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Chapter 7: Enhancing fiscal impact analysis by embedding intelligent algorithms into budgetary planning

7.1 Introduction

Currently, no Institute of Economic and Financial Studies in a Government recognizes the relevance of implementing in its system fiscal impact analysis (FIA) of a project of law for legalization or expansion of fiscal or para-fiscal tributary burden or for customary regimes of exemption or zoning. This study proposes to modify this situation.

It all started almost two years ago, when we had to describe to the Ministry of Budget and Public Function of our Country the process by which our Institute elaborated its Opinions about the fiscal impact –collection at most and deficit at least– of a project of law. In fact, our procedure was very similar to the one developed when it indicated that "the first task of the economic adviser of the government consists of preparing a Macro Projection of the economy –usually for the next five years–, consolidating the Programmatic Budgets that support the projections of income and expenses of the governments, and evaluating if there are coverage deficits or fiscal surpluses that require adjustments to other functions of the State or those different from the Microprogrammed Objectives". However, what any technician should consider as normal, surprised and discomforted some of the members of that Ministry. "Why do we transfer to you this Initiative which is ours and which is one of our Budgets?" They asked us, perplexed, from a Ministerial Office (Bertot & Choi, 2018; Gamage & Sciulli, 2020; IMF, 2020).

7.1.1. Purpose and Scope of the Study

Recognizing the importance of budgetary planning, there has been a recent push for increased scientific rigor in assessing its impacts, particularly the fiscal impact. This has

resulted in the production of ever-increasing amounts of tax and government revenue data to support insight in the decision and assessment processes. With the explosion of digital data, we are now seeing in all domains data-driven solutions, seeking insights that support expertise, and assist in decision-making in uncertain environments. Such solutions need to combine intelligent algorithms with the computers' capability for big data processing, enabling predictive and prescriptive insight at scale and speed. The emerging domain of data-driven decisions is enabling individuals and firms to make decisions that have traditionally fallen within the realm of the public sector. Such decisions include transaction volumes, timing, and other structural features, and directly affect tax bases such as income, capital gains, unemployment, sales, and property values as well as the external financing of public expenditures(Vranic & Markovic, 2022; Zhang & Hu, 2021).

Through our deep involvement with the Government of Saint Lucia and the Inter-American Development Bank in designing and applying a Protocol for Fiscal Impact Analysis, we have become aware of the limitations of the existing approaches to gainfully utilize tax and other data for fiscal impact assessments. The need for powerful, data-driven solutions to fill the gap has become ever more pressing. We have therefore set out on a journey to create such solutions. In this paper, we provide an overview of our efforts to date, relying on the tools and methods of the new science of entrepreneurship. Within this context, we apply some intelligent algorithms to approach investors, visitors, and other influencers and thereby augment and power up the conventional tools and types of analyses for fiscal impact assessments. Our strategy combines natural language processing with different topic modeling methods to mine social media, public media, and news, and money transfer data to help with decisions regarding which fiscal impacts are the most and least attractive or unfavorable components of new initiatives for the government.

7.2. Literature Review

The design of the general expenditure budget of the State, Subnational Governments and their agencies has been for many years, throughout the world, mainly of a political nature, varying the priorities of the same depending on the party or coalition that governs. The need to demonstrate the efficiency of government activity and the achievements resulting from the implementation of budgetary policies was not an important factor for budgetary practice and much less a necessary condition to guarantee a good image of those who governed. However, a decade and a half ago, with the advent of New Public Management, the idea began to gain strength that the great expenditure budgets, particularly, were instruments of State policy, not of political will. The new paradigm of once again "politicizing" the budgets favored the emergence of budgetary

programming and planning techniques. The same ones that up to that moment allowed the increase of the bureaucracy in the State economic areas without achieving better results. It is increasingly necessary, for those public officials in charge of budget preparation traditionally relegated to marginal roles, to possess the appropriate tools and instruments to quantify the impacts of education, social, health, security measures, among others, on the set of variables of the society to which their actions are directed, in order to guide the final decision on the respective policies. It is based on these needs that we propose research that deepens the study of fiscal impact analysis within the framework of budgetary programs.

In the field of public finance there are numerous instruments, techniques and tools to quantify the different variables of fiscal impact analysis, however, and given the high level of complexity that fiscal impact analysis has in planning and programming, it is also true that traditional instruments have limitations in estimating different variables. Due to their nature, economic and econometric models can take a long time to develop and respond to user demand. For that reason, many of them are not generally prepared for short-term forecasts. These limitations are resolved through the use of intelligent algorithms. Virtually any technique or tool to develop models capable of executing automated learning processes is an AI algorithm. AI has a broad range of applications in public finance tasks, such as access patterns in deduction models for income tax, fraud leak detection in VAT, ex-ante and ex-post tax collection assessments, demand forecasting for tax and tax services, models of foresight of the economic evolution, creation of predictive models for international trade flows, among others.

