITROPOLEOS” and “IONOS DRAGOUMI” are expected to increase their revenues, while others like “P.P. GERMANOU” and “ERMOU” are expected to reduce their revenues. Given this information, the Municipality of Thessaloniki **could monitor sectors that are expected to provide less revenues** closely and **reduce the ratio of residents/visitors** in order to increase the number of parking spaces or **adjust prices** in order to ensure a steady flow of revenues.

## 2.4.2 User interfaces

The results of the econometric analysis are depicted on a devoted *kibana* dashboard; the “thessaloniki\_parking\_scenario\_gen\_data” index refers to the existing operation of the CPS, while “thessaloniki\_parking\_scenario\_svr\_data” index is related to projections on its future evolution, respectively. In Table 41, we report the fields of the “thessaloniki\_parking\_scenario\_gen\_data” index.

**Table 41: Fields of the “thessaloniki\_parking\_scenario\_gen\_data” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
Parking Spaces	number	Yes	Yes	Number of provided parking spaces
Parking Tickets	number	Yes	Yes	Number of parking tickets
Sector ID	string	Yes	Yes	ID number of CPS sector
Sectoral Performance	number	Yes	Yes	Sector performance
Total Revenues	number	Yes	Yes	Sector total revenues

The data used to create the visualization widgets are extracted from the econometric model in ndjson format. In Figure 82, we depict the format of the “thessaloniki\_parking\_scenario\_gen\_data” index.

```

{"index":{"_id":0}}
{"Sector ID": "FILIPPOU", "Total Revenues": 389181, "Sectoral Performance": 0.23, "Parking Spaces": 249, "Parking Tickets": 134070}

{"index":{"_id":1}}
{"Sector ID": "ETHINIS AMINIS", "Total Revenues": 287596, "Sectoral Performance": 0.19, "Parking Spaces": 224, "Parking Tickets": 92770}

{"index":{"_id":2}}
{"Sector ID": "P.P. GERMANOU", "Total Revenues": 271991, "Sectoral Performance": 0.38, "Parking Spaces": 106, "Parking Tickets": 81105}

{"index":{"_id":3}}
{"Sector ID": "ERMOU", "Total Revenues": 265678, "Sectoral Performance": 0.35, "Parking Spaces": 125, "Parking Tickets": 68150}

{"index":{"_id":4}}
{"Sector ID": "PAULOU MELA", "Total Revenues": 236786, "Sectoral Performance": 0.37, "Parking Spaces": 94, "Parking Tickets": 73280}

```

**Figure 82: Thessaloniki City - The selected data format for “thessaloniki\_parking\_scenario\_gen\_data” index**

The fields of the “thessaloniki\_parking\_scenario\_svr\_data” index are reported in Table 42.

**Table 42: Fields of the “thessaloniki\_parking\_scenario\_svr\_data” index**

Name	Type	Searchable	Aggregatable	Description
_id	string	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	string	Yes	Yes	Meta-field with the name of the index
_score	number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	string	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
1st Year	number	Yes	Yes	Forecasted revenues for the first year
2nd Year	number	Yes	Yes	Forecasted revenues for the second year
Sector ID	string	Yes	Yes	ID number of CPS sector

In Figure 83, we depict the format for the “thessaloniki\_parking\_scenario\_svr\_data” index.

```

{"index":{"_id":0}}
{"Sector ID": "FILIPPOU", "1st Year": 420007.71, "2nd Year": 831533.61}

{"index":{"_id":1}}
{"Sector ID": "ETHINIS AMINIS", "1st Year": 256820.50, "2nd Year": 515789.29}

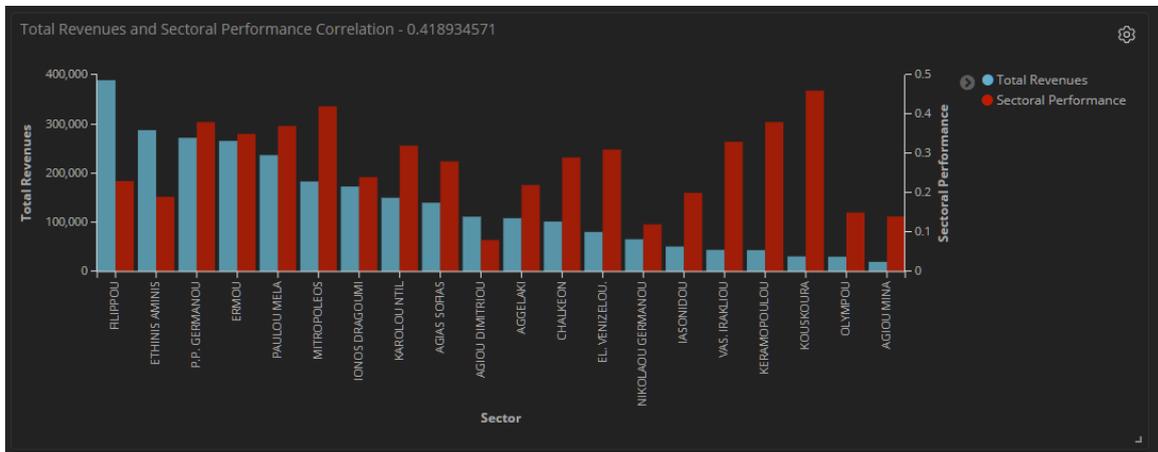
{"index":{"_id":2}}
{"Sector ID": "P.P. GERMANOU", "1st Year": 190754.19, "2nd Year": 383107.64}

{"index":{"_id":3}}
{"Sector ID": "ERMOU", "1st Year": 248349.04, "2nd Year": 498783.55}

{"index":{"_id":4}}
{"Sector ID": "PAULOU MELA", "1st Year": 242764.83, "2nd Year": 487521.80}
    
```

