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A holistic approach for measuring quality of life in “La Condesa” district in Mexico City

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Abstract

Mexico City government has empowered central and historical areas implementing public policies intended to activate their economy. This is the case of the district *La Condesa* located 4 Km. from the Historical Downtown Area of Mexico City. Yet, beyond the activation of economy, promoting massive tourism, leisure activities and business life, these policies have had questionable social implications. For example, valuing spaces for the benefit of the real estate investors that do not live in the areas and that promote non-permanent lodging. Authentic quarter life with inhabitants of different socio-economic strata that create and act upon the urban environment of the district. Besides, the district attracts franchises that do not promote “authentic” services and products (e.g., local food, goods and handicrafts). Thus, it seems that the growth in economy with this approach is not compatible with citizens wellbeing, with the cultural preservation and the conservation of the green areas of the area.

This paper presents our approach for computing an index of quality of life considering quantitative and qualitative measures seeking to help to promote the maximisation of a holistic return of investment that we name elasticity of quality of life. Our notion of return of investment is holistic because it considers both quantitative and qualitative aspects calibrated to find and "optimum" of economic and wellbeing benefit. Wellbeing is an immaterial value difficult to measure, so we adopted a data science method for providing an objective model to this subjective value. The objective model would help us experiment and support exploring different perspectives of citizens' wellbeing and how public policies impact it. Our method includes gathering data regarding different indicators associated to wellbeing and economic empowerment of the district. Our proposal combines different data collections provided by the Mexican National Institute of Statistics and Geography (INEGI) that feed a novel mathematical model proposed for computing determining the elasticity of the index of quality of life. Given the volume of data sets about Mexico City and its inhabitants it has been necessary to use adapted computational methods to model urban phenomena happening in the district *La Condesa* in Mexico City. We have applied data analytics computational techniques¹ based on mathematical methods, statistics and knowledge discovery to find patterns within data sets that represent the behaviour of quality of life as a social phenomenon measure.

Context and motivation

Mexico City government has implemented public policies to empower the economy of the central and historical district *La Condesa* located 4 Km. from the Historical Downtown Area of Mexico

¹ Data analytics is a process of inspecting, cleansing, transforming, and modelling data for discovering useful information, informing conclusions, and supporting decision-making.

City. Beyond the activation of economy, that promotes massive tourism, intensive leisure activities and business life, these policies have had questionable social implications. For example, the increase in the m² price, that provides economic benefits to real estate investors that do not live in the district and that promote non-permanent lodging. “Authentic” neighbourhood life with inhabitants of different socio-economic strata is no longer possible because they cannot afford the high cost of the m², access to parking, markets and supermarkets, and leisure activities. The emergence of franchises does not promote authentic local services and products, besides franchises can leave the district when the economic flourishing is no longer possible or interesting. Thus, it seems that the growth of economy is not compatible with a harmonic human development, cultural benefit and conservation of the green areas of the district².

We believe that these issues emerge because public policies are designed empirically neither defining quantitative and qualitative objectives nor using quantitative measures to assess them. Public policies are designed considering seeking a one variable objective for example economy activation. When public policies are applied to activate the economy in urban areas, computing the quality of life index (QoL index) seems to be a "natural" assessment strategy. This index is defined as a “multidimensional index measuring good living conditions and degree of wellbeing. It includes the collective satisfaction of needs obtained through social and public policies”³.

Different mathematical models have been proposed for measuring QoLI⁴. Some consider measurable variables often based on economic indices⁵. Others consider qualitative variables such as happiness, noise and stress⁶. Other visions like the theory of utilitarianism by Jeremy Bentham define QoL index as the maximum wellbeing that can be experienced by the maximum number of people. According to utilitarianism, public policies must generate the highest benefit to the maximum number of people. Inspired by utilitarianism, we developed a holistic approach for measuring the impact of public policies applied to activate the economy of the district *La Condesa* in Mexico City. The questions addressed by our study were: To which extent have public policies, transformed QoL standards? Did they result in an improvement in the inhabitants’ QoL? Are segregation, exclusion, changes in the use of land, lack of water, overpopulation, desertification really beneficial to economy and acceptable for the area long time?

Our work introduces the concept of “elasticity of quality of life” (E-QoL) that defines a relationship between the QoL of the inhabitants in a territory with respect to variables affecting inhabitants’ welfare. E-QoL goes beyond computing an index, it rather finds a point where economic and wellbeing benefits obtained through public policies are optimised. Thus, E-QoL maximises a holistic return of investment that considers quantitative and qualitative variables calibrated to find an "optimum" of both economic and wellbeing benefits. The following questions can be answered using E-QoL: Until which extent the construction of high standing buildings will create unbalance in social diversity and a feeling of exclusion in middle class inhabitants in a given area? Which is the limit of number of restaurants and night clubs that can be attracted before generating an important shortage of parking areas?

2 Rodrigo Fernández, M. (2010). Políticas Públicas. Beneficios Privados. Foro de Turismo Responsable

3 Nussbaum, M. C., Sen, A., & Mazzoni, R. R. (1996). La calidad de vida (Vol. 588). México: Fondo de Cultura Económica.

4 Paškorius, S. (2015). The Methodology for Computing the Quality of Life Index. International Journal of Information Technology, Vol. 5, No. 2, February, 2015.

5 Stiglitz, J., Sen, A., & Fitoussi, J. P. (2009). Measurement of economic performance and social progress. Online document <http://bit.ly/JTwmG>. ; Nacional index of quality of life,

http://hdr.undp.org/sites/default/files/HDR2016_SP_Overview_Web.pdf 25 February 2018.; OCDE. (2013). *Índice para una vida mejor. Enfoque en los países de habla hispana de la OCDE. Chile, España, Estados Unidos y México*. Retrieved from http://www.oecd.org/centrodemexico/Índice para una Vida Mejor resumen_130529.pdf

6 García, V. J. J. (2011). Hacia un nuevo sistema de indicadores de bienestar. Revista internacional de estadística y geografía, 2(1), pp. 78-95; IMCO, ¿Cómo se mide la felicidad?, Retrieved from https://imco.org.mx/articulo_es/como_se_mide_la_felicidad/ Accessed the 2nd March 2018.