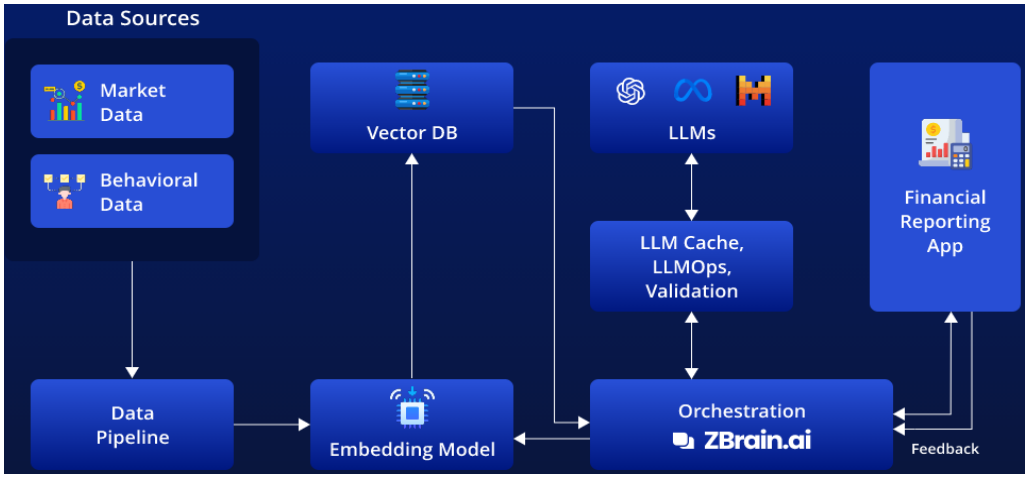

Fig 7 . 1 : AI for financial reporting

7.2.1. Historical Context of Fiscal Impact Analysis

There are two strands of literature that are relevant for the work presented in this chapter. The first is the fiscal impact analysis, as the field is known. While the roots of fiscal impact analysis may go back to the 1930s, when the first macroeconomic models were developed, the topic really made headway after a seminal research report on the Canadian economy. Over the years, fiscal impact analysis has taken more specific forms. Urban and regional planners employed it to analyze how the tax revenues of a municipality, region, or state are affected by proposed land use changes or under different development scenarios. One reason for this use is that developed countries have increasingly moved towards a decentralized system of government. At the same time, the amount of financial resources transferred by higher levels of government to regional and local governments has grown. Increasingly demanding cost-benefit analysis legislation has enabled detailed fiscal impact analyses to supplement enthusiasm for the benefits procedure's too-often-irreconcilable numbers. Perhaps the largest volume of information and research into mostly small-scale and recurring fiscal impact analysis practice is to be found in local planning agency studies, five of which are reported. In addition, the fiscal impact analysis found favor in the rapidly urbanizing states of Madison, Wisconsin; Oregon; California; and New Jersey in the 1980s. An early fiscal impact analysis study surely must rank as the most cited.

7.2.2. Current Trends in Budgetary Planning

Budgeting is traditionally an exercise where an organization translates its goals into monetary terms. By defining at least one year ahead periods where these goals are expected or accepted, the organization has the needed plans to monitor deviations between actual performance and budgeted amounts. For a public sector organization, a budget is a statement of priorities. It draws a line on the amount of funds that should be allocated to the different services that make up that organization. This means that priority allocation is an essential function of a public sector budget. The budget is a statement of policy at a point in time. It details the services offered, is priced and quantity-quantity plan and it lays down the financing arrangements for the public sector, including the surplus or deficit of the budget. However, many activities that are considered a burden at times may bring future benefits and thus should rather be viewed with a multi-annual perspective.

Traditionally, budgets are planned on a yearly basis. Annual budgeting is adopted because it allows a state to combat regulations. In planning possible onerous costs of such actions for the whole forecasting period would not have the desired deterrent effect against budgetary penalties, such as a decrease in the State’s credit rating. This is the key argument for annual budgeting, which hinders the possibility of associating the costs of

such events with the period in which they occur. Additionally, an annual budget gives a chance for citizens to influence decisions concerning the allocation of funds for priorities that are important for their communities but not for their country. The aim of budgetary games is to show citizens that the prioritization of every service is equal. The effectiveness of budgetary regulations can then be described as a cost, something rationally calculated. Cosy budgets based only on political and not economic factors are not the aim of budgetary regulations. These budgetary regulations should be a deterrent for every irrational action concerning the finances of the state and should be analyzed with the use of political budgets.

7.2.3. Role of Intelligent Algorithms in Public Finance

Doubtless, we have recently witnessed the exponential growth of narratives discussing the application of intelligent algorithms to society, politics and economy's most diverse areas. Budgetary planning, with its uniqueness and complexity, is no exception from the acceleration of its digital transformation process and the increasing interest for the possible opportunities brought along by artificial intelligence. The emergence of intelligent algorithms' potential, in recent years, is far from being a recent or discrete phenomenon. Intelligent algorithms, in the last decade, have come to act as beacons during the transition that societies are experiencing. After an initial and pioneering enthusiasm in the utility of big data in several fields of knowledge, we have seen the gradual refinement and definition of the role of intelligent algorithms, namely, during several formulation phases of the public policy decision-making process, throughout the exploratory, comparative, predictive and prescriptive budgetary analysis.

In the presence of a scale of uncertainty, hastening the digital transformation process, which is fully asserted on the massive use of information and communication technologies, associated with society's increased complexity and the economic, political and geopolitics instability, it seems only sensible to share, in advance, knowledge which allows the implementation of intelligent algorithms supporting the main goal of centralizing the citizen in budgetary management, so it is possible to jointly and collaboratively, foresee, decide and monitor the impact of budgetary decisions through fiscal impact analysis. In this context, we sought to share the lessons and experiences learned with the digital budgeting project, designed and developed.

7.3. Methodology

The study adopts a qualitative approach in its design. This method is commonly used to expand upon quantitative results provided by statistical programs when generating them, contributing much to descriptive studies, particularly in exploratory phases. It contains

an analytical component. To do so, qualitative research relies on scientific disciplines which do not use statistics, thus engaging students in a general interpretation of the meanings of facts, that is, they guide them to search for the rules of logical inference that allow studying social phenomena. This type of research presents several benefits and is currently in high demand within organizations. These include the ability to explore new fields, clarify doubts and help record feelings, impressions, opinions, and motivations of different administrative sectors, developing new insights according to stakeholder statements.