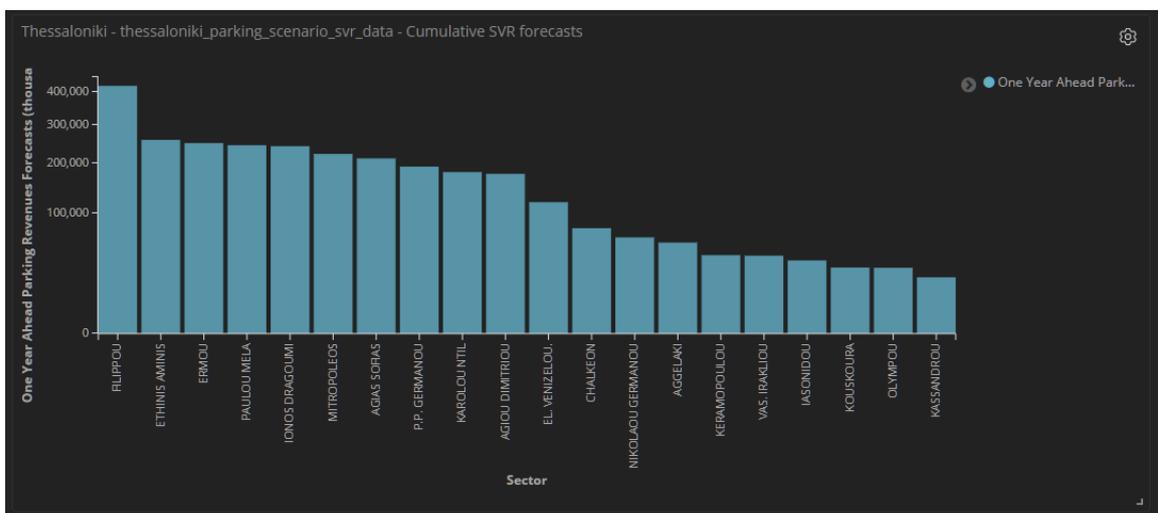
**Figure 83: Thessaloniki City - The selected data format for “thessaloniki\_parking\_scenario\_svr\_data” index**

In Figure 84, we depict the total revenues and the sectoral performance of the CPS in a multiple bar plot. The correlation between revenues and performance is 0.42, also reported on the dashboard.



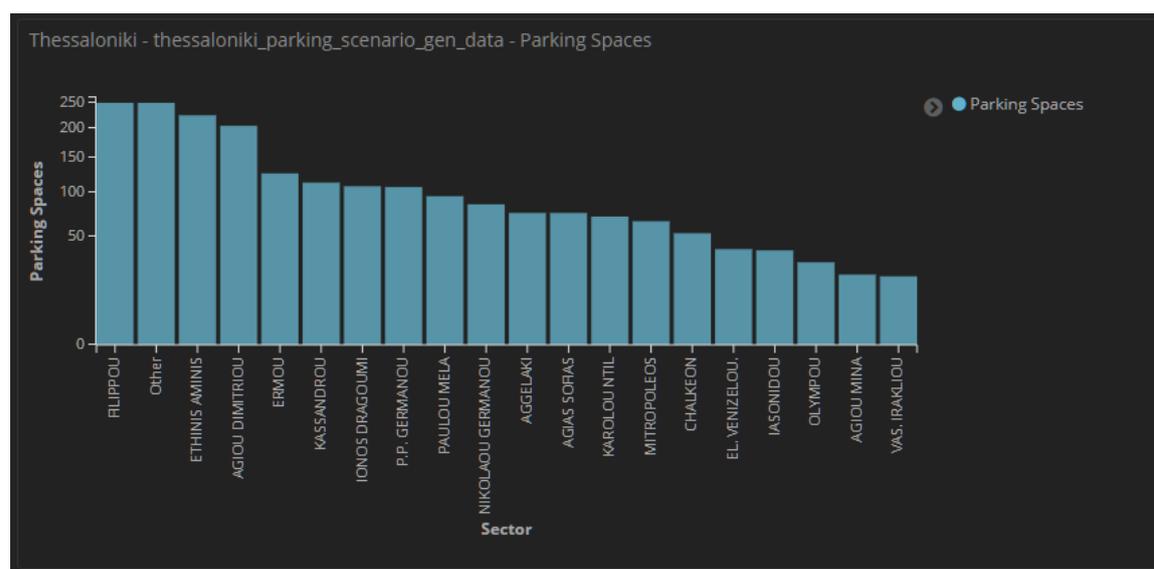
**Figure 84: Thessaloniki dashboard – Cross- correlation of total revenues and sectoral performance for Thessaloniki’s CPS**