We adopted a data science method for experimenting and supporting our approach for measuring QoL as an assessment indicator of public policies intending to activate the economy of *La Condesa* district. The method includes gathering data regarding different indicators associated to wellbeing and economic empowerment of the district. Our proposal combines datasets provided by the Mexican National Institute of Statistics and Geography that feed the mathematical model proposed for computing the e-QoL. Given the volume of data about Mexico City we have used adapted computational methods to compute e-QoL in the district *La Condesa* in Mexico City. We have applied data analytics techniques based on statistics and knowledge discovery to find patterns that represent the behaviour of QoL as a social phenomenon measure.

This paper proposes a data science-based method used for studying QoL in the district *La Condesa*. It shows how digital data can be used defining a possible mathematical model and apply it to have a possible view of an immaterial value, like citizens' wellbeing. Accordingly, the remainder of the paper is organized as follows. We first discuss about existing approaches devoted to the identification of variables for measuring the QoL index and discusses which are the aspects that we adopt and those that we redefine and enhance to have a more representative definition of the index so that it can be useful for assessing public policies. Then, we review the most prominent QoL index models with particular interest in the variables (quantitative and qualitative) used for defining the index. The next section introduces our proposal of data-based quality index, defines the measures that compose it and discusses the analytics approach proposed for computing it. The paper concludes insisting on the possibilities provided by data science techniques in addressing urban problems and discussing about future work.

Modelling Quality of Life as a Mathematical Artefact

The challenge of measuring wellbeing is that a subjective concept determined by different factors and also by cultural and personal perspectives must be modelled and transformed into a mathematical artefact that is, into an objective concept, quality of life (QoL). It is not possible to have one unique mathematical representation, QoL can be modelled by different possible mathematical models that turn different indicators into variables. Indicators are used as "sensors" that together are intended to influence a personal or collective impression of wellbeing. Transformed into variables (indicators and their associated way of computing them) indicators participate in mathematical formulae that combine them according to a specific strategy. The result of applying a formula to specific variables' values leads to a value, the index of QoL. Thus, different indicators and different way of relating them implies different perspectives of QoL. Next, we describe some representative approaches.

Measuring the QoL and wellbeing of inhabitants in urban areas has been discussed and studied by international forums and commissions⁷. For example, the study "How is life?" (OCDE. 2011) proposes 11 quantitative and qualitative groups of indicators (housing, income, jobs, community, education, environment, civic engagement, health, life, safety, work-life balance) that characterize wellbeing and that can be used for measuring QoL. The Human Development Index (HDI)⁸ includes three main indicators health, education and living standards. The Organization for Economic Co-operation and Development (OECD) and the United Nations (UN) measure the QoL of their member countries using criteria that contribute to (i) determine whether public policies

⁷ Beyond GDP was held in November 2008)

⁸ Sagar, A. D., and Najam, A. (1998). The human development index: a critical review. *Ecological economics*, 25(3), 249-264.

close the gap among inequalities; and (ii) to measure general progress. The European Parliament, the OECD and the World Wide Fund for Nature (WWF) have been seeking to develop indices based on accurate measurements that model daily life, poverty, inequality and the needs of the inhabitants in specific areas. The study proposed by National Statistics Institute in Spain defined a QoL index based on different studies like Eurostat which includes qualitative measures. The National Institute of Statistics (ISTAT) defined 12 indicators for evaluating progress that included economic, social and environment aspects⁹. The Commission on the Measurement of Economic Development and Social Progress (CMPEPS) created in 2008 in France defined new measures to evaluate social progress. This report, today called Stiglitz-Sen-Fitoussi, is a guide and basis for different QoL indices in the world¹⁰. In 2016 the Stiglitz-Sen-Fitoussi report included a new section on multidimensional analysis introducing welfare components. This measurement made by the Quality of Life Expert Working Group that includes 9 indicators (material living conditions, product or main activity, education, health, leisure and social interactions, economic and physical safety, governance and basic rights, natural and living environment, overall experience of life). Data are collected through surveys answered by individuals. Other data are gathered from the Living Conditions Survey (LCS) and the Economically Active Population Survey (EAPS). QoL indexes proposed in Hong Kong include personal, social, political, cultural, economic and environmental measures, along with 21 indicators classified into three groups: social, economic and environmental. It introduces variables such as degree of press freedom and stress.

In Latin America, Chile, for example, conducts a QoL study conducted by the Ministry of Health (MISAL), the last ENCAVI 2015-2016, executed by DESUC (Social Studies Directorate) and is carried out to determine the status of society for the design, development and evaluation of public policies¹¹. The project "Quality of life in Argentina"¹² proposes a ranking approach of wellbeing by department. It identifies different strategies for measuring poverty and QoL. Poverty is defined as a measure of deprivation including those who do not reach and established minimum threshold. QoL is defined with respect to an optimum economic level, where, poverty is measured with respect to a minimum value, the QoL is measured with respect to a maximum value. Then, for computing the QoL index, the study uses quantitative and qualitative indicators that are considered to model personal satisfaction. This index is defined by combining 5 categories and 20 indicators defined by socioeconomic and environmental variables. The data used for computing these measures are gathered in census, statistical sources, satellite images and surveys.

The Mackenzie Presbyterian University, through its Nucleus of Research in Quality of Life (NPQV) is preparing the Economic Index of Quality of Life (IEQV). This index uses other indicators besides the ones proposed by the Human Development Index (HDI) like transport, visual pollution and noise. These variables are pondered with different weights when they are combined to define the QoL index. Data used for computing these variables are collected by the Brazilian Institute of Geography and Statistics and the national survey for housing sampling. The IEQV aims to achieve a deeper analysis of the various elements that affect the evolution of human development. "The question is not to substitute any indicator (like the HDI), but to provide a

⁹ It consists of 12 indicators and by 2017 has the fifth edition.