We adopted semi-structured interviews as a primary form of data collection to investigate the opinions of lead agents involved in the budgetary planning of municipalities located in the northeast of Brazil. This technique is characterized by themes previously defined by the researcher related to the research problem, being freely developed afterwards, the purpose being to find relevant information which corroborates the defined objectives. We opted for this method since expert opinions are valuable resources for data collection, mainly on unexplored subjects or little known in the literature. In total, nine interviews were conducted. Interviewees were selected on the basis of availability, accessibility, and experience. Finally, we triangulated the interview data with participants' speeches in public events and meetings and available documents. As a result, we believe the methodological option we adopted was important in achieving the intended objectives, since triangulation contributed to data complementarity and validation. In the sections that follow, we present the analytical framework including the Fiscal Genealogy method which enables us to explore dynamic fiscal relationships through intelligent algorithms.

7.3.1. Research Design

For the development of the present study, which aims to demonstrate the potential of Intelligent Algorithms for Enhancing Fiscal Impact Analysis in Budgetary Planning, we have opted for a qualitative and exploratory approach. Exploration or exploratory research has two main objectives: to provide an empirical clarification of the phenomena studied and to allow the establishment of a more precise direction for more detailed studies in specific areas. Thus, we are aligned with the perspective that the role that exploratory research plays in the natural and social sciences is the same as that played by a map for someone who goes to a distant and inaccessible place for the first time.

The collection of primary data was done through a semi-structured interview with a team that is part of the Transformative Cities program. It is worthy of note that intergovernmental transfers, i.e., the transfer of financial resources from central government to state and local governments, are important for determining the level of public expenditures by these governments. These transfers can be used for different

purposes, for example, for covering current expenditures, for the execution of specific projects of the decentralized entities, or still for transferring resources to the decentralized entities in order to cover its budget deficits, whose levels are dependent on the stage of the economic cycle. With this in mind, we believe that the analysis carried out is important for supporting the decision of municipal managers regarding the incorporation of Intelligent Algorithms into fiscal impact analysis.

7.3.2. Data Collection Techniques

The aim of this paper is to use both qualitative and quantitative data collection methods in order to analyse the contribution of intelligent algorithms to the impact analysis of budgetary planning costs, while also using a logic model. Using qualitative data sources - verified script and original transcripts of interviews in a qualitative data analysis framework - the authors prepared a hierarchical set of elements of interest through which the index statistics obtained from the respondents were processed.

A categorised questionnaire using Likert scale intervals offered quantitative data which were processed statistically in order to explain several variables in the hierarchical categorised model detailed previously. Budgetary planning - by creating budgetary programs necessary for government services and budgetary constraint both on budget revenues and expenses - has an important impact on the fiscal impact of the public budgets. On one hand we identified the effects of the development of a public service or its degradation through a forecast that uses the same budgetary model and have an oscillating nature and on the other hand budgetary planning based on projected rolling flows expressed in the same currency and which have a cyclical nature, make possible to reduce decision making errors due to the duration of the budgetary process and of its last moment.

7.3.3. Analytical Framework

Broadly, our research asks three types of questions, which compose three building blocks: (i) What input characteristics sway the opinion of output characteristics? What are their relative effects over time? (ii) Are the classifications supplied by the assigned artificial intelligence congruent with the attributed classification? (iii) Are the probabilities supplied by the assigned artificial intelligence associated with automatic approval-rejection decisions? Our answer to the first question supplies the overall budgetary planning framework in which the intelligence algorithm operates. Our answer to the second question supplies the initial layer of the fiscal impact analysis intelligence algorithm. Our answer to the third question indicates the operating domain of the intelligent algorithm. Each question is deployed temporally and for the expenditure

categories of budgetary authorities, using three steps, three necessitous characteristics, and three different analytical strategies, all performed for these expenditures. For each research block and question, we define the budget structure, its input-output characteristics, and the associated classification technique. The current fiscal impact classification is compared with econometric techniques – linear regression in the first step and Gaussian Mixture Model in the second one. Finally, we associate the probabilities with decision rules derived from a Gaussian Kernel Density Estimator in the third step.

The budget composition refers to the fiscal path/search and order of magnitude of the informed features that pave the way to the artificial intelligence debate. The input-output characteristics of the fiscal impact matrix comprise the proportion of budgeted and released amounts of the full year, the multi-annual average of the previous five budgets, the annual differences flagged as exceptional by the legal framework, the bootstrapped, artificialized expectations of the sums released specifically for the budget category based on trend-extrapolation methods, indicators of the fiscal balance year and size, and the size of the authentication and decision-making hierarchy of the budget authority. The research analytical strategy for the input-output classification batches is a combination of the regression and decision trees and Random Forests.

7.4. Intelligent Algorithms Overview

Machine learning is a complex and versatile scientific domain that estimates functional relationships, known as models, with data fluxes of different natures and in different types of implementations. Supervised learning improves the prediction of the label of an unknown instance, offering the possibility of classification or regression. Unsupervised learning seeks the creation of clusters, finding interesting relationships in the database. Semi-supervision combines both ideas to take advantage of labels administered in small quantities or to unveil categories in large datasets.

Machine learning encompasses techniques capable of analyzing structural and semantic aspects of data - we can mention nearest neighbor classifiers, Bayesian networks, decision trees, support vector machines, neural networks, random forests, supervised or unsupervised deep learning, hidden Markov models, kernel methods, convex programming, spectral clustering, and many others. The estimation of time series can also be handled from the perspective of machine learning, relying on autoregressive moving average for time series analysis, and recurrent neural networks or convolutional neural networks for regression and classification.