In Figure 85, we depict the estimated sectoral future revenues of the CPS one-year-ahead.



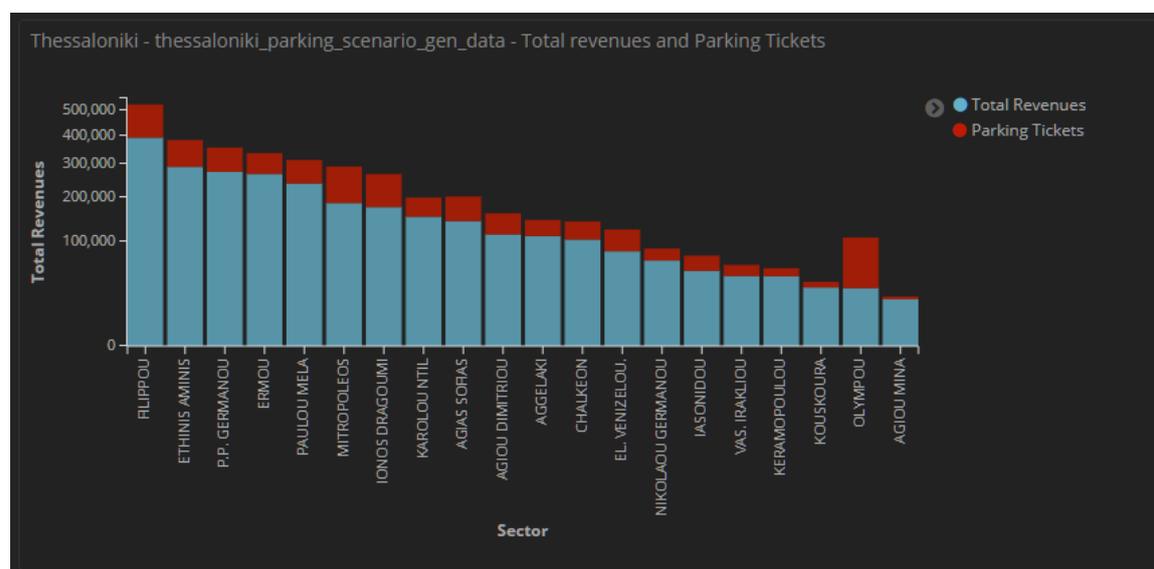
**Figure 85: Thessaloniki dashboard – One Year Ahead Parking Revenues Forecasts (thousands Euro)**

In Figure 86, we report the available parking spaces for each sector of the CPS.



**Figure 86: Thessaloniki dashboard – Thessaloniki’s parking spaces per CPS sector**

Finally, in Figure 87 we report the total revenues from parking tolls and parking tickets in a stacked bar chart, that provides a complete picture on current sectoral revenues. As it is obvious, there are certain sectors where parking tickets (red bars) are inexplicably higher than other sectors. This element could be of use to the Municipality of Thessaloniki in determining new patrol routes and smoothing these discrepancies that cause public distress. An example is sector “OLYMPOU”, where parking tickets are much higher than all other sectors and inexplicably high compared to the parking toll revenues of the sector.



**Figure 87: Thessaloniki dashboard – Thessaloniki’s total revenues and parking tickets per CPS sector**

In order to estimate the indirect economic effects of the CPS to rent and sale prices such, we compile data from spitogatos.gr (described in section 1.2). The data comprise

index “thessaloniki-spitogatos”. In Table 43, we report the fields of the “thessaloniki-spitogatos” index.