¹⁰ Since 2013, a report produced to obtain knowledge of how the quality of life is, for the benefit of creation of public policy. This measure of fair and sustainable wellbeing is carried out by the. The National Institute of Statistics (ISTAT) defined 12 variables for evaluating progress that included economic, social and environment aspects. It consists of 12 indicator and by 2017 has the fifth edition

¹¹ <http://www.minsal.cl/encuesta-de-calidad-de-vida-y-salud-del-minsal-674-de-la-poblacion-reconoce-tener-una-calidad-de-vida-buena-o-muy-buena/> accessed the 3rd September 2018.

¹² <https://teleport.org/cities/buenos-aires/>

broader evaluation, because we are building an index from a more extensive database", explains Roseli da Silva, coordinator of the Nucleus of Research on Mackenzie's Quality of Life¹³.

In Mexico, the welfare index named National Index of Quality of life (INCAVI) proposed by the University of Monterrey 2011 uses seven classes of measures each divided into different qualitative and quantitative values variables. The National Institute of Statistics and Geography (INEGI) proposed the BIARE index (self-report of wellbeing) used to measure the way people experience their own QoL. It is based on measuring the subjective indicators of wellbeing and defines the OECD guidelines.

The Paradise of Michalos (Michalos, A. C., 2013). recognises that people living in the same area can have different points of view concerning the conditions of life. (Michalos, A. C., 2013) proposes a matrix where he identifies (i) the paradise of the fools (ii) the real paradise (iii) the real hell and (iv) the hell of the fools. In these spaces the perception of life depends on the perception of the people who live there. He underlines the importance of the conditions in which surveys are applied to gather the perception of people about their QoL. The sequence of the questions, the working are factors that strongly influence the answers of to a survey.

According to existing approaches for measuring QoL, they must include both quantitative and qualitative measures. We also underline the importance of the quality of data used for computing the different variables. This quality includes the provenance, the choice of the population interviewed for collecting data (socio-economic level, education, age, gender), the reliability of the data, the freshness, etc.

Discussion

Many studies are aware of the importance of considering the socio-economic level of the population because the perception of QoL, expectations of public policies intended to make life better are highly determined by this indicator. The inclusion of qualitative measures (e.g., happiness, mood, peace, serenity, noise, smell) can be useful to observe this perception which, as said previously, can be calibrated by the socio-economic level. Considering quantitative indicator can lead to a real knowledge of the problems and needs of the inhabitants of the city. One point to explore is finding the right space to obtain the data and information that will be used to fill in each of the items that will define the proposed QoL index. Most countries work with censuses and surveys organized by public bodies and applied every 5 and 10 years directly to some inhabitants. This information may not be as representative because data are not recurrently updated, and analysis are done months and even years later. The use of Information and Communication Technologies (ICT) and particularly of data science techniques open new possibilities for designing different data collections methods that include explicit and implicit participation of citizens through social networks, online games, sensors and cameras. These data collection techniques complete the classic surveys and interviews applied to "representative" citizens. Data can be maintained, updated and shared with different qualities explicitly described by providers. Different analysis and models can be computed automatically and thereby enable the comparison of analysis that can lead to more representative interpretations.

¹³ <https://www.knowledgeatwharton.com/es/article/brasil-y-la-guerra-de-los-indices-de-calidad-de-vida/>

Public Policies, Economic Prosperity and Quality of Life

Contemporary urbanism addresses the relationship between quality of urban environments with the social, economic and environmental performance of societies, and citizens' wellbeing. Yet, some local governments have proposed public policies that go against this vision because they insist on economic growth rather than on wellbeing or on a proportional combination of both. During the last decade, the economic growth of the real estate market and tourism has been achieved through the revaluation of historical downtown areas. Revaluation is the result of urban processes achieved through public policies aimed at bringing about changes in the territory. In

For example, the Ministry of Tourism in Mexico has implemented public policies under the Magic Towns Program since 2001¹⁴. By March 2018, 118 magical towns had been labelled. This program is intended to activate the economy, in particular tourism, in small villages and historical downtown quarters insisting in their material and immaterial cultural patrimony. Public policies associated to this program seem to have activated the economy of the tourism sector, as seen in the Datatur ranking¹⁵ where Mexico moved from the 8th in 2016 to the 6th touristic attractive country. Public policies of the program Magic Villages have been also controversial regarding the respect of cultural patrimony, particularly in places where archaeological zones are not completely discovered, and the construction of touristic infrastructure can damage this patrimony.

In Mexico City, the government has implemented public policies to activate the economy by privileging the construction of lodging spaces in the central districts (e.g., Cuauhtémoc and Benito Juárez districts see Figure 1) instead of letting citizens leave to external residential areas. These policies seek a social diversity balance but insist on economic goals intended to be achieved by promoting the architectural charm of urban spaces in these central counties. The principle is that if economy is activated, people will increase their purchasing power and consequently their QoL will increase too. The activation of the economy is thereby achieved by promoting massive tourism, leisure activities and business life. However, these policies have had questionable social implications too. For example, valuing spaces for the benefit of the real estate investors that do not live in the areas and that promote non-permanent lodging; franchises that do not promote authentic services and products, habitability of these areas and their desertification in favour of so called, artificial empty zones. Thus, it seems that the growth in economy with this approach is not compatible with human development, with the cultural benefit and the conservation of the green areas of the district. In the case of Mexico City, very often public policies have not been designed in accordance with ministries and agencies taking care of the environment, the protection of indigenous groups, ecology and preservation of the environment.

