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The Sustainability of Retirement System: Comparative Study and Predictive Models Based on NATIXIS Index

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Abstract

Retirement systems are complex tools that are part of the financial systems of countries. There are different pension systems and retirement plans around the world, from the most sophisticated actuarial system to the emerging governmentally controlled one. The goal of this paper is to analyze the current retirement security level of the United States, France, Japan, and Morocco. It also aims to create an assessment model, inspired from the Natixis Global Retirement Index, that is capable of evaluating the retirement system of a country at a specific point in time. In this paper, we use it to assess the Moroccan Retirement System.

Using substantial Macroeconomic data over the period 2012-2021, the study provides a Regression model that allows to estimate the Natixis Index of Morocco to 10 Global Retirement Index with an accuracy of 94%. It also provides Neural Networks model but with a lower accuracy of 69 to 70%.

Most of the changes in the retirement system aim to reduce pension expenditure as a share of the Gross Domestic product. As common factors, the three countries' focus of the study increase their life expectancy and undergo great changes in disposable income and saving over generations.

Variables used in the model include; Retirement Type System: Government dominated system/ Private dominated/ Hybrid, Health Care Type System, GDP per Capital in USD, Inflation Consumer Price, Interest Rate, Average age of retirement, Life expectancy, Fertility Rate, Government debt in USD, Annual Growth Rate in Population, Average Government Spending in Pension as a % of GDP, and Human development Index.

Introduction

Retirement systems are complex elements of societal context and differ from country to country. This research presents four different systems from the United States, France, Japan, and Morocco. Variables that influence the construction of retirement systems are historical, economic, and cultural. In today's world, the sustainability of our established systems has been questioned in many fields. The scarcity of resources and increasing demography raised issues never faced before. In this context, retirement systems have been studied and questioned in many ways. Moreover, the emergence of data analytics tools changed the study approach to this subject.

Firstly, this paper presents and compares the retirement system of the four previously mentioned countries. Secondly, It uses macroeconomic data from the United States, France, and Japan to create a predictive model. The predictive model constructed is a Regression model and Neural Networks model. The paper also presents the use of the predictive model in Morocco. The ultimate purpose is to show the usefulness of a predictive model to assess the sustainability of the retirement system in a country at a specific time given.

Overview of Retirement Systems

In 1881, Otto von Bismarck, the minister-president of Prussia, presented an idea never seen before to the Reichstag: a system of financial support run by the government for older members of society. It was then the start of the retirement system in the world. In the United States, it was in the mid-1800s that some municipalities offered public pensions to their employees. In 1875, the American Express Company started to offer private pensions as well (Laskow Sarah, 2014).

Over time, the life expectancy at normal pension age has changed between countries and even between genders- See Appendix 1- (Whitehouse, Edward, 2014). It is not the only difference observable between countries and their economy. The level of economic development, the population age structure, and politics are factors that differentiate countries and affect the retirement income systems appropriate for different countries (Turner, John, 1998). Following is a brief explanation of the retirement system assessed in the research.

Retirement system in The USA :

The federal government of the United States provides Social Security (SS) programs, including retirement. It utilizes the Social Security taxes to distribute different types of benefits to retirees. However, as an American worker, the SS retirement program should only be a part of the retirement plan. On average, American will receive 40% of their pre-retirement income from SS; therefore, the necessity to plan complementary retirement income resources is primordial (Social security Administration: Retirement Benefits).

The SS retirement in the U.S. system works with a credit earning system. If you were born in 1929 or later, you need 40 credits to benefit from the SS retirement system– often equivalent of 10 years of work. Individuals can choose when to start receiving their retirement benefit. This choice can affect the amount received. The Full Retirement Age (FRA) is the age when you can start receiving

your full retirement benefit. Over the years, the FRA has kept increasing. It went from 66 for the individuals born between 1943 and 1954 to 67 starting after 1960 (Social security Administration: Retirement Benefits).

Aside the public retirement system of the United States, the country also has a complex private pension system. To understand it, one can refer us to the OECD Private Pensions Outlook 2008 which gives a concise description of it (OECD Private Pensions Outlook 2008).

In the United States, employers can offer different mechanisms of private pensions. They mainly use private pension funds - Defined Benefit (DB), Define Contributions (DC) or a combined system. The states and federal political system unique to the United States also creates a particular system of retirement. In addition to the SS retirement program mentioned earlier, state and municipal employees can also benefit from state retirement program or even municipal program. These programs are by large DB pension funds sponsored by states and municipality (OECD Private Pensions Outlook 2008). As an example, since 1923, Pennsylvania offers a large panel of state employees' retirement system. DB plan called Traditional Pension, DC plan or Investment Option, Hybrid plan or Pension + Investments, and Deferred Compensation also called Supplement Benefit (PA. GOV, 2022).

Historically, DB plans were by far the most offered option by companies, but overtime, the DC plan overtook its place mainly thanks to its 401(k)program (OECD Private Pensions Outlook 2008).

401(k) is a very popular option offered in the U.S. Under this plan, employees can make before-tax contributions from their salaries through salary reduction. Often, the 401(k) comes with a matching employer contribution. The plan contribution can reach a match equal to 50% of the employee's before-tax contributions up to 6% of salary (OECD Private Pensions Outlook 2008).

In other words, employees defer receiving this money that will usually not be taxed until distributed. Moreover, the 401(k) contributions being pre-taxes help reduce it – except for the Roth 401(k) a format where the contribution is done on the after-tax income (Marquit, Miranda et al., 2021). The money that they do not receive now will be in the stock market and grow over time. Employees might directly enroll in a 401(k) plan and can choose to opt-out, or they might have to choose when hired if they want to enroll or opt-out, it will depends on the employer. As of today, the IRS maximum employee contribution is up to $20,500 plus an extra $6,500 if you are 50 or older (Marquit, Miranda et al., 2021).

The other less popular option offered by US employers comprehend Profit-Sharing plans a specific contribution formula such as a percentage of salary, and Employee Stock Ownership Plans (ESOPs). Under this plan the employees' accounts are invested in shares of the company stock, and eventually, Individual Retirement Arrangements (IRAs). These plans are investment vehicles of employers and employees contributions (OECD Private Pensions Outlook 2008). Alongside with the complex retirement system of the United States, American have a complex opinion about it. 55% of them believe that the government should pay for the care of older adults but only 28% actually trust the government to take responsibility for it (Parker, Kim et al., 2019). The American skepticism about the future solvency of the Social Security system is wildly spread reaching 42% who believe that they would not receive any Social Security benefits (Parker, Kim et al., 2019).

Retirement system in France:

The skepticism of the Americans regarding their retirement system is something shared by the French community. To be more specific, the French perceive attempts to change the public pension system with great skepticism. Many remember the endless strike of Christmas 2019

against the Macron administration pension reforms. Public employees were likely to lose their right to early retirement with the pension overhaul suggested, among other modifications. Additionally, the strikes were more perceived as anti-government than anti-retirement reforms. Thus, they gather the support of 46 to 69% of the French population -depending on the pull. Meanwhile, 76% of the French people are said to be in favor of the pension reforms (Horcajuelo, Guillaume, 2019).

The existing pension system in France was established in 1945 (ApRobert, 2011). It has three pillars of a benefice: the French state pension, compulsory supplementary pensions, and voluntary occupational and personal arrangements (Pensions At A Glance 2019: Country Profiles-France, 2019). The public system is based on a contributory pension scheme; the contributions of those who are currently working fund the pension for those who are no longer working (ApRobert Lucy et al., 2011). The public pension reserve fund (FRR) created in 1999, supports the spending of the government in the pension system. It is funded by income tax, the French National Old Age Fund, and the sales of certain state-owned assets (Pensions At A Glance 2019: Country Profiles-France, 2019).

Compulsory occupational pension schemes, also called Occupational mandatory, is divided into two programs: *Asssociation des régimes de retraites complémentaires* (ARRCO) and *Association Générale des institutions de retraites des cadres* (AGIRC). ARRCO is specifically for blue-collar workers and AGIRC for white collar workers. After 2019 reforms, the two programs merged to cover private and agricultural sector employees (Pensions At A Glance 2019: Country Profiles-France, 2019). Benefits are earned on 6% earnings below the ceiling of the public pension and 17%, between one and eight times the ceiling (EUR 324 192 in 2019). The system is measured in contributive points converted into pension benefits at retirement. The pension-point value is

assumed to increase along the prices increase over time. Companies have also to provide a retirement plan called Indenité de Fin de Carrière (IFC), and benefits are taxed as income (Pensions At A Glance 2019: Country Profiles-France, 2019).