**Table 43: Fields of the “thessaloniki-spitogatos” index**

Name	Type	Searchable	Aggregatable	Description
_id	String	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	String	Yes	Yes	Meta-field with the name of the index
_score	Number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	String	Yes	Yes	The _type field is indexed in order to make searching by type name fast.
date	Date	Yes	Yes	The date (format: yyyy-mm) the crawler downloaded the data
category	String	Yes	Yes	Property category
Τύπος (subcategory)	String	Yes	Yes	Property subcategory category
Περιοχή (Location)	String	Yes	Yes	Property postal code
Τιμή ανά τ.μ (Price per square meter)	Number	Yes	Yes	Property price per square meter (if applicable)
purpose	String	Yes	Yes	Either property for sale or property for rent
Έτος κατασκευής (Construction year)	Number	Yes	Yes	Property construction year

The data used to create the visualization widgets are downloaded in ndjson format via the SPITOGATOS.GR crawler. Figure 88 depicts the format of spitogatos.gr data.

```
{
  "index": { "_id": "0" }
  { "Τύπος": "Διαμέρισμα", "Περιοχή": "-", "Έτος κατασκευής": "2012", "category": "Κατοικία", "year": "2019-2", "Τιμή ανά τ.μ.": "2.560", "purpose": "Αγορά" }

  "index": { "_id": "1" }
  { "Τύπος": "Studio/Γκαρσονιέρα", "Περιοχή": "Ευαγγελίστρια, 40 Εκκλησιές - Ευαγγελίστρια", "Έτος κατασκευής": "1958", "category": "Κατοικία", "year": "2019-2", "Τιμή ανά τ.μ.": "851", "purpose": "Αγορά" }

  "index": { "_id": "2" }
  { "Τύπος": "Διαμέρισμα", "Περιοχή": "Αρετσού, Καλαμαριά", "Έτος κατασκευής": "2010", "category": "Κατοικία", "year": "2019-2", "Τιμή ανά τ.μ.": "2.000", "purpose": "Αγορά" }

  "index": { "_id": "3" }
  { "Τύπος": "Μονοκατοικία", "Περιοχή": "Νέο Ρύσιο, Θέρμη", "Έτος κατασκευής": "2008", "category": "Κατοικία", "year": "2019-2", "Τιμή ανά τ.μ.": "1.850", "purpose": "Αγορά" }

  "index": { "_id": "4" }
  { "Τύπος": "Studio/Γκαρσονιέρα", "Περιοχή": "40 Εκκλησιές, 40 Εκκλησιές - Ευαγγελίστρια", "Έτος κατασκευής": "2007", "category": "Κατοικία", "year": "2019-2", "Τιμή ανά τ.μ.": "1.667", "purpose": "Αγορά" }
}
```

**Figure 88: Thessaloniki City - The selected format for SPITOGATOS.GR data**

The following figures depict the visualization widgets regarding the spitogatos.gr data. In Figure 89, we present the dashboard controls panel. The user can select one of the property categories (Κατηγορία) and the subcategories (Τύπος) to present to the dashboard.