Budgeting and fiscal planning are, in these conceptual terms, ways to make decisions. These decisions are based on the anticipation of future impacts generated by the

government via its financial policies, which consist in its revenue forecast and its allocation of funds in a huge volume of services, programs and projects. However, decision making can be done based purely on expert opinion, based solely on historical data, or based on a combination of the two. The last approach, which combines expert opinion with historical data analysis, has produced the so-called decision support systems which attempt to bring to the decision makers a consolidation of the various predictions regarding the variables or events of interest, such as the forecast of revenue and expenditure, project return, service provision quality, etc. These systems allow, in fact, a correct decision model formulation that deals with the uncertainties about the future impact of decisions. Most of the systems in operation today are based more on accumulated knowledge than on systematic analysis of data.

7.4.1. Machine Learning Techniques

Machine Learning (ML) is a branch of Artificial Intelligence (AI) that addresses the problems in the traditional programming approach and proposes a more flexible heuristic optimization approach, in which ML enables a computer to learn from experiences and adapt its behavior without explicit programming for specific tasks. Although AI and ML are different fields of study, focusing on different problems, it cannot be denied that what AI systems do today is done borrowing the contributions of the different branches of ML. Within ML we find two major categories: Supervised Learning, where a model is built based on the pre-existing input-output mapping of the problem and is validated on separate test data; and Unsupervised Learning, where no previous information about the problem is available.

ML covers a broad spectrum of techniques, all of which are based in some way on the idea of estimating a particular mathematical form based on some observed data. The functions that are estimated with ML could be: Taxonomy into learning categories: the main differentiating factor of the various ML techniques is established by the type of function being estimated. While some techniques learn models of the input-output mapping and represent their own output as an approximation of the target function, estimating the model that groups the input vectors is another weakly explored technique for Function estimation: the more common task is to train a model capable of imitating the relationship between the input and output, whose objective is an irreversible transformation of the input space.

7.4.2. Artificial Intelligence in Decision Making

Efforts in investigating decision processes started with Simon, who was one of the first to propose a model of the decision maker as a rational processor of information,

iteratively organizing the information that is relevant for making an optimal decision until he or she attains a satisfactory solution. Following Simon, attempts to implement models of decision making focused on the use of such mathematical devices as Markov decision processes and dynamic programming. These attempts provided a strong conceptual underpinning of decision making and were successfully applied to well-defined classes of problems. However, a major paradigm shift occurred in the 1970s with the introduction of artificial intelligence, which was then aimed at mimicking human (as well as animal) problem solving behavior and, so a direct imitation of the decision process.

The first attempts at implementing intelligent decision systems were through expert systems that sought to replicate human intelligence in a limited domain of knowledge. The basis of this research line was the belief that the representation of rules, hence the understanding of the decision making process of an expert human consultant, could be made explicit, so that other decision makers, the decision users, could use them as the sole basis to obtain conclusions regarding the specific decisions to make, on exactly the same basis as the expert would make when consulted, hence decision aids that would apply the same rules as the expert were solely used as a cognitive support. However, this belief was not confirmed and expert systems were successful only in a limited number of domains. As a matter of fact, it was soon realized that most decision processes are much too complex to be reproduced by a simple and explicit codification of rules.

7.4.3. Predictive Analytics Applications

The implementation of predictive models at the level of public administration can be used to more cleanly establish fiscal responsibilities, enhance the ability to predict real estate and corporate tax revenues, and update assessments of the contributions owed regarding taxation on virtually any activities of the taxpayer. Developing predictive models for the automation of classification activities can simplify, speed up and make more efficient tax collection processes. Predictive models are able, if designed and implemented correctly, to mitigate tax evasion phenomena by making governments aware of the areas that are most exposed to this particular effort. The automation of some support activities can free resources for greater advancement and control and support actions. The responsible institution, by applying advanced analytics techniques, can guide a very targeted and personalized campaign against unpaid contributions, minimizing their cost and maximizing the return of the operation. Predictive models can simplify the identification of evaders, automating some necessary activities. The public administration can use algorithms to assess the most opportune moment to change the behavior of the economic entity so that it begins to pay its taxes. Predictive models allow objectively evaluating the credit risk of both individual citizens and organizations, the

default cost and the speed of recovery in the event of default, establish and implement flexible loyalty plans and support the filing of complaints.

Fig 7 . 2 : Predictive Analytics Applications

7.5. Integration of Algorithms in Fiscal Analysis

This section covers the integration of algorithms in fiscal analysis from four perspectives: agenda setting, design and model structure, parameter setting, and policy sensitivity analysis. The first three of these topics are closely related to the mechanics of the algorithm itself. The last one focuses on a critical issue – how fiscal policy sensitivity relies upon algorithmic, model structure, and numerical settings. Due to subjective and user-selective guesswork, there are serious concerns about algorithms generating the worst of possible attention lurching policies or teleological racism – drift towards stasis traps at all costs while avoiding certain unpleasant dimensions of social costs like coercive dislocation, growing inequalities, and unchained crony and kleptocratic capitalism. In addition, algorithms can drift towards trap-like-stasis by automatically, unavoidably preventing clear programs of deep structural change in any policy domain. To prevent and generally manage the potential of algorithms producing undesirable attentional, tabulate, or trap-like-stasis consequences, a sensitivity analysis of fiscal policy implications is needed.