The Occupational Voluntary scheme is a funded occupational pension plan (Plan d'épargne retraite), PERCO. Under the PERCO, employers offer their employees three collective investment funds. Employees are allowed to contribute up to a quarter of their gross annual salary, employers can match the contribution with a ceiling of EUR 5149 per year (or three times the contribution). Under the PERCO, the tax regime is unique; if the employer contributions are higher than EUR4600, it is not considered as an employee's taxable income. If employer contributions are between EUR2300 and EUR 4600, it is under an 8.2% tax rate. The employee Contributions are subject to normal income tax, and investment income and retirement benefits are exempt (Pensions At A Glance 2019: Country Profiles-France, 2019).

Eventually, the Personal Arrangement is an individual retirement savings plan (Plan d'épargne retraite populaire), PERP. It represents an additional personal income in French people's retirement if they choose to take this coverage as well. The pension insurance plan sets the frequency, the rate, and the guarantee for a progressively incremented minimum level of benefits. The contributions are tax-deductible up to 10%, and the annuities are treated the same as ARRCO and AGIRC benefits (Pensions At A Glance 2019: Country Profiles-France, 2019).

The 2019 Macron's reforms merge the country's 42 existing pension programs into a single regime to ease the system but jeopardize the trust if not the stability of a historically great retirement system. Only 7% of the French elderly are at risk of poverty, which is the lower rate in the European Union (Strangler Cole, 2019).

Due to the pandemic crisis starting in 2019, the government postponed the latest reforms. The French retirement systems would likely adopt the changes mentioned after the election of 2022 if the government in place still wishes to pursue them (Spasova, Slavina et al., 2021).

<u>Retirement system in Japan :</u>

To define and understand the retirement system of Japan, we can look at different evolution studies. In 2007 the social security Administration, Office of retirement and disability policy published in their Social Security bulletin an update on the Japanese employer-sponsored retirement plans written by David Rajnes. Additionally, more recently, the OECD, in its Pensions At Glance publication of 2021 did a Country Profile on Japan.

Japan's retirement system is divided into two main categories, social system, and employer-sponsored retirement plans (U.S. Social Security Administration, 2007). The Public Pension System is composed of two tiers defined as the basic flat-rate scheme and an earnings-related plan (employees' pension scheme). The basic pension scheme covers everyone between the age of 20 to 59 who lives in Japan. In addition, if they are employed, they benefit from the employee's pension scheme, second tier, also called Employees' Pension Insurance(EPI). The contribution rate of the EPI had risen incrementally by 0.35 percent each year (Rajnes, David, 2007). In 2020, the contribution amount was 18.3% of the salary, with the employers bearing half of it (Pensions at Glance 2021).

Moreover, there is also a social assistance system for all citizens indiscriminately. The social assistance system guarantees a standard of living, even for individuals already benefiting from social security benefits, such as pensions (Pensions at Glance 2021).

On the employer-sponsored retirement side, Japanese companies were mostly offering package retirement with a lump-sum as a complement of the EPI. However, in 2001, a new law

came in place offering more options for employer-Sponsored Plans, and in 2002, the employees lost their tax advantages on the package benefit, which declined the popularity of the lump-sum payments.

In 2001, the employer-sponsored retirement system in Japan evolved with the Defined Benefit (DB) Corporate Pension Law. The objectives of the law are to provide a larger amount of different fund designs compared to the available variety of Employment Pension Fund (EPF) and to answer financial pressure and difficulty to fund those EPF plans. Hence, since 2001, Japan went from one EPF to three forms of DB: Contract-type DB plan, Fund-type DB plan, and Cash balance plan. The Contract-type DB plan is close to the previously used Tax Qualified Pension Plan, itself close to the U.S. DB model. It is principally used by small to medium-sized companies. The Fund-type DB plan is like EPF but without the option to "contract out" of the social security system. It is used by large companies. Eventually, Cash Balance is a hypothetical account balance credited each year where the investment risks are carried by the Plan. The introduction of Defined Contribution Plan was motivated by the successful expending U.S. economy and stock market driven by DC plans and 401(k) plans (Rajnes, David, 2007). For example, Toyota has for Post-Employment Benefits that can work three ways: DB Lump-sum Allowance -historically popular-, DC, both through the company or Cash Balance through Toyota Pension Fund. Sony changed its system for new employees starting in 2012. Employees who entered before May 31, 2012, will beneficiate from a DB Lump-Sum Allowance and then, annuity through Sony Pension Fund for a lifetime or limited term. For employees who entered after, the amended plan after the DB Lump-Sum is now a defined contribution (Retirement Provision in Japan 2019).

Also, the unemployed might be exempted from the earnings-related scheme and are still entitled to one-half of the basic pension. They have an adapted scheme of contribution and entitlement under the Japanese system (Pensions at Glance 2021).

Japanese see their Public Pension (PP) Benefits as a blessing. They are extremely thankful for it. The Japanese philosophy regarding their PP is not based on entitlement but rather a side-by-side mentality, and a strong perception for equality and impartial treatments (Takayama, Noriyuki, 2017).

Retirement system in Morocco :

Morocco's pension system is a Pay-As-You-Go (PAYG). The current contributions are collected and used to pay current retirement benefits. The system is mainly supervised by the government. There are two retirement regimes for the public sector: the Moroccan Pension Fund (Caisse Marocaine des Retraites – CMR) and the Collective Scheme for Retirement Allowances (Régime Collectif d'Allocation de Retraite – RCAR). There is also a mandatory retirement regime for the private sector, the National Social Security Fund (Caisse Nationale de Sécurité Sociale – CNSS) (El-houjjaji, Hind, 2020). These systems follow a "pay as you go" scheme differentiated by the rate and the method of calculation used for the benefit (Achy, Lahcen, 2013).

 These are the three principal coverages available in Morocco. It exists also the Moroccan Interprofessional Fund (la Caisse Interprofessionelle Marocaine de Retraite). Independent from the government, it provides another optional coverage for private workers. Despite the available fund listed above, a large number of Moroccans do not beneficiate from retirement options (Oxford Business Group, 2016). As of 2013, the system covered only one-third of the working population, it is partially due to the common practice of unregulated employment (Achy, Lahcen, 2013).

Additionally, the retirement system in Morocco is facing other challenges as well. In the past few years, the life expectancy for Moroccans increased from 48.45 in 1960 to 75.52 years in 2015. In parallel, the fertility rates fell from 7.07 to 2.53 children by women. These metrics explain the increase of the old-age dependency ratio – the number of a person aged 65 or older as a percentage of the potentially active population. Similar to Japan, the number of contributors decreases compared to the number of beneficiaries (El-houjjaji, Hind, 2020). The sustainability of the PAYG in this situation is said to be in danger since 2015 by the IMF in its Article IV consultation for the country (Oxford Business Group, 2016).

The assessment of the retirement system became very popular in the economic literature after the World Bank Policy Research Report of 1994 of the World Bank: Averting the Old Age Crisis (El-houjjaji, Hind, 2020). The observation made by the World Bank at the time are highlighting the effect of the aging population and the unsustainable and very difficult to reform government-backed pensions.

"As we grow old we work, produce, and earn less, and therefore need secure source of income to see us through life. Societies and governments have developed mechanisms to provide income security for their older citizens as port of social safety net for reducing poverty."

(Averting the Old Age Crisis 1994)

Literature Review

Among the economics and business literature, different factors have been studied for their impact on the retirement system around the world. The United States experienced a low-interest rate due to the Great Recession, first, and again recently due to the covid crisis. Interest rate role in Social Security benefit is not directly linked to its calculation but has more to do with the federal government contribution. Moreover, the individual behavior is likely to impact the effect on his income while retiring. For instance, one could save and accumulate most of its wealth during its young years taking advantage of the interest rate fluctuations. He would have earned a higher return before these years of recession.