¹⁴ <http://www.pueblosmexico.com.mx/>

¹⁵ <https://www.datatur.sectur.gob.mx/SitePages/RankingOMT.aspx>

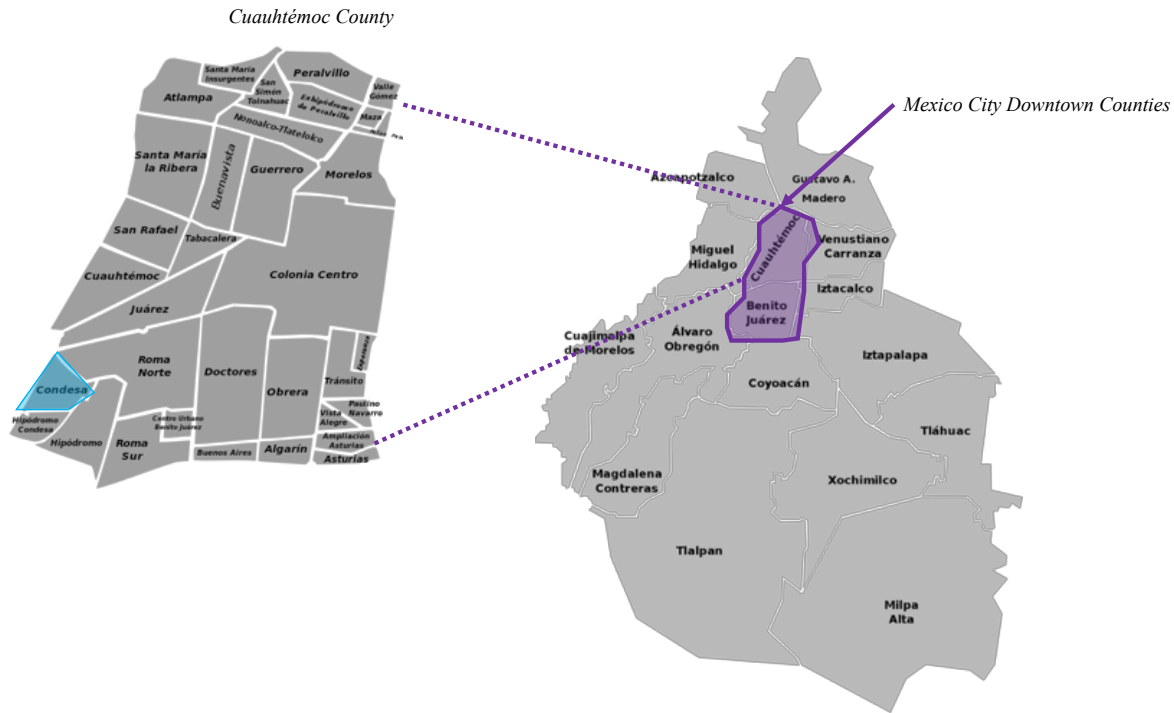


Figure 1 Urban distribution of the Mexico City Counties & location of *La Condesa*

In fact, this kind of economy activation strategy has been implemented in different countries. In many cases around the world, it has been possible to observe negative side effects not always reasonable to justify the positive ones. The following section describes examples and side effects that seem to support the hypothesis that economy activation policies have been empirically defined, or at least without taking into consideration all variables affecting the economy and possible side effects in the QoL of urban areas. That is, public policies often focus only on one “optimisation objective”: economic welfare.

Revaluation policies for activating economy

This section analyses a sample of countries that have applied similar policies and have observed disadvantageous implications in the social and human aspects. We chose examples of developing economies willing, like Mexico, to build their economic development strategy on top of tourism and related economic categories (e.g., Morocco). We also chose as examples, developed economies that aim at consolidating and accelerating some aspects of their economy (e.g., Barcelona).

Morocco created public policies aimed at the economic growth of the tourism and real estate sectors seeking to benefit from mass tourism (characterized by the standardization of its provision and the high seasonality of consumption). The consequences of mass tourism in Morocco are translated into "territorial imbalances, disappearance of traditional economic activities, environmental degradation and increased economic dependence" (Rodrigo Fernández, M. 2010). In the environmental aspect "the Moroccan tourism development has been source of deprecation of the territory and its ecosystems" (Rodrigo Fernández, M. 2010), increasing problems such as the lack and supply of water, the price of land, displacement of people, increase in environmental

pollution, concentration of wealth in the North of Morocco and greater social differentiation in the south, threat of identity, discrimination, among others¹⁶ (Rodrigo Fernández, M. 2010).

In Europe, Barcelona is an example of a city that implemented public policies applied in historical areas for the benefit of the tourism and real estate sectors. Tourism is the first concern of Barcelona according to the biannual barometer of the city council of Barcelona¹⁷. The consequence has been the emergence of mobility conflicts, increased pollution, increased consumption of water and energy, dispossession of public spaces and denial of the basic right to housing (Romero, J. 2009)¹⁸. Tourism represents 15% of Barcelona's Gross Domestic Product (GDP) it is good, but needs regulation says the mayor:

"Both tourists and citizens agree that tourism is very positive for the city of Barcelona. But also, to keep it positive, we must put order, we must regulate it to be sustainable".

In some neighbourhoods there are more tourists than residents, which results in an increase in rent and lack of lodging for citizens themselves that have to leave to suburbs¹⁹.

The side effects of public policies in urban spaces like the ones we have described above can be described through the notion of gentrification. Gentrification denotes an economic, social and politic phenomenon that redefines the “value” of central areas in cities and that causes the emigration of citizens with low income (low classes) to suburbs to privilege the arrival of citizens with middle and high income.

Few studies have been done about the gentrification in phenomena in Mexico City. The most prominent ones have analysed the consumption sphere to determine (i) the behaviour of consumers of the revalued urban areas, particularly in the way new middle classes, artists, and creative millennials invest to increase their patrimony; (ii) the public policies that create the gentrification processes²⁰. Delgadillo, Díaz and Salinas (Delgadillo, V., Díaz, I., and Salinas, L. 2015) conclude that revalorized historic districts are at the end considered elite territories thanks to a multidimensional model consisting of aspects like real state (urban property), architecture and urban rehabilitation and renovation, change in the socio-economic strata of inhabitants, cultural, social (urban space/district identity).

Studies are based on the definition of quantitative models that can provide a better understanding of the aspects that characterise public policies, the context in which they are implemented, and the side effects caused by their implementation. The challenge is to determine the indicators (variables) to be considered for modelling public policies and QoL. Economic indicators already exist. In order to correlate and compare the growth of economy and the side effects on wellbeing every aspect must be Mathematically modelled. The notion of QoL index describes quantitatively the QoL of citizens in a given urban area.

¹⁶ Rodrigo Fernández, M. (2010). Políticas Públicas. Beneficios Privados. Foro de Turismo Responsable

¹⁷ https://elpais.com/ccaa/2017/06/23/catalunya/1498212727_178078.html

¹⁸ Romero, J. (2009). Gobernanza Territorial en España. Más Sombras que Luces. Instituto Interuniversitario de Desarrollo Social. Oviedo. Spain.