The integration of algorithms provides a powerful basis for fiscal impact analysis during the ‘technical’ phase of the policy process undertaken and decided by political authority – agenda setting, selection of program options, cost, and benefit estimate, execution, and specified target program evaluation. By doing so, algorithms can be related and

reconciled to advanced micro simulatable models that are often used for short run demand policy formulation, fiscal impact statements, including sensitive fiscal multipliers for short, medium, and long run, or concise expansionary size or timing inertia risk estimation functions of the demand-side impact of fiscal policy and sensitivity in demand multipliers.

7.5.1. Algorithm Selection Criteria

Choosing an algorithm that is appropriate for a particular circumstance requires consideration of a number of different factors. In this section, we outline six major factors that should be used when selecting an algorithm and its integration. The factors are not unitary; they often overlap in the criteria they use, as we also explain, but present a different priority in their analysis. The reason for presenting multiple selection criteria is not to confuse the reader, but to add different aspects to the selection process, thereby increasing the information available to decision-makers. The factors that we present in this section are: Neat and Clean Effect (NCE) of the Budget, Complexity of the Algorithms, Availability of the Tools, Transparency in the Results, Multiplicity of the Data, and the Content and Effect of the Budget Policy. We provide an analysis of each of these factors below.

Neat and Clean Effect (NCE) of the Budget. The aim of the selection process is to obtain the optimum impact on fiscal results. This should be a neat and clean effect, meaning that the effect is large relative to direct outlays used to achieve this. For this to happen, the models used and preparation of the input data should be capable of being put together properly with clear information on how to do it. This reflects the KISS principle: simple is beautiful. If true and important choices are made, it allows for the condition that a vast number of simulators and models exist, often impinging on the same area.

7.5.2. Case Studies of Successful Integration

This section presents several real-world examples of integration of smart algorithms in fiscal analysis. Close to the area of macroeconomic fiscal forecasting, a neural network model for forecasting fiscal revenues is presented, based on the digitized historical performance of the corresponding aforementioned relation, with practical application to several Latin American and the Caribbean countries.

Algorithms from deep learning are used to predict the performance of the fiscal accounts' basic balance in the three years ahead of the forecast, compared to other potential forecasting alternative models, specifically, simple regressions, lags, ARIMA, unobserved components model, and a specific Bayesian regressions alternative

incorporating the typical predictors. Artificial neural networks were the better of this alternative group, close to predicted performance of deep learning. The group also recently updated this work, forecasting the general government deficit for 16 European countries, where deep learning models were again the better ones, as compared to more classical econometric forecasting contexts using also different AI models. These studies are useful for fiscal authorities in charge of public finance sustainability monitoring. In fact, the better the deficit being predicted, the better the future fiscal debt evolution structure forecasting, in order to take corrective measures looking for public finance permanent sustainability.

7.6. Budgetary Planning Framework

The purpose of budgetary planning is to analyze, compare and approve the appropriating of future resources in order to minimize errors of estimation of revenues and expenses for the periods needed by the organizations. The budget must translate in money terms, the objectives set for the organization and the programs planned in order to accomplish them. A budget is thus, a concrete expression of the decisions taken, of the anticipations made and of the standards used by the organization. Budgeting represents the connection between the anticipation function and the management control.

The recommendations and the required specifications to consider in the building-up process of the budget must be based on the possibility of exercising a higher degree of control possible to a unit of the economy as an integrated whole. In order to do so, there is need for well-established relationships and coordination between those charged with the budget responsibilities in the planning and budgeting phases. More precisely, the several units of the organization must be associated in the exercise of management politics, as well as in the compilation and administration of the budget. These relationships as well as articulating the cost-and-revenue relationships, and describing the operational chain of the organization expressing the transfer between the inputs and outputs, and why-achieving the establishment objectives must be clearly shown in the budget. These requirements are seriously neglected in the traditional budgeting process, severely reducing the budgets quality as an assurance and control tool of how objectives must be realized.

7.6.1. Components of Budgetary Planning

In this section, we present budgetary planning, a specific module of spatial fiscal impact analysis that enables an exhaustive and prospective view of the fiscal implications of the delivery of policy interventions. Budgetary planning is detailed within the broader budgeting framework, followed by the description of two of the three specific products

of budgetary planning: the multi annual budgetary expenditure plan and the budget calendar. The third product, that is, the budgetary revenue plan, is not described as it is not considered in the thesis.

Budgetary planning is here defined as the module of fiscal impact analysis that produces explicit plans for budgetary resources allocation and sequencing. Within the broader budgeting framework and in coordination with the mobilization of additional budgetary revenue resources and other costs incurred in the delivery of the policies, budgetary planning describes with the appropriate detail the long-term trajectory of budgetary resources allocation for their different uses to support the solution of the problem or the achievement of the objectives envisaged in the developmental strategy. Budgetary planning is preeminently a manual exercise, considering the expressed need for fiscal space and the restriction that the components of total expenditure should not be higher in a certain number of years before an election campaign. It allows for the definition of the policy areas where the budgetary effort will be intensified and the ones where it will be moderated or even minimized. The expected duration of the specific policies corresponds to the ones pertaining to the different government missions, such as health, education, infrastructure, labor, and poverty alleviation.