However, the latest study suggests that households would not change their saving habit and thus, have a lower wealth-to-income ratio due to the low-interest rate. Delaying retirement is also a possible change in one behavior that would affect retirement and be an indirect consequence of the low-interest rate. Through the spectrum of the retirement system of the United States, the results of low-interest rates are different between the different benefit plans. For the Public defined benefit plans, if the fed keeps the interest rate low, it makes it difficult to maintain full coverage of the existing pension obligations. Thus, public DB plans revise in hybrid plan (DB-DC) and lower benefits for new members.

Long-term consequences for public benefit will be a higher risk for participants and a lower level of benefits. The low-interest-rate consequences are almost similar for the Corporate benefit plans with the only difference being that it might accelerate the transition from DB to DC. Regarding retirement savings and asset management firms, the consequences of low-interest rates are subject to debate. They might try to improve the risk-return profits with illiquid assets (Yin, Yimeng 2021).

Among the factors studied, the impact of future growth is also a focus in the business literature. Published by the Insee in 2015, Corinne Prost's research stated that the adaptive reforms-increasing the age of retirement, decreasing the pensions- make the ration pension/ GDP more sensitive to economic growth. Moreover, price indexation will also be sensitive to productivity growth. Indeed, if the productivity growth is high the difference between income growth and pension growth will increase. Consequently, the purchasing power level of the active population will be lower than the pensioner level. "By 2060, the purchasing power of the retirees should be between 70% and 85% of the purchasing power of people in the labor force" (Prost Corinne, 2015).

Moreover, in a study aiming to identify the affects the funding levels of the public retirement system in the United States, a linear regression estimated the effects of the various factors at a state's level. The variables found significant at the 99% confidence interval were plan type, actuarial assets, annual required contributions (ARC), payroll, the employee contribution rate, and employer contributions (at the 90% confidence interval). Published in 2013 by the University of Kentucky, Jenna M. Skop's research, State Public Retirement Systems: An Examination of Factors Affecting the Funded Ratio, presented the framework resulting in this regression model (Skop Jenna, 2013). Besides the different scale focus of our studies, Jenna Skop's framework is particularly interesting in constructing a Research Design later in this paper.

Among the economic literature demographic changes are shown to have multiple effect in elements impacting retirement system, as well as the system itself. Population ageing is firstly due to increases in life expectancy in most part of the world and low fertility rates. These phenomena are as whole responsible for downward pressure on components of growth. Ageing population

reduce the labor force and thus, impact the productivity of a country and by extrapolation the GPD per capita (Carolin Nerlich, Joachim Schroth, 2018).

Additionally, alongside direct elements impacting retirement, the nature of the health care provided in a country is likely to influence the decision to retire. In the United States, insurance is mainly provided by employers and not all employers provide this benefit. In 1990, 17% of the total compensation of employers was directed toward benefits (Brigitte C. Madrian 1994). Thus, health insurance being the largest composite of this 17%, it is logical to assume that the impact of benefit in the job market and the decision to retire is directly connected to health insurance (Brigitte C. Madrian 1994).

Moreover, health care is mainly provided by employers, one can observe a job-lock effect where employees stick to one position to conserve their employee's benefit besides their dissatisfactions (Brigitte C. Madrian 1994). The job-lock effect is interesting to observe in a job market that evolves with a higher turnover. In a linear regression study, M. A. Sanjeev shows in 2017 a negative correlation in job satisfaction and job turnover, with a focus on sales and marketing professionals. In other words, if we considered this sample representative of behavior, nowadays employees are more attentive to their job satisfaction, which increases job turnover (M. A. Sanjeev 2017). Hence, this study considers the overall retirement system to assess its sustainability, even for the United States, where employers provide most benefits.

The literature review inspired the choices for the financial and economic variables said influential in retirement system in this paper. Parallel to it, the world demographic changes are also influential. The global population increases of 7.7 billion in 2019 to 10.9 billion by the end of the century. Projection show that it will excide 10.88 billion in 2100 (Roser Max, 2013).

Looking closer at the specific countries in this study, demographic changes are estimated to be significant in the coming years. Appendix 2 shows that the U.S. census bureau estimated in 2017 that the population of people 65 years and older will reach 23% of the whole U.S. population, growing 8-point base from 2016 (Jonathan Vespa et al., 2018).

Moreover, in another report, the U.S. census bureau studies the evolution of the birth rate since 2008. Between 2000 to 2019 the number of daily births declined by 0.39% a year on average. It also decreases significantly during the pandemic. Along with these changes, the United States population is projected to grow by almost 79 million in the next 40 years (Jonathan Vespa et al., 2018).

The demographic observation is similar in France, the share of the population aged 65 and older will increase and reach about 25% in 2030 (Daniel Beland et al., 2013). According to the World Population Review website, France's population is expected to keep growing for the next 40 years. The peak will be reached in 2045 up to 67.67 million people – the current population being approximately 67.39 million- (World Population Review Live). The birth rate trend followed by the United States is also similar. It kept decreasing at a slow rate over the past decades, as shown in Appendix 3 (Statistica).

Likewise, Japan experiences aging population and a low birth rate. However, for the country with the greatest longevity the situation has been worrying for years now. In 2001, the IFM published a report on Japan : Population Aging and the Fiscal Challenge. At the time, they already estimated that by 2025, there will be roughly one elderly person for every two persons of working age (Martin Muhleisen et al., 2001). Simultaneously, Japan's birth rate is one of the lowest in the world and is still decreasing today- in 2021, 1.31% decline from 2020- (Statistica).

On the other side, Morocco remains a demographically young country. Nonetheless, the share of elderly population increases as well in Morocco reaching only 7.5 to 8% in 2020 (Statistica). According to the Work Bank data collection Morocco has a decreasing birth rate but it is still the highest among the 4 countries the study focuses on (the Word Bank Data).

This paper methodology is inspired by the framework of the Mercer CFA Institute Global Pension Index and the Global Retirement Index published by Natixis. Both Indexes report provide insight on the factors that drive retirement system, and they provide a tool for comparison between different retirement policies. However, there is limitation to the use of these indexes. Natixis index does not provide data in Morocco. The only countries present in the study are the country from the Economic Co-operation and Development (OECD) the International Monetary Fund advanced economies and the Brazil, Russia, India and South Africa (BRICS). The same way the Mercer Index is limited in countries the list is available in Appendix 4.

The construction of the Mercer Index aims to be as objective as possible while recognizing that it is artificial because it brought purpose. This paper is similar to the Mercer index in this aspect. The international data available are used and split into three weighted categories: Adequacy (40%), Sustainability (35%), and Integrity (25%). The Adequacy accounts for much of the index because the main objective to retirement systems is to provide adequate retirement income. This category is calculated accounting for six features: voluntary member contributions, minimum access age, resignation, income stream, divorce separation and income support. From these three large categories the Index drive a ranking to assess the retirement systems of countries. Through a yearly report Mercer also highlight issues and recommendation to enhance the sustainability of current retirement system in the world. Furthermore, the report states the limitation to the index:

" it cannot recognize every aspect of a pension system, particularly the more subjective matters such as community confidence in the system" (Mercer CFA Institute Global Pension Index 2021).

The Natixis index was publishing the first time in 2012. It is constructed with 4 main categories (health, material wellbeing, quality of life/ environment, and Finances in retirement) within which there is in total 18 indicators. Appendix 5 is showing the 18 performance indicators within the four thematic indices. The GRI index cover a broad macroeconomic landscape to assess the retirement system of many country in the word. It is also an evolutive index that adapt over years (Natixis Global Retirement Index 2021). Therefore, the GRI index represents a resourceful information to governments. This research will tried to construct and use a predictive model capable of giving an GRI index at any point in time.

As a notable element in research about retirement, psychology literature research has been increasingly prominent. Retirement is often study in the psychology field as a decision-making process, a choice that implies motivation and a behavioral withdraw from work-related activates (Mo Wang Junqi Shi 2014). Consequently, the psychological implication in assessing retirement sustainability between different cultures is pushing the study to take the broadest approach to bring the most complete result.