Thessaloniki Dashboard spitogatos - Controls

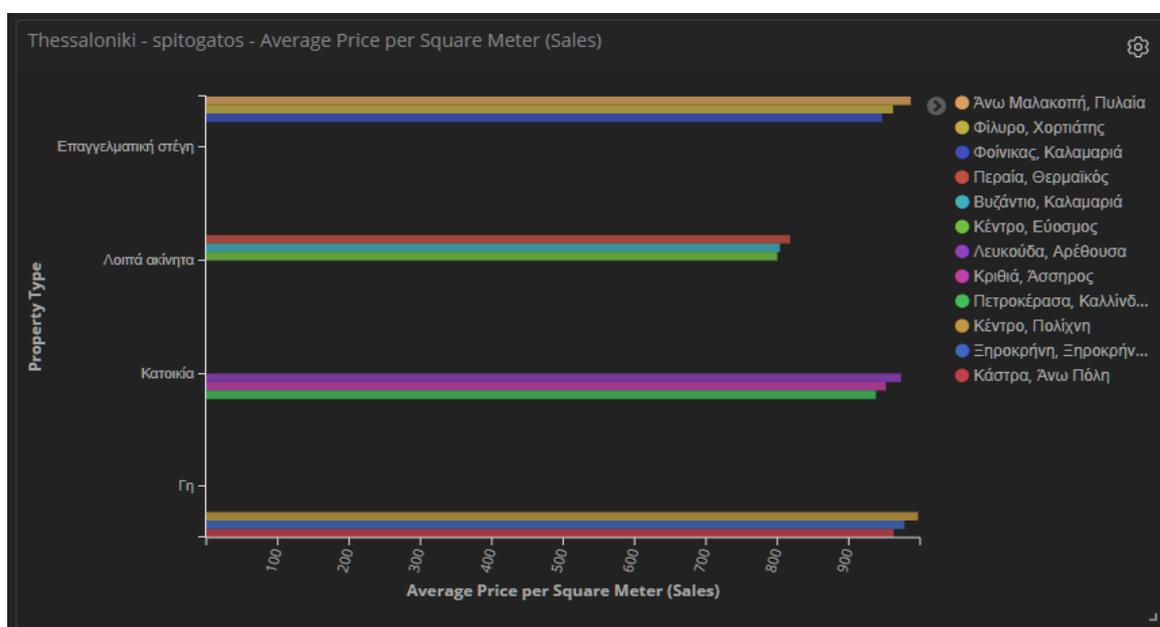
Κατηγορία Τύπος

Select... Select...

Clear form Cancel changes Apply changes

**Figure 89: Thessaloniki dashboard – Spitogatos.gr data control**

Figure 90 presents the average sale price for five property categories in Thessaloniki.



**Figure 90: Thessaloniki dashboard – Spitogatos.gr average sale price per square meter**

In Figure 91, we present the average rent price for five property categories in Thessaloniki.

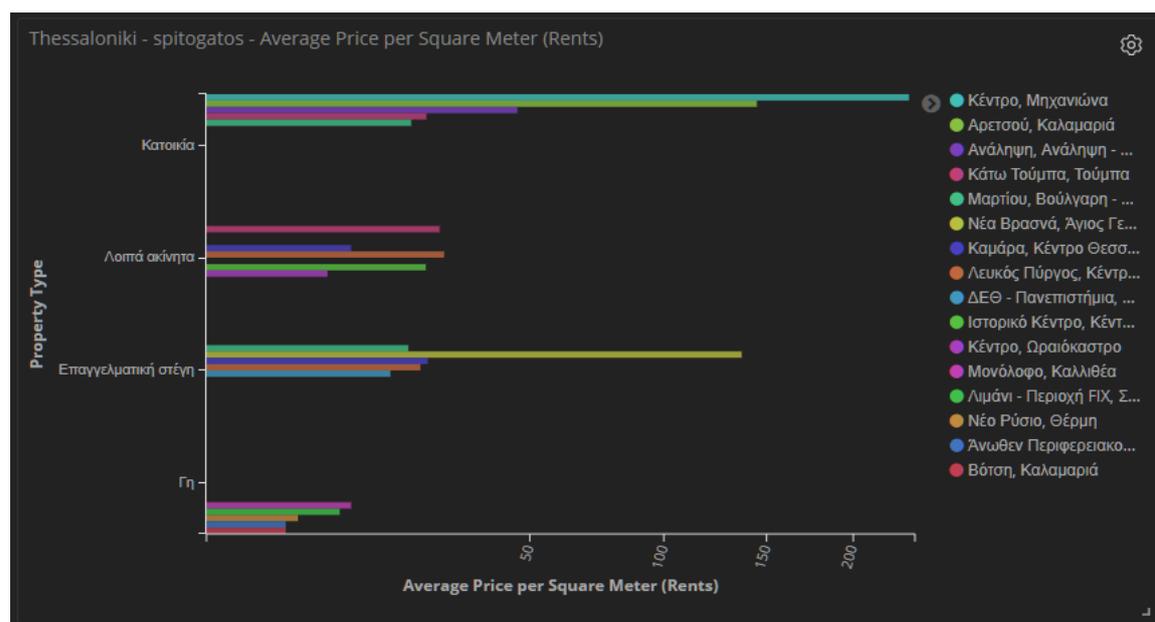


Figure 91: Thessaloniki dashboard – Spitogatos.gr average rent price per square meter

We concentrate all data on sale and rent prices in table format, depicted in Figure 92.

Thessaloniki - Data from spitogatos - Table

2019: Time (years)

Λοιπά ακίνητα: Category

Location	Subcategory	Purpose	Average Price per Square Meter
Περαία, Θεσσαλονίκη	Επιχείρηση	Αγορά	818
Βυθόνιο, Καλαμαριά	Επιχείρηση	Αγορά	803.5
Κέντρο, Εύοσμος	Επιχείρηση	Αγορά	800
Φυλίου, Αμπελόκηποι	Επιχείρηση	Αγορά	800
Καραμπουρνάκι, Καλαμαριά	Επιχείρηση	Αγορά	750
Καραμπουρνάκι, Καλαμαριά	Πάρκο	Αγορά	667

Export: Raw Formatted

Figure 92: Thessaloniki dashboard – Spitogatos.gr average sale price per square meter (table)

Additionally, we create an index named “thessaloniki-mapsme-dashboard” including all data from maps.me, regarding the supported amenities in Thessaloniki. Table 44 presents the fields of “thessaloniki-mapsme-dashboard” index.