7.6.2. Challenges in Traditional Approaches

The budget is vital to a government's resource allocation decisions and its consequences, if not managed properly, may lead to adverse consequences with massive pathological effects. Each year, a vast amount of data is created that includes forecasts, estimates, and projections, perhaps from many different agencies. Such understandable information, if examined together using intelligent methods, can lead to the creation of an integrated model that can generate a more reliable version of the underlying fiscal function, enhance the transparency of each indicator, and provide useful information to policy makers on the interaction between the government and the economy. Budgetary planning has important components such as revenue estimates, expenditure estimates, economic forecasts, and economic impact, for the functioning of democratic system. Traditional approaches to forecast government revenue and the related economic impact of its changes, are plagued by several issues. First, revenue estimates are not credible, in part because the task is given to native amateurs who usually lack the requisite background and experience in fiscal affairs. Second, revenue estimates are based on overly naïve technique-based models that are not customized to the peculiarities of economies and their underlying fiscal functions. Third, economists have made little progress in developing reliable techniques for forecasting growth in real GDP and its major components as a basis for revenue estimates. Revenues are influenced by several factors including population growth, average tax rates, changes in average tax rates relative to

GDP growth, and the cyclical position of the economy. However the usual approach used by revenue forecasters is to attempt to assess each of these factors in isolation.

7.6.3. Proposed Framework with Intelligent Algorithms

In the proposed framework, the Rational Decision-Making for Results-Based Budgeting uses Intelligent Algorithms Role and its articulate relationship with three components of budgetary planning. Intelligent algorithms provide the preparation of fiscal impact analysis, the quality control of the traditional planning models possible and the preparation of innovative models specific to the budgetary decision. These models should be used and analyzed by multi-experienced teams together with specialists of the Intelligent Algorithms.

With the accelerations of the cycles of planning and execution of fiscal policies, the lack of integration of the main tax and social activities, the demands for results, efficiency and transparency from Government Accounts, the need to monitor the impacts of economic-fiscal policies and the need of the perfect articulation, transparency and social results of the Fiscal Impact Analysis, it is imperative that the Intelligent Algorithms be adapted, tailored to the fiscal policies of results. The preparation of models is still a challenge for all the existing Artificial Intelligence and Data Science technologies.

However, the transfer of knowledge for the improvement of traditional planning activities and the preparation of innovative models is not a unilateral process. The fact that manipulation and the use of Intelligent Algorithms to the budgetary decision-making processes and the analysis of the main results of the decision are not an easy process. The estimation of Automatic Budgetary Model for example is proposed as a tool, not a replacement, for the budgetary decision.

7.7. Impact Assessment

This chapter discusses the costs and benefits of the budgetary planning solution to help sort budgetary projects by their fiscal impact. It also comments on the potential bias of the proposed solution and its useful impulse for public policy. Public budgetary projects affect certain social groups positively or negatively. However, the population is diverse and this diversity can heavily influence how long the impacts will last and how many of them will be. The proposed approach to evaluate fiscal impact in budgetary projects and present a solution is based on assumptions that guarantee similar impacts in the same social groups, if they result from the same reason. It does not take into consideration reasons, only impacts resulting from certain criteria. Some of the criteria that are analyzed in evaluating the fiscal impact and sorting projects by how much they

contribute to it are real GDP, total unemployment level, the number of employed, the number of people with below-relatively-poor income, own revenues, and transferring revenues, including share without extra budgetary transfers and the share of the poorest and richest.

We calculate the relative significance of sorting criterion for the projection error and how it is distributed on the ranks of sorted projects, then we present algorithms for expert sorting. The solution helps propose priorities for capital expenditures intending to sort proposed projects according to the weight achieved with each of the sorting associated criteria. It can work as a tool to help economic experts who are allowing for many constraints associated with structural issues in the economy. The decision variables are determined based on how each project is categorized. Algorithms are provided that compute the probability of a capital project to have a negative fiscal impact. The system helps experts propose priorities for capital expenditures intending to sort proposed projects according to the offset achieved or with each of the associated criteria.

7.7.1. Measuring Fiscal Impact

Important questions arise when using an integrated system for public analysis and budget and fiscal planning. First of all, users have to consider and define fiscal impact measures of function or program using a selected data set. The tradition for the budget and fiscal planning research is to develop an analysis of strategic planning documents which often are needed to allocate necessary funds to the corresponding institutions. At that it is often realized only preliminary and simplified analysis of social-economic effects of implemented programs which do not reflect such important issues as induced multi-cycle effects of planned actions, the actual budgetary flow generated by the examined document on positive and negative sides during the planned horizon, the formation of socio-economic consequences and budgetary effects during social or economic crises, the compliance with the main goals of the integrated development placed in the programs.

International and Russian practices for the development of macroeconomic models is to implement and to use diverse types of macro modeling systems for the preparation of official mid- and long-term governmental forecasts or for estimations of the dynamics of government financial flows during realized intermediate shocks. Differences in practices usually are in the construction of open multi-sector models, models with a more detailed sectoral structure but closed on one or several determined protocols. These labeled models are frequently used for the expression of detailed traditional CBA data. Each of the mentioned approaches permits us to solve serious and interesting tasks in the sphere of modeling but to overcome possible break-in in the obtained results each type of model should be used in its own area of applicability.

7.7.2. Cost-Benefit Analysis of Algorithm Integration

Integrating specialized algorithms in legislative fiscal impact analysis has a cost. Algorithms need to be developed or at least adapted to the specific problems of the micro experiences being studied. Furthermore, the legislative unit needs to hire data science professionals, regularly trained about updates in the specific algorithms or techniques, to develop and run the algorithms required previously to the importance of the legislative proposal. Running a complex machine learning algorithm not only consumes time set to notify the government about relevant proposals and plans. It also needs computing power, reducing the number of documents that can be processed in one run. Considering these costs requires a complete discussion of the price to pay for the legislative branch for more effective reviews and clearer guidelines, as well as more complete, more user-friendly, and accessible fiscal impact analysis. Strengthening the decisions made by parliament essentially requires better organization of the data that feeds the algorithms. Integrating algorithms into legislative procedures is risky and easy to question. Given the costs, expected output, and sensitivity of changing or execution decisions that will shape the structure of taxpayer income – which we expect to be as seamless and clear as possible – it is essential to clearly understand the question that will be answered through the algorithm; this should incorporate the designs and choices, the data variables, and their coverage scope. Therefore, it is essential to understand that despite the development of fiscal impact analysis being a more intensive process in the legislative activity, on occasion, the legislative function would rely more on the qualitative analysis by the competent sector than on balance computers or estimations contained in the reports.