Methodology

Macroeconomic Data were gathered from multiple sources from the years 2013 to 2021. One source for each variable was the most efficient way to assure consistency. The main obstacle encountered in the gathering of data was the scarcity of the data available for Morocco. In addition, the 2021 data are extremely new and thus the sources are not as wildly recognized as the World Bank or the IFM database. However, if they were recognized by such trustworthy sources, they sometimes were estimated on the 2021 metric. The overall data are shown in Appendix 6.

The Retirement System (RS) type was defined in the overview of the countries' RS, as well as the health care system. The world Bank database was the source for the GDP per capita in USD, as well as for the Inflation (consumer price) on annual percentage, and the fertility rate. For the Interest Rate, the data are similar to the Natixis Index and the Moroccan Banker Association. The change in data sources here is considered insignificant because the models are constructed in the USA, French, and Japanese data.

The Average Age of Retirement and Life expectancy is from statistica database. The main sources of their data are government and statistical agencies. The Government debt in USD was also from statistica and compared with the Organization for Economic Cooperation and Development OECD data for the countries part of it (USA, France, and Japan). The comparison helped to use the statica predicted value for their proximity with the reported OECD value. OECD is also the source for the Average Government Spending on Pension as % of GDP. However, for the Moroccan value, the government estimation gives only an average of 3.5%. Thus, this variable will be a constant in the models. Eventually, the Human Development Index is from the "Countryecomy" website.

MacroTrend is the source For the Annual Growth Rate in population. Eventually, the Human Development Index is from the "Countryecomy" website. All the previously mentioned variables are independent variables and the Natixis Index is used as the dependent variable.

The data collection is organized into three sub-index: Socio-political, Financial and Economic, and Demographic. The Sociopolitical sub-index comprehends Retirement System Type, Health Care System Type, and Human Development Index. In the Financial and Economic there is the Gross Domestic Product, Inflation rate, Interest rate, Government Debt, and the Average Government Spending on Pension. The Demographic sub-index gathers the average age of retirement, Life Expectancy, Fertility rate, and Annual Growth Rate in Population. The initial purpose of the sub-index was to potentially weight them differently. However, later on, in the construction of the models, the equally weighted sub-index was more conclusive.

To use the data in R software I created three new binary variables accounting for the categorical variables. I also removed the Mercer Index. It represents a crucial source of information and inspiration for this research but in terms of data is not usable. The data are available only for the three years 2019, 2020, and 2021 in the training data. Appendix 7 shows the data used to construct the models.

The first model was a simple regression model constructed in R, the code is in Appendix 8. The 27 observations seemed little as data used to train a model. However, the result of this first regression model- see result in the upcoming part- were conclusive and inspired the second model. The second model was also a regression with fewer data that improved the accuracy of the model and the significance of variables. The code is shown in Appendix 9.

As a third model, I tried to run the 27 observations into a Neural Network model. The first Neural Network had three hidden layers and three interactions. I also tried to change the number

of hidden layers and interactions between (1,1) to (5,5). The accuracy of the Neural Network model was maximum with (3,3). Otherwise, it will just drastically decrease or stay around the same percentage of accuracy. Appendix 10 is showing the code to use to build the Neural Network model. The result part of this paper provides details on the regression models.

After selecting it, I used the model to predict the Natixis index of Morocco from the years 2013 to 2021. I also analyzed the evolution of the independent variables for Morocco during the same period. The methodology adopted for this research is a systematic approach that has for goal to provide an approach re-usable in different scale.

Result

The Neural Network Model gave an accuracy of 69 to 70%. It could be considered a decent first step for the result of the analysis. However, the difficulty in the situation of a Neural Network is the interpretation. It is hard to interpret the model process to indicate variables. The model uses interaction to create new independent variables from the data that will be used to define the Natixis Index.

The first Linear Regression gave an accuracy of 94%. It seems to be a great result. However, only a few variables are significant at the 90% level. The only significant variables in this model were the Interest rate, the Human Development Index, the Health Care type, and the government debt. The significance of these variables was estimated concerning their P-value close enough to 0.1 or lower. This model stresses the importance of the Socio-political Financial and economic sub-index. It is, however, like the Neural Network hard to interpret because of the few significant variables.

To continue to improve the accuracy, the second Linear Regression had fewer variables. The observation of the P-value shows that all the variables are significant except the government spending (e) one. The variables kept were the Inflation a, the Interest Rate b, the Life expectancy c, the government debt e, the Human Development Index f, and the Health Care System.

Here is the 2nd regression model :

$$y=468-0.39a+1.79b+3.41c+0.001d-0.29e-760f+9.23g+3.3h+9.23i$$

Using the 2nd predictive Linear Regression model in the Moroccan data the model predicted a 10% GRI which in 2021 raked it between < Mexico score and > India score.

Moreover Looking at the evolution of the data as well as the literature review, the margin of improvement in the financial system of morocco is considerable. The interest rate data and GDP data evolution show a slow improvement. Moreover, the Socio-political sub Index gathers data that stagnates.

The government spending on pension as a percentage of the GDP did not appear as significant in the second model, which in the case of Morocco was not problematic. The usefulness of this data was already questionable because it was a constant for our predictive process.

Conclusion and Discussion

The implementation of the Regression Model in Morocco shows a young retirement system with a marge of progression in multiple fields such as financial in retirement and health care. These results are preliminary work that could serve as Guidance for the policymakers.

In the literature review, we saw the reluctance expressed by French people toward reforming their system. The results shown here are also guidance for alternatives to direct reforms. Indirect policies targeting improvement in Socio-political conditions and finance are likely to be the most influential in the improvement of the Moroccan Retirement system.

Moreover, the Natixis Index report of 2021 reports the USA financial in retirement as the best system available and the health care system of Japan and France as two of the most efficient systems. Consequently, the research also provides sources of inspiration for adjustment of policy to indirectly change the sustainability of the Moroccan Retirement System.

The usefulness of this model does not stop its implementation in Morocco. The enlargement of the training data could make it suitable to assess retirement systems across a country, and across the world. It could also be used in different schedule, quarterly for instance. It is also capable of assessing potential retirement systems not created yet. For instance, if the European Union were to create one common retirement system, the predictive model based on macroeconomic data will predict its sustainability.

The model also shows the opportunity for use at a state's level in the United States. Many states have specific public retirement plans and resources available to their citizen. For an American citizen, the choice between states to work and retire is a common dilemma. Thus, it would be a good use of such a model to implement the model at a state level and compare the GRI score between states.

Eventually, such a model is also capable to use predicted independent variables to predict the progression of sustainability in countries. However, the accumulation of prediction variables might increase the margin of error to an unsuitable value. The use of the model form and forecasting data might need adjustment in data sourcing.

The different possible use of the regression model for the GRI index is implementing data-driven logic to a personal choice: Where to retire? Different personalities might be more or less attracted by the data-driven decision, it allows making that decision based on a systematic approach to the dilemma.