Table 44: Fields of the “thessaloniki-mapsme-dashboard” index

Name	Type	Searchable	Aggregatable	Description
_id	String	Yes	Yes	Meta-field that each kibana document has a id that uniquely identifies it
_index	String	Yes	Yes	Meta-field with the name of the index
_score	Number	No	No	Relevance score related with queries made to the index
_source	_source	No	No	Meta-field that the original document is stored (without any analyzing or tokenizing)
_type	String	Yes	Yes	The _type field is indexed in order to make searching by type name fast.

date	Date	Yes	Yes	The date (format: yyyy-mm) the crawler downloaded the data
poi_category	String	Yes	Yes	Point of interest category
poi_subcategory	String	Yes	Yes	Point of interest sub-category
poi_geo_point	geo_point	Yes	Yes	The given GPS coordination (latitude and longitude) for each point of interest

The data used to create the visualization widgets are downloaded in ndjson format via the MAPS.ME crawler described in section 1.2. In Figure 93, we depict the data format.

```

{"index":{"_id":0}}
{"date": "2019-2", "poi_subcategory": "Cafe", "poi_category": "food", "poi_geo_point": " 40.6345,22.9419"}

{"index":{"_id":1}}
{"date": "2019-2", "poi_subcategory": "Fast Food", "poi_category": "food", "poi_geo_point": " 40.6708,22.7985"}

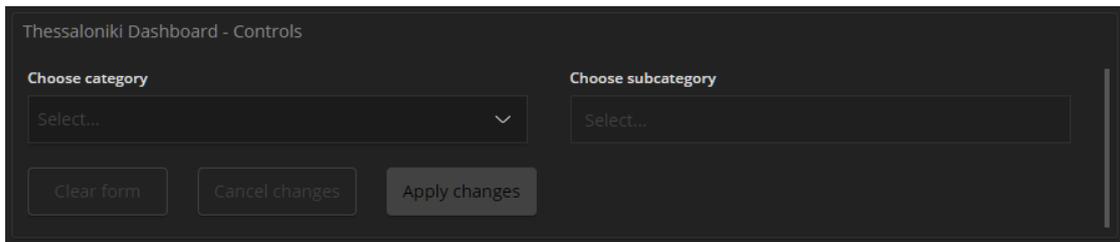
{"index":{"_id":2}}
{"date": "2019-2", "poi_subcategory": "Church", "poi_category": "attractions", "poi_geo_point": " 40.6611,22.9078"}

{"index":{"_id":3}}
{"date": "2019-2", "poi_subcategory": "Fast Food", "poi_category": "food", "poi_geo_point": " 40.5746,22.9492"}

{"index":{"_id":4}}
{"date": "2019-2", "poi_subcategory": "Bar", "poi_category": "food", "poi_geo_point": " 40.7019,22.9396"}
    
```

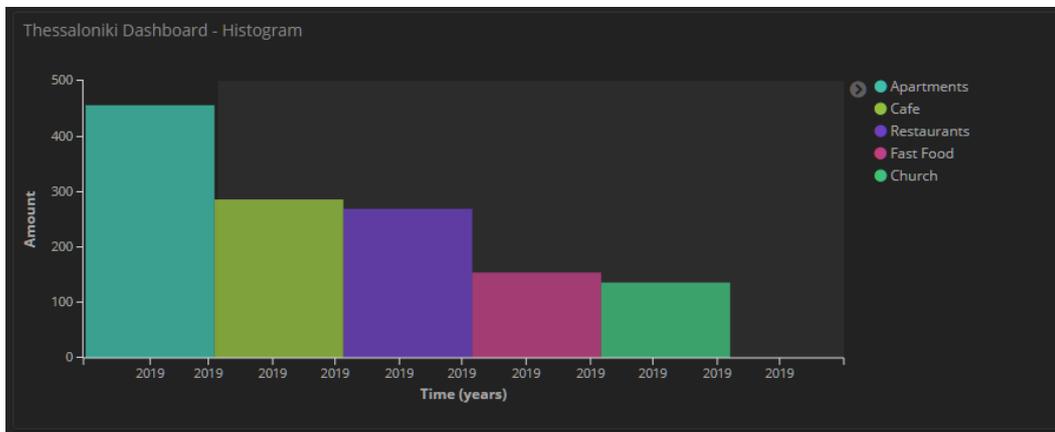
**Figure 93: Thessaloniki City - The selected format for MAPS.ME data**

In Figure 94, we present the control panel for maps.me data. The user can select the point of interest categories and subcategories presented to the dashboard.