7.7.3. Long-Term Implications for Budgetary Policy

As artificial Intelligence systems gradually evolve to be a fundamental part of our life and decision-making, implications for both budget and budget policy may change drastically. Implementation of AI budget tools may change the way how the planning process is performed through potential impact on both the costs and the way decisions are made and hence the expenditure structure. Decision-making is the main tool for fiscal policy and since the behavior of authorities will be affected by the integration of external budget tools, the implications go beyond the agency costs embedded within decision-making. If tools are integrated which are of primary interest for the tools performing authority, they may put more emphasis on broader objectives than only efficiency, thereby enacting responsibility costs, which are the disadvantage of outward-oriented tools. As a consequence, modern budget tools designed, performed, and executed by external authorities may not be used by decision-makers to reach targets that are in line with the outward orientation of the tool. Responsibility costs may mainly become more

important for externally imposed tools, while agency costs may dominate for tools that are primarily used to improve inward-oriented performance.

The issue is whether such a development is less utopian than it seems at first glance. Who tightly believes in the independence of expert-oriented tools, will narrate as to what extent responsibility costs are caused and not agency costs and agency costs not responsibility costs as well. Could it not also be that at some point in time a tool is used with respect to expenditure correction, while at other times an expert tool is used due to agency costs and not responsibility costs engaged as budgetary cuts result in less popularity of decision makers?

7.8. Future Directions

We believe the exploratory work examined in this paper can lead to the development of an Intelligent Knowledge-Based Budgeting Support System capable of addressing and encompassing a much wider range of factors and events of interest — and capable of informing decision-makers of the fiscal impact within their constituency of changes in tax policies, transfers and any public investment. Moreover, we believe many other aspects of interconnected decision factors and disciplines can be incorporated into the fiscal and budgetary models in the future, leveraging recommendation algorithms used for consumer product selection, location-based services, social networks, treasury info, input-output models, and connected public policies.

To disclose the impact of a much wider range of factors and conditions, these Bayesian-based functions should be based on feedback learning techniques. With the advent of big data, and associated costs increasingly becoming lesser, much more data sets could be added to be monitored. The Corresponding Principle can elegantly deal with the problem of dimensionality and interpretability experienced by the above-mentioned Bayesian approaches; associated with the adoption of manifold learning and exploring ideas of sparse coding, the Corresponding Principle becomes very useful for recovering dynamics and potential from observations of the data. Probabilistic modeling and generative models could be further explored and merged.

The budgetary problem is an essential aspect of economy-based science. We believe that our work could be extended in many other directions. These enhancements would not only assure decision-makers of the effects of changes in budgetary items but also present them with inherent feedback loops aiming at steering the economy automatically to minimize negative imprints and ensure citizen welfare improvement continuously. Indeed, such systems, instead of waiting for cyclic adjustments in policies, could apply budgetary forecast correction autonomously and overcome the biased economic

predictions of the various models being used and revised but whose algorithms and data invariably seem to lead to the same ineffective predictions.

7.8.1. Emerging Technologies in Fiscal Analysis

Thinking about the digital age merits placing digital technologies at the service of decision-making in critical areas such as public budgeting by automating, digitizing or even transforming the processes involved in decision-making. In addition, innovation should not only be available to decision-makers, very often with struggles on which information and how to deliver it in order to perform adequate budgetary choices and incentives, but also to citizens so that they can demand from their institutions the impact of certain spheres of the budget in their lives. The delivery of texts, deliberation spaces, and impact simulations are increasingly present, especially in local government, where the convergence between the disciplines of participatory and digital democracy has shown important results. The involvement of citizens and companies in public policy impact generation is a reality that is becoming more and more tangible with the use of interactive platforms that allow users to create, share and value short-term effects for the proposal of any type of spending. In the case of infrastructure investment, the users' valuation of the costs used in a project, the time it takes to go from one place to another using it, and the tourist potential indirectly presented through the generation of economic activity around these places, works for the different budget spheres, constitute the variables able to go beyond the data retrieval in multiplying the results and applying weights between results that correspond to different areas of public action. It is yet routine to populate spreadsheets, usually presentations, with budgetary results with some historical comparativeness to try and tell a story. The challenge is data science.

7.8.2. Policy Recommendations for Implementation

We conclude by outlining two areas where focus and commitment from governments can aid in the implementation of intelligent fiscal impact analysis techniques in budgets: capacity building and international research collaboration initiatives. Significant effort is needed to develop an agenda on training and teaching in government institutions on the uses of artificial intelligence techniques to build tools that will expand and make more accurate the work of the central planning direction in economic programming for agency budget allocation and costing of proposed new policies as well as to build confidence in existing systems. Routine operations in universities and research centers must be established to help government institutions and public universities to enhance their skills of public budget modeling and make tangible advancements towards the use of intelligent fiscal impact analysis tools with the purpose of enabling governments to

provide better country planning and policy structuring with the ultimate goal of improving the welfare of their citizens. Investments from different non-state actors really interested in using this kind of technology to better for everyone the current budget systems of their country must be made and will pay off. We propose to start as a first step to have systematized pilot tools to be made available to governments in order to practically show them how intelligent fiscal impact analysis tool techniques could function and if they can make use of these kinds of modeling systems. They are assumed to be government specific and unique. Once they have been built, or if some government-specific budget backup has been installed, the policy department can come out with suggestions for public investments needing a fiscal impact analysis and be made available to help budget policy teams model their budget processes if they feel there is a need for these kinds of models around.