Trends in life expectancy at normal pension age

Source: OECD *Pensions Outlook 2012*
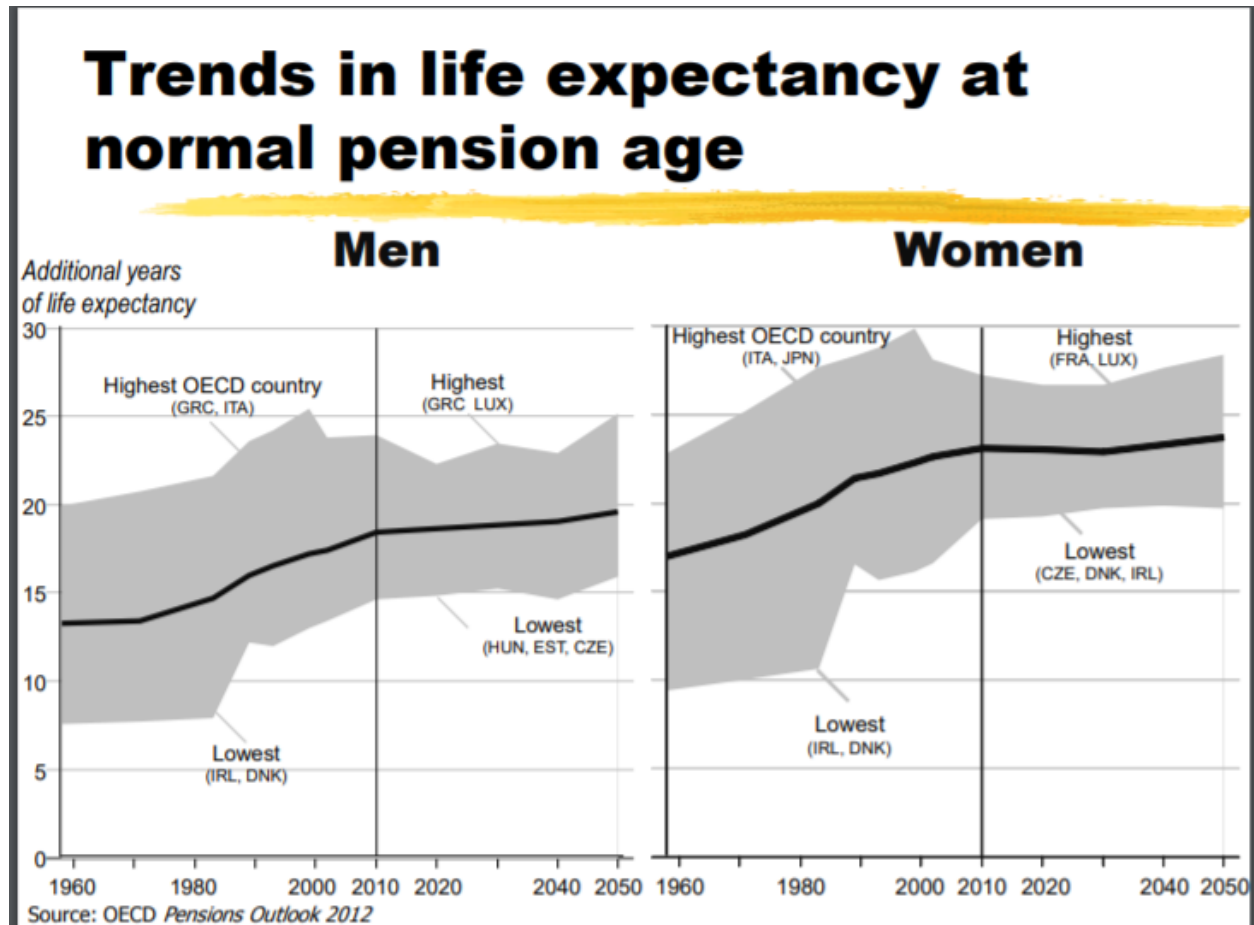
Appendix 2:

Figure 1.
Projections of the Older Adult Population: 2020 to 2060
By 2060, nearly one in four Americans is projected to
be an older adult.

Millions of people 65 years and older   Percent of population

Year	Millions	Percent
2016	49.2	15
2020	56.1	17
2030	73.1	21
2040	80.8	22
2050	85.7	22
2060	94.7	23
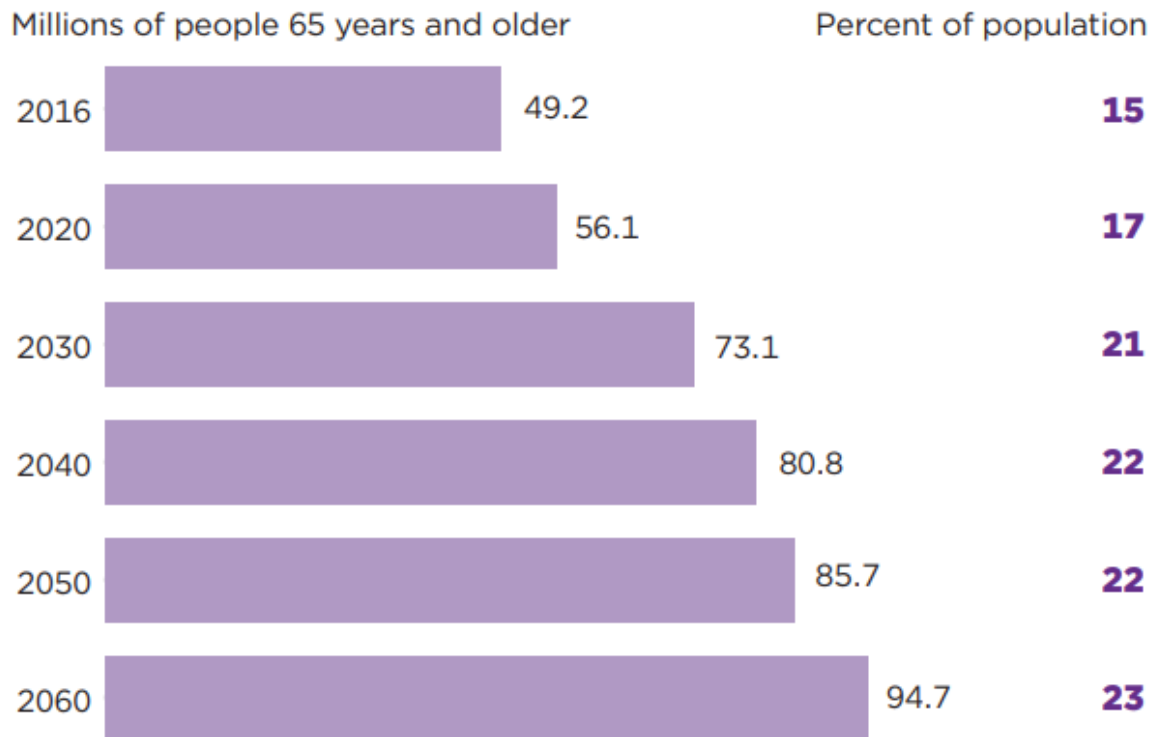
Source: U.S. Census Bureau, 2017 National Population Projections.

Appendix 3:

Birth rate in France from 1982 to 2020

(per 1,000 inhabitants)

Appendix 4:

A comparison from 2020 to 2021

Table 4 compares the results for 39 systems from 2020 to 2021. Comments in respect of each system are made in Chapter 5.

Table 4: Comparison index values for each system, including the three sub-indices