¹⁹ <https://es.euronews.com/2017/06/28/barcelona-el-problema-del-turismo-masivo>

²⁰ Delgadillo, V., Díaz, I., & Salinas, L. (2015). Perspectivas del estudio de la gentrificación en México y América Latina. Geografía para el siglo XXI, Serie: Libros de investigación, (15), pp.120

Defining a quantitative model for Quality of Life

For the time being, public policies are often designed empirically without defining quantitative and qualitative objectives and quantitative measures to assess them. Besides few efficient methods have been developed first to collect the data and then transform these data that can come from polls, interviews, crowdsourcing procedures, social networks and digital sensing. Representative indexes have to be defined to transform as much as possible, reported observations and comment from citizens and city actors into abstract models that can be analysed and understood. Urban computing, urban informatics are emerging sciences willing to define such indexes. In the case of the strategies applied to activate the economy of urban areas, the QoL index has been an immediate and "natural" assessment strategy.

QoL is defined as a "multidimensional index that measures good living conditions and degree of wellbeing. It also includes the collective satisfaction of needs obtained through social policies"²¹ (Palomba, R. 2002). Another definition proposed by Amartya Sen²², focusses on the individual as a fundamental element for observing wellbeing and the ability to define and measure QoL. For Professor Sen, the most precise measures of social welfare have to do with the abilities that human beings have to be able to develop in their daily lives and that are part of their rights. Some studies and QoL measures used today are part of this theory. Once the epistemological principle underlying the notion of QoL is defined, it is necessary to define mathematical models that translate this definition into measures and variables. These models are the initial tool that can lead to the computation of indexes that can be analysed in an immediate manner, which particularly useful for political communication to citizens and decision makers.

Different mathematical models have been proposed for measuring QoL (Puškorius, S. 2015)²³. Some models consider measurable variables often based on economic indices. Other models adopt holistic approaches and consider qualitative variables such as happiness, quality of experience and stress. Other models are based on the theory of utilitarianism by Jeremy Bentham, that defines QoL as the maximum wellbeing for the maximum number to act in a way that produces greater benefit to a greater number of people. This goes beyond the measurement of an index, which means computing a value, but it seeks to define a point within a spectrum where economic and wellbeing benefits searched by public policies are optimised.

In any case, the challenge is to choose the variables that determine QoL and then collect meaningful and objective data that can be used for computing them. For example, the United Nations Organization (UNDP) makes a report every year, which includes all its member countries, in which it measures the Human Development Index (HDI). The interesting thing about this index is that in addition to measuring. Macroeconomic values of the country investigated introduce values on health, education and income. This organization "seeks to direct the attention of the government and civil society towards one of the most pressing challenges facing the country: achieve development with less inequality"²⁴. The OECD conducts a study called How is life? This analysis considers eleven variables (objective and subjective): employment, income, housing, community, education, work balance, environment, citizen participation, health, satisfaction with

²¹ Palomba, R. (2002). Calidad de vida: conceptos y medidas, https://www.cepal.org/celade/agenda/2/10592/envejecimientorp1_ppt.pdf

²² Nussbaum, M. C., Sen, A., & Mazzone, R. R. (1996). La calidad de vida (Vol. 588). México: Fondo de Cultura Económica.

²³ Puškorius, S. (2015), The Methodology for Computing the Quality of Life Index. International Journal of Information Technology, Vol. 5, No. 2, February, 2015.

²⁴ Hassler, J., Mora, J. V. R., & Zeira, J. (2007). Inequality and mobility. Journal of Economic Growth, 12(3), 235-259

life and safety. It is done with the intention that their governments direct public policies towards the problems of their population, seeking greater equality²⁵.

Having measures makes it possible to apply data science techniques for running different types of analysis starting from descriptive statistics, discovery of causal and temporal correlation among variables, discovery of urban events' patterns. Data science has opened possibilities for understanding and solving problems in the city. Proposals such as Data City, Smart City or Urban Computing and Urban Informatics are facilitating decision-making by their governments in real time and with more efficient and effective results. First intents to use Information and Communication Technologies to address cities management problems can be explained through the notion of *smart city*. Cities governments implemented as public policy the use of different types of electronic data collection to supply information used to manage assets and resources efficiently to monitor and manage traffic and transportation systems, power plants, water supply networks, waste management, law enforcement, information systems, schools, libraries, hospitals, and other community services. The promise is that Smart City technology allows city officials to interact directly with both community and city infrastructure and to monitor what is happening in the city and how the city is evolving. *Other terms that have been used for similar concepts include cyberville, digital city, electronic communities, flexicity, information city, intelligent city, knowledge-based city, MESH city, telecity, teletopia, ubiquitous city, wired city*²⁶.

Urban computing is a process of data acquisitions, integration and analysis for the study and research of urban areas.

*“It is a process of acquisition, integration, and analysis of big and heterogeneous data generated by a diversity of sources in urban spaces, such as sensors, devices, vehicles, buildings, and human, to tackle the major issues that cities face, e.g. air pollution, increased energy consumption and traffic congestion”*²⁷.

Urban computing connects unobtrusive and ubiquitous sensing technologies, advanced data management and analytics models, and novel visualization methods, to create win-win-win solutions that improve urban environment, human life quality, and city operation systems. Urban computing also helps to understand the nature of urban phenomena and even predict the future of cities²⁸. The Urban Informatics Research Lab, founded in 2008, works across research and development at the intersection of people, place and technology with a focus on cities, locative media and mobile technology. Their team is transdisciplinary in that it comprises and collaborates with architects with degrees in media studies, software engineers with expertise in urban sociology, human-computer interaction designers with a grounding in cultural studies, and urban planners with an interest in digital media and social networking. Being hosted by the creative industries faculty, and specifically the cross-faculty research Institute for Creative Industries and Innovation enables their projects to embrace the creative energy of a range of disciplines across design, performance, production and writing²⁹.