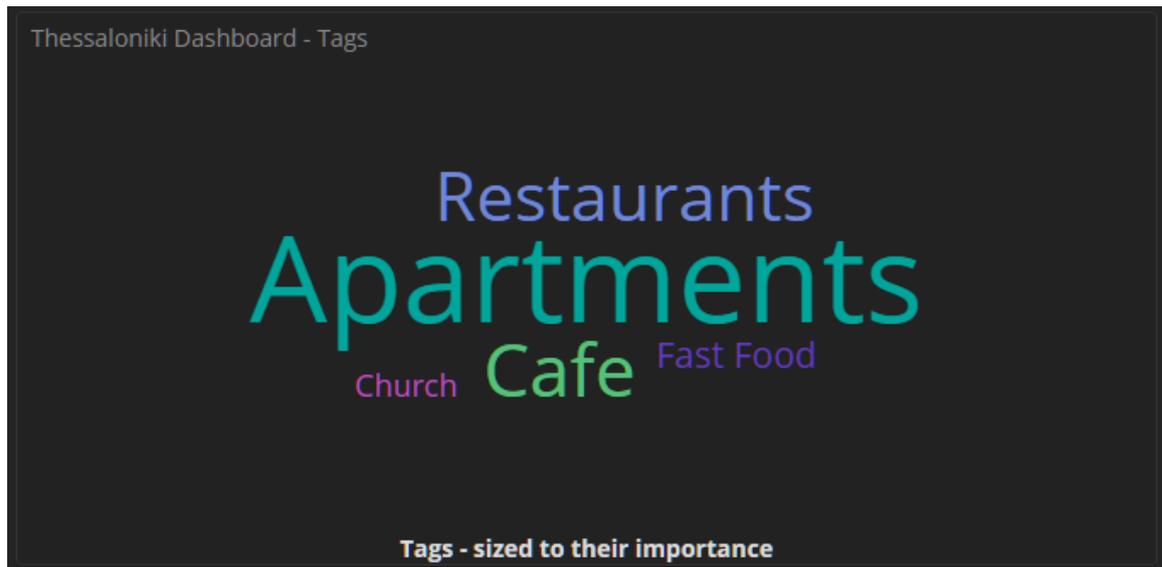
**Figure 94: Thessaloniki dashboard – Maps.me data control**

As with the other city pilots, the histogram in Figure 95 depicts the top-5 subcategories based on the number of available points of interest in the database. The X-axis measures time in years, while the Y-axis reports the number of points of interest, including only 2019 data.



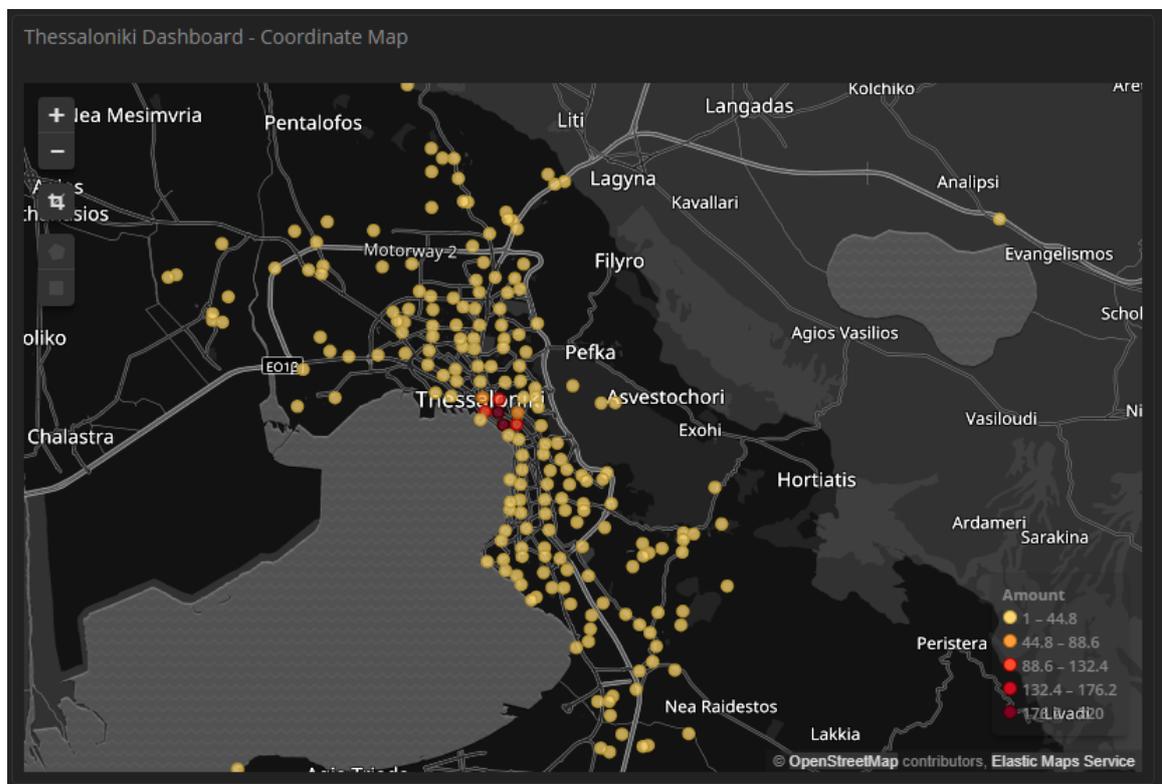
**Figure 95: Thessaloniki dashboard – Maps.me top-5 subcategories (yearly)**