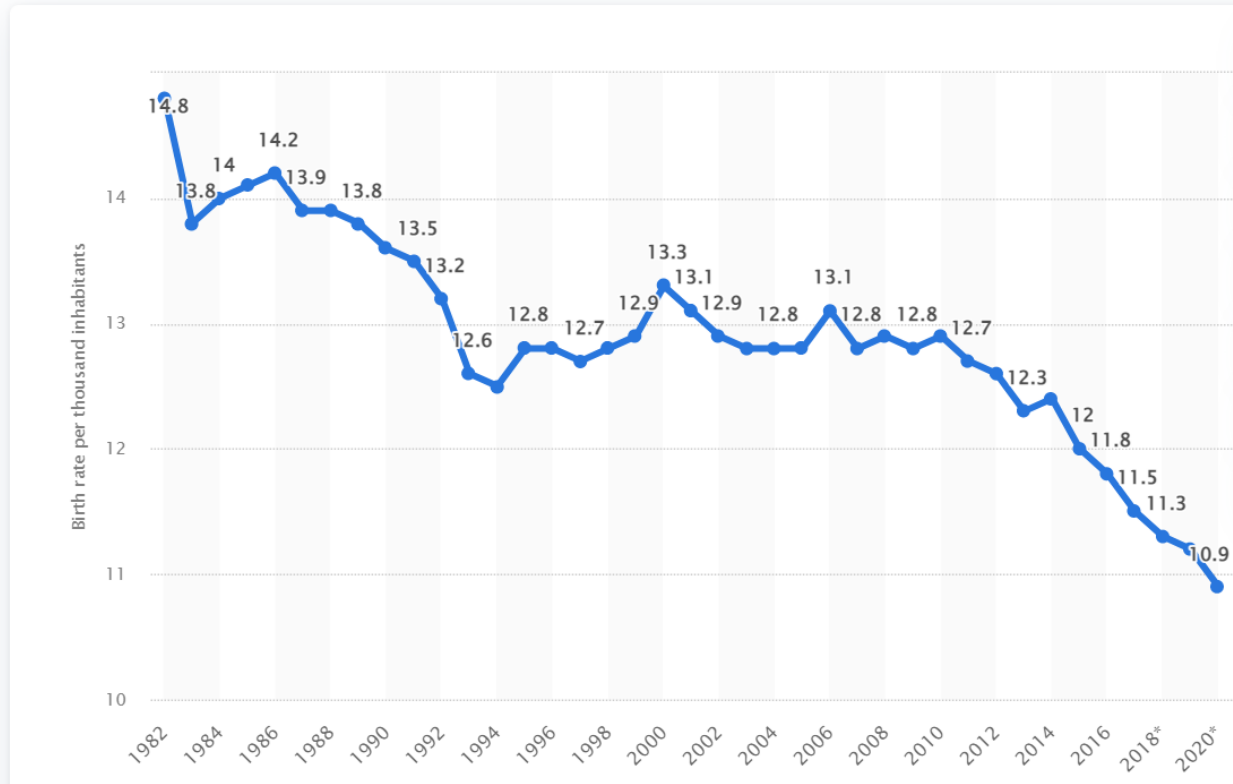| System	Total		Adequacy		Sustainability		Integrity	
	2020	2021	2020	2021	2020	2021	2020	2021
Argentina	42.5	41.5	54.5	52.7	27.6	27.7	44.4	43.0
Australia	74.2	75.0	66.8	67.4	74.6	75.7	85.5	86.3
Austria	52.1	53.0	64.4	65.3	22.1	23.5	74.6	74.5
Belgium	63.4	64.5	74.6	74.9	32.4	36.3	88.9	87.4
Brazil	54.5	54.7	72.6	71.2	22.3	24.1	70.7	71.2
Canada	69.3	69.8	68.2	69.0	64.4	65.7	77.8	76.7
Chile	67.0	67.0	56.5	57.6	70.0	68.8	79.6	79.3
China	47.3	55.1	57.4	62.6	36.2	43.5	46.7	59.4
Colombia	58.5	58.4	62.5	62.0	45.5	46.2	70.5	69.8
Denmark	81.4	82.0	79.8	81.1	82.6	83.5	82.4	81.4
Finland	72.9	73.3	71.0	71.4	60.5	61.5	93.5	93.1
France	60.0	60.5	78.7	79.1	40.9	41.8	57.0	56.8
Germany	67.3	67.9	78.8	79.3	44.1	45.4	81.4	81.2
Hong Kong SAR	61.1	61.8	54.5	55.1	50.0	51.1	87.1	87.7
India	45.7	43.3	38.8	33.5	43.1	41.8	60.3	61.0
Indonesia	51.4	50.4	45.7	44.7	45.6	43.6	68.7	69.2
Ireland	65.0	68.3	74.7	78.0	45.6	47.4	76.5	82.1
Israel	74.7	77.1	70.7	73.6	72.4	76.1	84.2	83.9
Italy	51.9	53.4	66.7	68.2	18.8	21.3	74.4	74.9
Japan	48.5	49.8	52.9	52.9	35.9	37.5	59.2	61.9
Korea	50.5	48.3	48.0	43.4	53.4	52.7	50.3	50.0
Malaysia	60.1	59.6	50.1	50.6	58.6	57.5	78.0	76.8
Mexico	44.7	49.0	36.5	47.3	55.8	54.7	42.2	43.8
Netherlands	82.6	83.5	81.5	82.3	79.3	81.6	88.9	87.9
New Zealand	68.3	67.4	63.8	61.8	62.9	62.5	82.9	83.2
Norway	71.2	75.2	73.4	81.2	55.1	57.4	90.3	90.2
Peru	57.2	55.0	59.5	58.8	49.2	44.2	64.6	64.1
Philippines	43.0	42.7	38.9	38.9	53.4	52.5	34.8	35.0
Poland	54.7	55.2	59.9	60.9	40.7	41.3	65.9	65.6
Saudi Arabia	57.5	58.1	59.6	61.7	51.6	50.9	62.4	62.5
Singapore	71.2	70.7	74.1	73.5	59.9	59.8	82.5	81.5
South Africa	53.2	53.6	43.0	44.3	46.7	46.5	78.3	78.5
Spain	57.7	58.6	71.0	72.9	27.5	28.1	78.5	78.3
Sweden	71.2	72.9	65.2	67.8	72.0	73.7	79.8	80.0
Switzerland	67.0	70.0	59.5	65.4	64.2	67.2	83.1	81.3
Thailand	40.8	40.6	36.8	35.2	40.8	40.0	47.3	50.0
Turkey	42.7	45.8	44.2	47.7	24.9	28.6	65.3	66.7
UK	64.9	71.6	59.2	73.9	58.0	59.8	83.7	84.4
USA	60.3	61.4	58.9	60.9	62.1	63.6	59.9	59.2
Average	**59.7**	**60.7**	**60.8**	**62.3**	**50.0**	**50.9**	**71.3**	**71.8**

The results show that the average score for the overall index increased by 1.0 with increases in each sub-index for a variety of reasons.

Appendix 5:

Source: Natixi. Framework: Global retirement index. 2020

Appendix 6:

Data Collection

Country	Natixis Index	Natixis Index ranking	Mercer Index	Retirement System Type	Health care system type	GDP per capita in US$ (world bank)	Inflation consumer prices (annual %) (word bank - moroccowo)	Interest rate (Natixis - moroccan banker association)	Average age of retirement	Life expectancy	Fertility Rate	Governement debt in billions USD (OECD - statistica - countryecono my)	Annual Growth Rate in population	average government spendic in Pension as a % of GDP (OECD -	Human Development Index (countryec onomy)
United States 2013	74%	19		Private dominant	Private	53,106.537	1.465%	2.40%	61.0	78.94	1.875	$ 16,738.18	0.70%	6.700%	0.918
United States 2014	73%	19		Private dominant	Private	55,049.988	1.622%	2.50%	62.0	78.91	1.855	$ 17,824.07	0.70%	6.750%	0.92
United States 2015	71%	19		Private dominant	Private	56,863.371	0.119%	2.10%	62.0	78.89	1.835	$ 18,150.62	0.70%	6.800%	0.921
United States 2016	73%	14		Private dominant	Private	58,021.400	1.262%	1.90%	62.0	78.86	1.816	$ 19,573.45	0.70%	6.840%	0.922
United States 2017	72%	17		Private dominant	Private	60,109.656	2.130%	2.20%	61.0	78.84	1.796	$ 20,244.90	0.60%	6.760%	0.924
United States 2018	72%	16		Private dominant	Private	63,064.410	2.443%	3.00%	61.0	78.81	1.776	$ 21,516.06	0.50%	6.690%	0.925
United States 2019	70%	18	60.6	Private dominant	Private	65,279.520	1.812%	2.20%	61.0	78.87	1.778	$ 22,719.40	0.50%	6.760%	0.926
United States 2020	72%	16	60.3	Private dominant	Private	63,593.440	1.234%	1.00%	62.0	78.93	1.779	$ 26,945.39	0.40%	7.140%	0.926
United States 2021	72%	17	61.4	Private dominant	Private	69,375.380	7.000%	0.50%	62.0	78.99	1.781	$ 28,428.92	0.10%	6.690%	0.926
France 2013	78%	10		Hybrid	Public	42,592.935	0.864%	2.30%	62.7	81.94	1.981	$ 2,626.63	0.50%	13.796%	0.889
France 2014	76%	15		Hybrid	Public	43,011.263	0.508%	1.80%	63.0	82.04	1.955	$ 2,709.99	0.50%	13.870%	0.893
France 2015	71%	18		Hybrid	Public	36,638.185	0.038%	0.90%	63.3	82.15	1.929	$ 2,331.34	0.40%	13.798%	0.895
France 2016	71%	20		Hybrid	Public	37,037.374	0.183%	0.50%	63.2	82.25	1.904	$ 2,477.31	0.30%	13.803%	0.894
France 2017	71%	19		Hybrid	Public	38,685.258	1.032%	0.90%	63.3	82.36	1.878	$ 2,556.66	0.30%	13.641%	0.897
France 2018	69%	21		Hybrid	Public	41,572.485	1.851%	0.90%	63.4	82.46	1.852	$ 2,620.39	0.30%	13.596%	0.898
France 2019	69%	22	60.2	Hybrid	Public	40,578.644	1.108%	0.10%	63.5	82.59	1.851	$ 2,693.51	0.20%	14.800%	0.901
France 2020	67%	25	60	Hybrid	Public	39,030.360	0.476%	-0.10%	63.5	82.73	1.85	$ 2,999.82	0.20%	14.400%	0.901
France 2021	67%	25	60.5	Hybrid	Public	45,028.270	1.960%	0.31%	62.0	82.89	1.85	$ 3,228.26	0.23%	14.400%	0.901
Japan 2013	77%	15		Gornement dominan	Public	40,898.648	0.335%	0.80%	61.0	83.32	1.409	$ 11,972.28	-0.10%	9.726%	0.902
Japan 2014	69%	27		Gornement dominan	Public	38,475.395	2.759%	0.70%	61.0	83.54	1.401	$ 11,451.09	-0.10%	9.460%	0.906
Japan 2015	71%	17		Gornement dominan	Public	34,960.639	0.795%	0.40%	61.0	83.76	1.393	$ 10,156.03	-0.10%	9.391%	0.908
Japan 2016	71%	21		Hybrid	Public	39,400.739	-0.127%	-0.10%	62.0	83.99	1.386	$ 11,162.96	-0.10%	9.375%	0.912
Japan 2017	70%	22		Hybrid	Public	38,891.086	0.484%	0.10%	62.0	84.21	1.378	$ 11,287.70	-0.10%	9.358%	0.915
Japan 2018	69%	22		Hybrid	Public	39,808.169	0.989%	0.10%	62.0	84.43	1.37	$ 11,404.93	-0.20%	9.400%	0.917
Japan 2019	69%	23	48.3	Hybrid	Public	40,777.609	0.469%	-0.10%	63.0	84.55	1.369	$ 11,625.36	-0.20%	10.600%	0.919
Japan 2020	68%	23	48.5	Hybrid	Public	40,193.252	-0.025%	0.10%	65.0	84.67	1.369	$ 12,073.22	-0.30%	14.395%	0.919
Japan 2021	68%	22	49.8	Hybrid	Public	40,704.300	-0.170%	-0.10%	65.0	84.79	1.368	$ 12,538.24	-0.34%	14.400%	0.919
Morocco 2013				Gornement dominan	Public	3,121.680	1.881%	3.00%	60.0	75.03	2.6	$ 65.89	1.40%	3.500%	0.644
Morocco 2014				Gornement dominan	Public	3,171.699	0.442%	3.00%	60.0	75.29	2.564	$ 69.67	1.40%	3.500%	0.652
Morocco 2015				Gornement dominan	Public	2,875.258	1.558%	2.50%	60.0	75.55	2.528	$ 64.64	1.40%	3.500%	0.658
Morocco 2016				Gornement dominan	Public	2,896.722	1.635%	2.50%	60.0	75.81	2.492	$ 71.11	1.30%	3.500%	0.667
Morocco 2017				Gornement dominan	Public	3,035.454	0.755%	2.25%	60.0	76.07	2.456	$ 74.89	1.30%	3.500%	0.673
Morocco 2018				Gornement dominan	Public	3,226.983	1.804%	2.25%	60.0	76.33	2.42	$ 78.17	1.30%	3.500%	0.68
Morocco 2019				Gornement dominan	Public	3,235.001	0.303%	2.25%	60.0	76.55	2.395	$ 81.14	1.20%	3.500%	0.686
Morocco 2020				Gornement dominan	Public	3,058.692	0.706%	2.00%	60.0	76.77	2.37	$ 88.83	1.20%	3.500%	0.686
Morocco 2021				Gornement dominan	Public	3,240.000	1.700%	1.50%	63.0	76.99	2.346	$ 95.39	1.18%	3.500%	0.686

Appendix 7 :