²⁵ <https://www.oecd.org/statistics/Better-Life-Initiative-country-note-Mexico-in-Espagnol.pdf>

²⁶ https://en.wikipedia.org/wiki/Smart_city

²⁷ https://en.wikipedia.org/wiki/Urban_computing

²⁸ Zheng, Y., Capra, L., Wolfson, O., and Yang, H. (2014). Urban computing: concepts, methodologies, and applications. *ACM Transactions on Intelligent Systems and Technology (TIST)*, 5(3), 38. <https://www.microsoft.com/en-us/research/project/urban-computing/>

²⁹ Foth, M., Choi, J. H. J., & Satchell, C. (2011). Urban informatics. In *Proceedings of the ACM 2011 conference on Computer supported cooperative work*, pp. 1-8. ACM., 10.1145/1958824.1958826.

This paper presents our approach for computing the index of QoL considering quantitative and qualitative measures seeking to maximise a holistic hybrid return of investment modelled by the notion of elasticity of quality of life (E-QoL) that we propose. Our notion of return of investment is hybrid because it considers both quantitative and qualitative variables calibrated to find and optimum of economic and wellbeing benefit. Therefore, our proposal combines different data collections that feed a novel mathematical model proposed for computing determining the elasticity of the index of QoL. Given the volume of data sets about the city and its inhabitants it has been necessary to use adapted computational methods to model urban phenomena. We have applied data analytics computational techniques that apply mathematical methods, statistics and knowledge discovery to find patterns within data sets that represent the behaviour of certain phenomena.

Holistic approach for measuring Quality of Life in *La Condesa*

Mexico City promotes central and historical spaces (*as a brand*) implementing public policies intended to activate the economy of these areas. Public policies include actions in urban areas that affect the daily life of people. As for the revitalization of historic districts, governments in Mexico have applied public policies to activate other sectors of the economy. For example, in Mexico City one of the policies promoted for the benefit of the real estate sector in 2000 were proposed by the *Bando 2* program (Cruz González, Rene, 2006)³⁰. This program privileged the construction of houses in the central counties of Mexico City, such as the counties Cuauhtémoc and Benito Juárez. Figure 1 shows the map of counties in Mexico City. Cuauhtémoc and Benito Juárez are considered the historical downtown area of the city. Social implications can be observed in central districts and particularly in the district *La Condesa* located 4 Km. from the core of the Historical Downtown Area of Mexico City.

La Condesa was founded in the early years of the XX century in an area of 450,320.02 square meters organized into 62 blocks where 40 % of the space was devoted to green areas (see Figure 2). Along the decades, *La Condesa* has had different transformations. During the 1970s, the country's political and social effervescence led to first urban changes seeking economic activation. The government built new urban areas outside downtown for middle and upper classes. Thus, this policy caused the emigration of inhabitants from central districts to the new promising areas. Later, the 1985 earthquake caused the decrease of the value of properties in central districts such as *La Condesa*. This accelerated its decline with problems such as subsidence, depopulation and wide spread of architectural, public services and social deterioration due to lack of buildings maintenance and investment.

In the early 2000's the program *Bando 2* activated again the district *La Condesa*. The government promoted projects to activate the real estate sector. As a result, the use of the land, the economic activity and the so called "vie de quartier" in *La Condesa* changed dramatically. The occupation of the buildings changed from housing to commercial and administrative activities. The socio-economical level of the inhabitants that could live in the area changed too and with this started the desertification of the area. *La Condesa* hosted 688 commercial points in only 68 blocks. From 2000 to 2010 (INEGI) there was a decrease in the number of inhabitants from 15,916 to 11,792. The same happened in the number of inhabited houses, with 5,350 existing housing, 4,508 were

³⁰ Cruz González, R. (2006), Bando 2 of AMLO Sacrificed Water and Energy Supply, Chronicle, <http://www.cronica.com.mx/notas/2006/257443.html>, accessed April 18, 2018

classified as habitable and the remaining 842 are classified under "other uses". All these changes caused an increase in the price of the land, which went from \$21,960.00 in 2012 to \$27,500.00 in 2015.



Figure 2 Google maps geographic description of *La Condesa* District in Mexico [Google maps]

The question is to which extent have public policies been adequate from the economic and social perspective? Did they result in an improvement in the QoL of inhabitants? Are segregation, exclusion, changes in land use, lack of water, over population, desertification beneficial to economy and acceptable for the area? These changes transform QoL standards. Modern urbanism promotes the balance between economic development and QoL. The current characterisation of central spaces in cities and particularly in *La Condesa* call for an analysis of QoL measures to study the way these changes have modified the daily life of inhabitants and to which extent this balance is respected? Social and economic studies have addressed these questions partially, particularly because data providing insight is quite heterogeneous, it is collected in different moments and therefore it provides different unsynchronized snapshots of the district as a complex dynamic system. Besides, the choice of indicators to be computed to evaluate and compare economic growth versus wellbeing of citizens, can change according to different methods of modelling wellbeing through the QoL index. We chose to use official indicators used by the Mexican Institute of Statistics and Geography (INEGI³¹).

Computing Quality of Life Index for *La Condesa*

Quality of life (QoL) is an index mathematically modelled by combining variables (i.e., indicators). The selection criteria for calculating and combining them are based on economic and political trends. We adopted the mathematical model proposed by Stasys Puskoruis (Puškorius, S., 2015) for measuring QoL, based on studies by Stiglitz et al. (Stiglitz, J., Sen, A., and Fitoussi, J. P. 2009). We chose this model because it considers economic variables together with variables that reflect the quality of human life. Thus, QoL index is given by the following formula:

³¹ <http://www3.inegi.org.mx/sistemas/TabuladosBasicos/Default.aspx?c=27302>

$$I = \sum_{i=1}^{10} a_i b_i$$

b₁ - health

b₃ - quality of time at work

b₄ - income status

b₅ - consumption

b₆ - environment and accommodation

b₇ - population's education

b₈ - law, security, order and corruption levels of the population

b₉ - ethics-morality, spirituality, value of culture and leisure of the population

b₁₀ - population's gender equality indicator

The index results of the summation of 10 pondered indicators. Weights used to ponder indicators are represented by a_i terms for instance b₁ and the weight coefficient of that indicator (a₁).

The collection of information and the analysis of the data becomes essential to obtain reliable and representative results. In Mexico, the INEGI provides statistics from the national census of different years. Most of the indicators chosen for computing the QoL index were already computed for Mexico City so we filtered them for computing the QoL index for different years and first results on elasticity. Next, we describe the data collections.