Figure 96 presents a word cloud representation of the top 5 subcategories with the font size representing quantities.



**Figure 96: Thessaloniki dashboard – Maps.me subcategories tags sized to their importance**

The coordinate map in Figure 97 depicts the location of the points of interest (based on maps.me data) on a map of Thessaloniki. The red points on the map show high concentration of points of interest and thus areas of highest economic interest.



**Figure 97: Antalya dashboard – Maps.me coordinate map with points of interest**

Finally, all data from maps.me are concentrated on a table format in Figure 98.

Thessaloniki Dashboard - Table

Time (years) ▾	Category ▾	Type ▾	Amount ▾
2019	food	Cafe	286
2019	food	Restaurants	269
2019	food	Fast Food	154
2019	food	Bar	78
2019	food	Pub	21
2019	lodging	Apartments	456
2019	lodging	Hotels	128
2019	lodging	Guest Houses	17

**Figure 98: Antalya dashboard – Maps.me table**

Nevertheless, once again, we decide not to include the visualizations from maps.me to the dashboard, given the low coverage of point of interest in the city. In a future version of the dashboard, as the database of maps.me will increase, we will include these data. The final version of the dashboard named “Thessaloniki Dashboard” is presented in Figure 99.



Figure 99: Thessaloniki dashboard – Kibana Dashboard

## Conclusions

The lack of a consistent way in presenting economic data often confides policy-making to intuition and experience. In contrast, the presentation of data in an easy-to-use dashboard could help to move towards an evidence-based policy implementation and evaluation. This deliverable focuses on the economic evaluation of the objectives posed by city pilots in D9.1 of the CUTLER program. We describe the econometric methodologies used in quantifying the economic impact of policy interventions to the regional economy and present the results of the analysis in user-friendly visualizations.

On a pilot city level, we estimate the expected economic spillovers from the renovation of Duden waterfall in the local economy and provide quantitative evidence that supports the decision-making process of the Municipality of Antalya. An increase in the expected numbers of visitors from the renovation of the area of the waterfalls will have significant economic spillovers to the local economy in terms of employment positions, economic activity and the overall output of the local economy. In the case of Antwerp, changes in the climate conditions pose certain threats to the economic activity in the region. By measuring the direct and indirect economic damages from floods in Antwerp we provide quantitative measures of risk that can be used by the pilot city in a cost-effective analysis. Moreover, our analysis suggests that the effects of economic damages from floods are already considered by local stakeholders (as reflected on the price of rents), which calls for policy actions to lower exposure to economic damages as a result of floods.

Cork will use the CUTLER platform as a decision tool to implement targeted policies in increasing the number of visitors in Camden Fort Meagher and establish it as a popular touristic destination. Based on scenario analysis we find that the renovation of Camden Fort Meagher will have a positive impact on the local economy in terms of employment and local GDP. Furthermore, on a project administration level, we find that the focus of the local administration should be on attracting foreign visitors in order to further boost revenues, which future revenues are expected to match the respective revenues of other similar touristic attractions in the area in the first two years in operation. Finally, our analysis provides an estimate on the minimum capacity of the parking facilities in the Fort.

The objective of Thessaloniki, is to use the CUTLER platform to design, implement, monitor, and evaluate the new controlled parking system in the 1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> Municipal Districts of the city. The detailed economic scopes of the city are the redistribution of parking spaces between visitors and residents, the increase of profits and public satisfaction as a result of a differentiated price policy. Our analysis pinpoints underperforming parking sectors, detects sectors of high public discomfort and proposes certain initiatives that will serve the objectives of the city.

The most important element of the deliverable is the presentation of the rigid econometric analysis in a user-friendly way that elaborates on the results and assist the decision-making process of the pilot cities. The dedicated *kibana* dashboards and the interactive (custom) econometric dashboard alleviate the need for expert field knowledge by the user, proving a useful tool to the planning, implementation and the evaluation cycle of the program.

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