7.9. Conclusion

Fiscal Impact Analysis is a significant matter that requires decision support beyond historical budget figures or "rule-of-thumb" approaches generally used by Non-Governmental Organizations, State Managerial Agencies, and the general public. Current predictive models generally retrieve and process information from historical relevant databases to predict the future behavior of fiscal aggregates or similar series. These models are limited in its exploring techniques and consider linear or polynomial relationships that may be imposed within the series. Developed intelligent algorithms, including Artificial Neural Networks, Random Forest, Extreme Learned Machine, Model Trees, and Adaptive Neuro Fuzzy Inference System, are explored and applied in this work and make use of available data on budgetary items. They directly create nonlinear relationships as a way of redistributing the available budget data. Creating these strategies with an Intelligent Algorithm seeks to enhance decision support and risk assessment in Fiscal Market Debt Management inside government accounting.

Results are presented for a more detailed proposal regarding the use of Algorithms for Non-Linear Budget Prediction, showing asymmetry prediction intervals and risk assessment through the Probabilistic Prediction Density Function. Graphics are presented, as well as Value at Risk statistics and portfolios distinctive features for a three and twelve-month period of prediction. Similar information is provided for Diagonal Band Method, Probabilistic Neural Network, and Statistical Detrend, but for External Receivables and External Loans and Credits and International Monte Carlo. Applied Intelligent Models showed efficiencies for assessing risk for Fiscal Impact Forecasting compared to Historic Data, while Univariate Seasonality Refit Models (Diagonal Band Method) and Singular Spectrum – Probabilistic Neural Network did not show risk for Internal Expenses and Revenues.

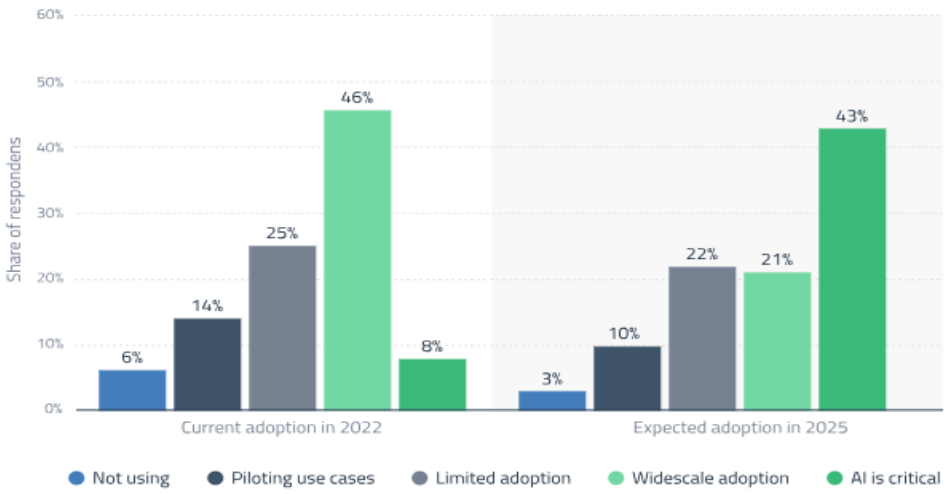

Fig 7 . 3 : AI in Finance

7.9.1. Summary and Implications of Findings

This research is tied to how fiscal impact analysis can be enhanced by advancing our understanding of techniques, approaches and workflows offered by machine learning and artificial intelligence. Concerning budgeting processes and their digitalization, we study the decision support element provided by financial algorithms. In merging insights from cognitive (behavioral) economics with public administration, decision modeling and budgetary theory, we investigate whether digital tools can help budget preparers to provide better, more reliable and impactful budget proposals. To analyze how AI supports budgeting processes, firstly, we present the consequences of the digital turn which society, as well as the public sector, are currently confronting. Next, we present a broad overview of prior research by connecting novel decision paradigms that employ algorithmic decision support with budgetary control theory. Using a multiple case study approach, we take a qualitative-empirical perspective on how budgetary planners use intelligent applications. Our findings show that innovators presented success stories about the implementation of novel tools which were a supportive element for lowering budget proposal distortions. We point out that these tools can facilitate better and more reliable budgeting, and thus prosper our economy. Finally, we provide a deeper discussion and implications of our findings. Hereby, we conclude by outlining open questions for future research regarding the complex interplay between digitalization and budgeting.

Our research illustrates the potential benefits offered by algorithms in budgeting processes, i.e. proposing budgets. All the tools analyzed support the efforts of budget

preparers. It may be possible to centralize the responsibility of the budget proposal process in the treasurer, allowing him or her to make use of the tools. The algorithms may guide the proposed revision of the budgets because they show the areas that might need closer examination. However, based on the cases analyzed so far, we cannot contribute to understanding that the tools are substitutive of redesigning the budget process, and a complete delegation of responsibilities in them. In other words, the participation of the budget preparers is still necessary and the tools would serve to guide the budget preparers, somewhat autonomously, to guarantee a higher degree of quality. As a future line of research, the ideal would be long-lasting case studies and the design of strategies for the different phases of the implementation of the tools in the governments and organizations that use them.

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