Wellbeing dimension	Indicators
1 Accessibility to services	(1.1) Access to health services, (1.2) houses with high speed Internet connection, (1.3) houses with access to basic services
2 Community	(2.1) quality of the support social network
3 Education	(3.1) dropping out of school, (3.2) years in school
4 Balance life - work	(4.1) satisfaction w.r.t leisure time, (4.2) people working more than 48 hours
5 Income	(5.1) gini family income per capita, (5.2) family income, (5.3) people in poverty, (5.4) people in extreme poverty
6 Environment	(6.1) air quality, (6.2) waste products
7 Civic compromise and governance	(7.1) civic and political participation, (7.2) electoral participation, (7.3) confidence in justice/law, (7.4) perception of corruption in the juridical system, (7.5) confidence on judges
8 Health	(8.1) living new born babies' expectation, (8.2) health control, (8.3) obesity rate, (8.4) motherhood mortality, (8.5) children mortality, (8.6) mother deaths/100 alive new born babies
9 Life satisfaction	(9.1) idem
10 Security	(10.1) homicides rate, (10.2) confidence in police, (10.3) insecurity perception, (10.4) criminal rate
11 Employment	(11.1) occupation index, (11.2) informal jobs rate, (11.3) unemployment rate, (11.4) economic contribution
12 Housing	(12.1) rooms/person, (12.2) solid construction rate

Table 1 Wellbeing indicators provided by the INEGI database

Data collections. We used twelve data sets for computing QoL. Each data set provides also aggregated data used by international organizations for measuring different indicators. We filtered data for observing the indicators in Mexico City and then in the area corresponding to *La Condesa*.

The wellbeing indicators database provides 35 indicators defined by the OCDE. The indicators are used for computing the better life index based on the notion of wellbeing and progress. The indicators are grouped into 12 dimensions (see Table 1): accessibility to services, community (social relations), education, balance life-work, income, environment, civic compromise and governance, health, satisfaction, security, employment, housing. Data collected for computing these indicators are a snapshot of the years 2010 - 2015. For our study, we did not use the aggregated indicators but the full data regarding the indicator required for computing the QoL index introduced in the previous section.

Computing quantitative and qualitative measures. Data sets regarding QoL indicators that have been exported by the INEGI correspond to census done every two years since 2010. We remarked that not all indicators were collected in every exported data set and those of 2018 are still not available. Thus, for our experiment we first computed the QoL index in Mexico for three years 2012, 2014, 2016. After analysing the distribution of the indicators' values, we saw that some were expressed as percentages of the population that answered the census others as interval values and ad hoc measures like for the quality of air. Since we did not have the raw data for the last ones, we decided to exclude them from the computation. Therefore, we decided to use the most homogeneous measures in order to ensure the precision of our computations (see Figure 3).

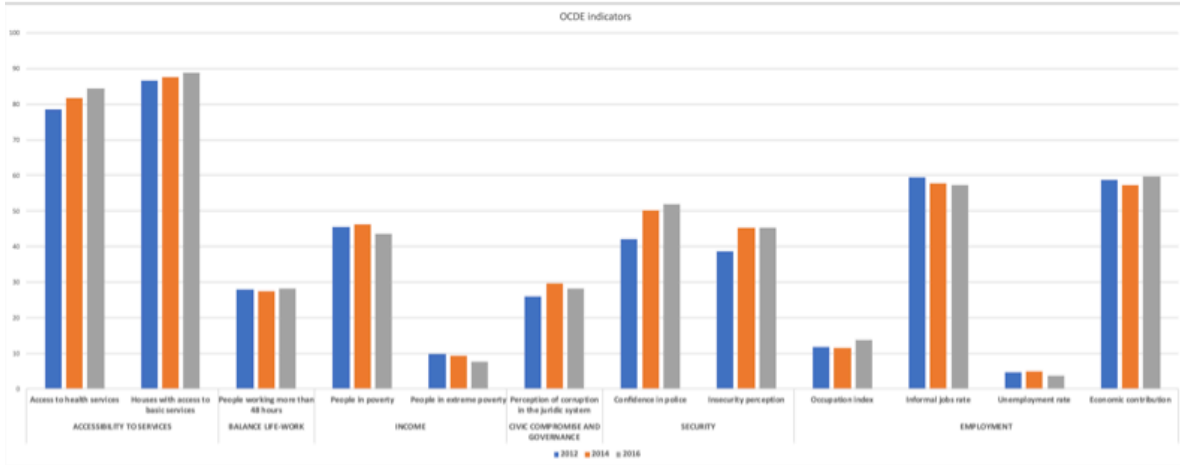


Figure 3 General overview of the distribution of the data of the indicators

As shown in the figure our experiment considered six dimensions namely, accessibility to services, balance life-work, income, civic compromise and governance, security and employment. For every dimension we chose those sub-dimensions that were expressed as percentages from the whole number of participants of the census. Given that these censuses are promoted by the government and are considered a civic commitment a representative amount of the population participates in this task.

According to the QoL formula that we adopted we pondered indicators according to the knowledge of the domain of our colleagues' experts in urbanism. We privileged those concerning qualitative perceptions like security and we gave less importance to those concerning economic measures. This is because our study wants to have a picture of the perception of population about their QoL in the district *La Condesa*. The resulting revisited formula is given as follows:

$$I = \sum_{i=1}^{12} a_i b_i$$

It considers 12 measures from the chosen groups of indicators shown in Figure 3, where accessibility to services and income (a_1, a_2, a_4, a_5) were pondered with 0,08; balance life-work (a_3) and employment were pondered with 0,04 ($a_9 - a_{12}$); and civic compromise and governance and security with 0,16 ($a_6 - a_8$).



Figure 4 Index of QoL 2012 - 2016 in *La Condesa*

As seen in Figure 4 the QoL index shows that QoL as perceived by citizens is not very high. This means that they consider that life is acceptable but still services, security, income need public policies that can make life better. As shown in the figure QoL has become better comparing 2012 and 2016, but the increase between 2014 and 2016 was not very significant. Our first perception through the evaluation of QoL index, validates our hypothesis that other strategies are required to measure it. Combining quantitative and qualitative indicators is a first step to provide a more representative view of QoL. Yet it is not correlated with the type of policies applied that have been applied and how they are related to indicators. Our current work is devoted to study this aspect.

We also want to use information from a project started by the Mexican INEGI willing to measure the mood of Twitter users in Mexico City. INEGI in collaboration with Twitter is making roads into data base applications to solve urban problems with technology applied to Big Data. Considering the mood of privileged citizens having access to social networks for measuring QoL index considering socioeconomic aspects can give a more representative measure. Social network users are a specific elite group, but the economic status of citizen in *La Condesa* are middle and upper level classes active in social networks so their voice can be representative for the type of study we are willing to perform.

Elasticity in Quality of Life

We believe that together, qualitative and quantitative variables generate a more inclusive assessment of QoL. Yet, existing mathematical models defining the QoL index do not consider the point of no return in QoL. That is, they do not measure to which extent it is possible to have a satisfactory QoL in a territory where specific public policies are applied.

The economic term "elasticity of demand" can be introduced into QoL index models. In Economy, elasticity is defined as the relationship between the percentage change in the quality demanded or offered and the percentage change in price.

$$E_p = \frac{\Delta Quantity}{\Delta Price} = \frac{\frac{(P_1) + P_2}{2}}{\frac{(Q_1) + Q_2}{I_{12}}}$$

We define elasticity in urban terms we will see that there is a relationship between the QoL of the inhabitants in the territory with respect to the variables that effect welfare behaviour. The concept is used in microeconomics and economic theory, introduced by Alfred R. Marshall to determine quantitatively how changes can influence another that depends on it³². It is a measure of the degree of response of the change of one variable due to the change of another. Numerically it is given by the percentage change in a dependent variable Y (i.e., the percentage of change of Quantity in the formula), divided by the percentage change of an independent variable X (i.e., the percentage of change of the Price in the formula). That is, the elasticity of Quantity with respect to the Price is given by the ratio between the percentage change in Quantity divided by the percentage change in Price.

We propose to revisit the notion of elasticity and apply it to urbanism, and particularly to the notion of QoL. In urban terms, Y denotes the index of QoL in a territory, which depends on the variables that determine the urban behaviour in the territory. The principle is to compute a range of values in which the QoL index denotes wellbeing while the variables that determine it change because of the application of public policies. To which extent given public policies affect the QoL index such that it can denote or not better or worse wellbeing in citizens. This can help to observe to which extent activating night life activities can generate a feeling of insecurity in citizens walking or arriving late at night? How much noise (decibels) is acceptable before people start feeling stress?

The “elasticity of quality of life” (E-QoL) can be used to assess public policies and provide understanding about the way the elasticity spectrum moves as a result of the implementation of public policies in a given urban territory. Public policies are of course, modelled as a composition of variables (indicators) that acquire specific values when a policy is applied. These values can vary depending on the urban territory where they are observed. Thus, for a given public policy, the values of the qualitative and quantitative QoL that model it, can vary according to the urban territory it is implemented in. Using data science techniques, the idea is to have a public policy meter showing its side effects in the urban territories in which it is implemented. The meter can work continuously so it would be possible to discover some indirect side effects. That is, which aspects of QoL were expected to be touched by a specific public policy and which were effectively touched after its implementation? Yet, it will be important to understand the conditions in which the QoL index is computed, the variables used and the conditions in which data are collected to assign values to these variables.

It is essential to first understand theoretically the range of QoL and wellbeing and the variables that affect them in a given urban territory since each urban space can be modelled by its own variables and definition of QoL. Thanks to data science techniques we can provide insight about the variables used to compute the QoL index that can adjust to different models and epistemological concepts. Therefore, we propose digital dashboard enabling the choice of variables and the definition of their Mathematical composition can let data analysts and decision makers observe the implications on elasticity when specific public policies are applied. Through the dashboard, we can for example, find the variables that define the term of QoL under the concept

³² <https://www.eco-finanzas.com/diccionario/E/ELASTICIDAD.htm>

of the capabilities of Amartya Sen. We can even apply the notion of utilitarianism³³ to design the E-QoL and observe Mathematically how people adjust their behaviour and perception of wellbeing while seeking the greatest happiness. Studying and understanding the rules of this adaptation phenomenon can guide the design of public policies. *"The utilitarian can realize that, since the joint good is the sum of individual interests, the best way to promote one's interest is to promote global interest"* (Mill, J., 1824).

Conclusions and Future work

In this research we proposed a first approach for computing the E-QoL, elasticity of quality of life index. In addition to quantitative measures, qualitative measures are used, as representative indicators of the life experience of an individual in a territory.

The study was based on the use of technology and computational tools (Big Data Analytics) and data science (statistical methods and know ledge discovery) to manipulate and combine different data collections. We used descriptive statistical to compute QoL. Then we used our results for proposing the possibility of equalising and tuning different measures to compute the E-QoL, the index proposed in this research. The interest of computing the QoL index is that it can help to design public policies that can revitalise urban spaces for empowering economy without scarifying citizens wellbeing. Therefore, we defined elasticity in urban terms establishing a relationship between the QoL of the inhabitants in the territory with respect to the variables that effect welfare behaviour, whether positive or negative. Elasticity is introduced in the qualitative and quantitative estimation of QoL. The result is an index that uses a range of day by day living permissible in a territory. In the case of this research, this index has been measured in the context of the *La Condesa* in Mexico City. This can be used for computing the elasticity of the QoL but this corresponds to our future work.

Studies, in our opinion must combine classic methods with the possibility of running experimental processes on top of collected data thanks to data science. Having a quantitative view of the urban, social and economic phenomena associated to gentrification of districts can help to discover side effects and in consequence a way of developing public policy assessment methods.

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³³ Sánchez-Migallón Granados, Sergio, *Utilitarismo*, en Fernández Labastida, Francisco – Mercado, Juan Andrés (editores), *Philosophica: Enciclopedia filosófica on line*, URL: <http://www.philosophica.info/archivo/2012/voces/utilitarismo/Utilitarismo.html>

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