Data Cleaned

Column1	Natixis_Index	Natixis_ranking	GDP_per_capita_WorldBank	Infla_word_bank_morocco	Interest_rate_Moroccan	Average_age	Life_expectancy	Fertility_Rate	Gov_debt_billions_USD	Annual_Growth_Rate	average_gov_spendic	Human_Dev_Index	Private dominant	Hyprid	Health_care_type	Retirement System Type	Health care system type
United States 2013	74	19	53 106,537	1,47%	2,40%	61,0	78,94	1,875	16738,18	0,007	0,067	0,918	1	0	1	Private dominant	Private
United States 2014	73	19	55 049,988	1,62%	2,50%	62,0	78,91	1,855	17824,07	0,007	0,0675	0,92	1	0	1	Private dominant	Private
United States 2015	71	19	56 863,371	0,12%	2,10%	62,0	78,89	1,835	18150,62	0,007	0,068	0,921	1	0	1	Private dominant	Private
United States 2016	73	14	58 021,400	1,26%	1,90%	62,0	78,86	1,816	19573,45	0,007	0,0684	0,922	1	0	1	Private dominant	Private
United States 2017	72	17	60 109,656	2,13%	2,20%	61,0	78,84	1,796	20244,9	0,006	0,0676	0,924	1	0	1	Private dominant	Private
United States 2018	72	16	63 064,410	2,44%	3,00%	61,0	78,81	1,776	21516,06	0,005	0,0669	0,925	1	0	1	Private dominant	Private
United States 2019	70	18	65 279,520	1,81%	2,20%	61,0	78,87	1,778	22719,4	0,005	0,0676	0,926	1	0	1	Private dominant	Private
United States 2020	72	16	65 593,440	1,23%	1,00%	62,0	78,93	1,779	26945,39	0,004	0,0714	0,926	1	0	1	Private dominant	Private
United States 2021	72	17	69 375,380	7,00%	0,50%	62,0	78,99	1,781	28428,92	0,001	0,0669	0,926	1	0	1	Private dominant	Private
France 2013	78	10	42 592,935	0,86%	2,30%	62,7	81,94	1,981	2626,629	0,005	0,13796	0,889	0	1	0	Hybrid	Public
France 2014	76	15	43 011,263	0,51%	1,80%	63,0	82,04	1,955	2709,986	0,005	0,1387	0,893	0	1	0	Hybrid	Public
France 2015	71	18	36 638,185	0,04%	0,90%	63,3	82,15	1,929	2331,342	0,004	0,13798	0,894	0	1	0	Hybrid	Public
France 2016	71	20	37 037,374	0,18%	0,50%	63,2	82,25	1,904	2477,31	0,003	0,13803	0,894	0	1	0	Hybrid	Public
France 2017	71	19	38 685,258	1,03%	0,90%	63,3	82,36	1,878	2556,66	0,003	0,13641	0,895	0	1	0	Hybrid	Public
France 2018	69	21	41 572,485	1,85%	0,90%	63,4	82,46	1,852	2620,39	0,003	0,13596	0,898	0	1	0	Hybrid	Public
France 2019	69	22	40 578,644	1,11%	0,10%	63,5	82,59	1,851	2693,51	0,002	0,148	0,901	0	1	0	Hybrid	Public
France 2020	67	25	39 030,360	0,48%	-0,10%	63,5	82,73	1,85	2999,82	0,002	0,144	0,901	0	1	0	Hybrid	Public
France 2021	67	25	45 028,270	1,96%	0,31%	62,0	82,89	1,85	3228,26	0,0023	0,144	0,901	0	1	0	Hybrid	Public
Japan 2013	77	15	40 898,648	0,34%	0,80%	61,0	83,32	1,409	11972,275	-0,001	0,09726	0,902	0	0	0	Gornement dominant	Public
Japan 2014	69	27	38 475,395	2,76%	0,70%	61,0	83,54	1,401	11451,085	-0,001	0,0946	0,906	0	0	0	Gornement dominant	Public
Japan 2015	71	17	34 960,639	0,80%	0,40%	61,0	83,76	1,393	10156,025	-0,001	0,09391	0,908	0	0	0	Gornement dominant	Public
Japan 2016	71	21	39 400,739	-0,13%	-0,10%	62,0	83,99	1,386	11162,96	-0,001	0,09375	0,912	0	1	0	Hybrid	Public
Japan 2017	70	22	38 891,086	0,48%	0,10%	62,0	84,21	1,378	11287,7	-0,001	0,09358	0,915	0	1	0	Hybrid	Public
Japan 2018	69	22	39 808,169	0,99%	0,10%	62,0	84,43	1,37	11404,93	-0,002	0,094	0,917	0	1	0	Hybrid	Public
Japan 2019	69	23	40 777,609	0,47%	-0,10%	63,0	84,55	1,369	11625,36	-0,002	0,106	0,919	0	1	0	Hybrid	Public
Japan 2020	68	23	40 193,252	-0,03%	0,10%	65,0	84,67	1,369	12073,22	-0,003	0,14395	0,919	0	1	0	Hybrid	Public
Japan 2021	68	22	40 704,300	-0,17%	-0,10%	65,0	84,79	1,368	12538,24	-0,0034	0,144	0,919	0	1	0	Hybrid	Public
Morocco 2013			3 121,680	1,881%	3,00%	60,0	75,03	2,6	$ 65,89	1,40%	3,500%	0,644	0	0	0	Gornement dominant	Public
Morocco 2014			3 171,699	0,442%	3,00%	60,0	75,29	2,564	$ 69,67	1,40%	3,500%	0,652	0	0	0	Gornement dominant	Public
Morocco 2015			2 875,258	1,558%	2,50%	60,0	75,55	2,528	$ 64,64	1,40%	3,500%	0,658	0	0	0	Gornement dominant	Public
Morocco 2016			2 896,722	1,635%	2,50%	60,0	75,81	2,492	$ 71,11	1,30%	3,500%	0,667	0	0	0	Gornement dominant	Public
Morocco 2017			3 035,454	0,755%	2,25%	60,0	76,07	2,456	$ 74,89	1,30%	3,500%	0,673	0	0	0	Gornement dominant	Public
Morocco 2018			3 226,983	1,804%	2,25%	60,0	76,33	2,42	$ 78,17	1,30%	3,500%	0,68	0	0	0	Gornement dominant	Public
Morocco 2019			3 235,001	0,303%	2,25%	60,0	76,55	2,395	$ 81,14	1,20%	3,500%	0,686	0	0	0	Gornement dominant	Public
Morocco 2020			3 058,692	0,706%	2,00%	60,0	76,77	2,37	$ 88,83	1,20%	3,500%	0,686	0	0	0	Gornement dominant	Public

```python
import pandas as pd
import statsmodels.api as sm
import statsmodels.formula.api as smf

donnees = pd.read_csv('C:/Administratifs_Personnels/Persos/000_E-TOWN_SARAH/Annee_2021-
2022/Analyse_DATA/RetirementAssesmentData_MHA333.csv')
formula = "Natixis_Index ~ GDP_per_capita_WorldBank + Infla_word_bank_morocco + Interest_rate_Moroccan + \
            Average_age + Life_expectancy + Fertility_Rate + Gov_debt_billions_USD + Annual_Growth_Rate + \
            average_gov_spendic + Human_Dev_Index + Private_dominant + Hybrid + Health_care_type"

donnees.head()


mod3 = smf.glm(formula=formula, data=donnees).fit()
print(mod3.summary())
```

```
                  Generalized Linear Model Regression Results
================================================================================
Dep. Variable:          Natixis_Index   No. Observations:                   27
Model:                            GLM   Df Residuals:                       14
Model Family:                Gaussian   Df Model:                           12
Link Function:               identity   Scale:                          2.2636
Method:                          IRLS   Log-Likelihood:                -40.474
Date:                dim., 03 avr. 2022   Deviance:                       31.690
Time:                        22:58:00   Pearson chi2:                     31.7
No. Iterations:                     3   Pseudo R-squ. (CS):             0.9488
Covariance Type:            nonrobust
================================================================================
                              coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------
Intercept                  651.4716    296.702      1.590      0.112    -109.873    1053.176
GDP_per_capita_worldBank     0.0001      0.000      0.461      0.645      -0.000       0.001
Infla_word_bank_morocco     -0.4652      0.512     -0.908      0.364      -1.469       0.539
Interest_rate_Moroccan       1.7530      0.867      2.022      0.043       0.053       3.453
Average_age                  0.5687      0.910      0.625      0.532      -1.215       2.352
Life_expectancy              3.3136      2.639      1.256      0.209      -1.858       8.486
Fertility_Rate              -1.5271     17.156     -0.089      0.929     -35.153      32.098
Gov_debt_billions_USD        0.0006      0.000      1.524      0.127      -0.000       0.001
Annual_Growth_Rate          -1.2679      8.623     -0.147      0.883     -18.169      15.633
average_gov_spendic         -0.6212      0.808     -0.769      0.442      -2.205       0.962
Human_Dev_Index           -788.6556    228.699     -3.448      0.001   -1236.897    -340.414
Private_dominant             9.1613      6.285      1.458      0.145      -3.156      21.479
Hyprid                       2.6954      3.037      0.888      0.375      -3.256       8.647
Health_care_type             9.1613      6.285      1.458      0.145      -3.156      21.479
================================================================================
```

Appendix 9:

```python
import pandas as pd
import statsmodels.api as sm
import statsmodels.formula.api as smf

donness = pd.read_csv('C:/Administratifs_Personnels/Persos/000_E-TOWN_SARAH/Annee_2021-
2022/Analyse DATA/RetirementAssesmentData_MHA333.csv')
formula = "Natixis_Index ~ Infla_word_bank_morocco + Interest_rate_Moroccan + \
           Life_expectancy + Gov_debt_billions_USD + \
           average_gov_spendic + Human_Dev_Index + Private_dominant + Hyprid + Health_care_type"

donness.head()

mod3 = smf.glm(formula=formula, data=donness).fit()

print(mod3.summary())
```

```
                 Generalized Linear Model Regression Results
==============================================================================
Dep. Variable:       Natixis_Index   No. Observations:                27
Model:                         GLM   Df Residuals:                    18
Model Family:             Gaussian   Df Model:                         8
Link Function:            identity   Scale:                       1.8209
Method:                       IRLS   Log-Likelihood:             -40.928
Date:           dim., 03 avr. 2022   Deviance:                    32.776
Time:                     23:21:19   Pearson chi2:                  32.8
No. Iterations:                  3   Pseudo R-squ. (CS):          0.9706
Covariance Type:         nonrobust
==============================================================================
                            coef    std err        z     P>|z|     [0.025     0.975]
------------------------------------------------------------------------------
Intercept                468.8016     66.395     7.061    0.000    338.669    598.934
Infla_word_bank_morocco   -0.3985      0.252    -1.579    0.114     -0.893      0.096
Interest_rate_Moroccan     1.7945      0.548     3.272    0.001      0.720      2.869
Life_expectancy            3.4185      1.503     2.274    0.023      0.472      6.365
Gov_debt_billions_USD      0.0008      0.000     5.281    0.000      0.000      0.001
average_gov_spendic       -0.2912      0.212    -1.373    0.170     -0.707      0.125
Human_Dev_Index         -760.5153    165.686    -4.590    0.000  -1085.254   -435.777
Private_dominant           9.2396      4.865     1.899    0.058     -0.295     18.774
Hyprid                     3.3058      1.282     2.579    0.010      0.794      5.818
Health_care_type           9.2396      4.865     1.899    0.058     -0.295     18.774
==============================================================================
```

Appendix 10:

```
library(caret)
library(neuralnet)
concrete <- read.csv("C:/Administratifs_Personnels/Persos/000_E-TOWN_SARAH/Annee_2021-
2022/Analyse_DATA/RetirementAssesmentData_MHA333.csv")
set.seed(123)
trainingIndices <- createDataPartition(y=concrete$Natixis_Index,p=0.7, list=FALSE)
training <- concrete[trainingIndices, ]
testing  <- concrete[-trainingIndices , ]

fit <- neuralnet(Natixis_Index~GDP_per_capita_WorldBank + Infla_word_bank_morocco + Interest_rate_Moroccan +
                 Average_age + Life_expectancy + Fertility_Rate + Gov_debt_billions_USD +
Annual_Growth_Rate +
                   average_gov_spendic + Human_Dev_Index + Private_dominant + Hybrid + Health_care_type,
                 data=training ,
                 hidden=c(3,3)
)

plot(fit)
summary(fit)
predicted <- compute(fit,testing)
cor(predicted$net.result,testing$Natixis_Index)^2
plot(predicted$net.result,testing$Natixis_Index,col="red")
abline(0,1,lwd=2)
```
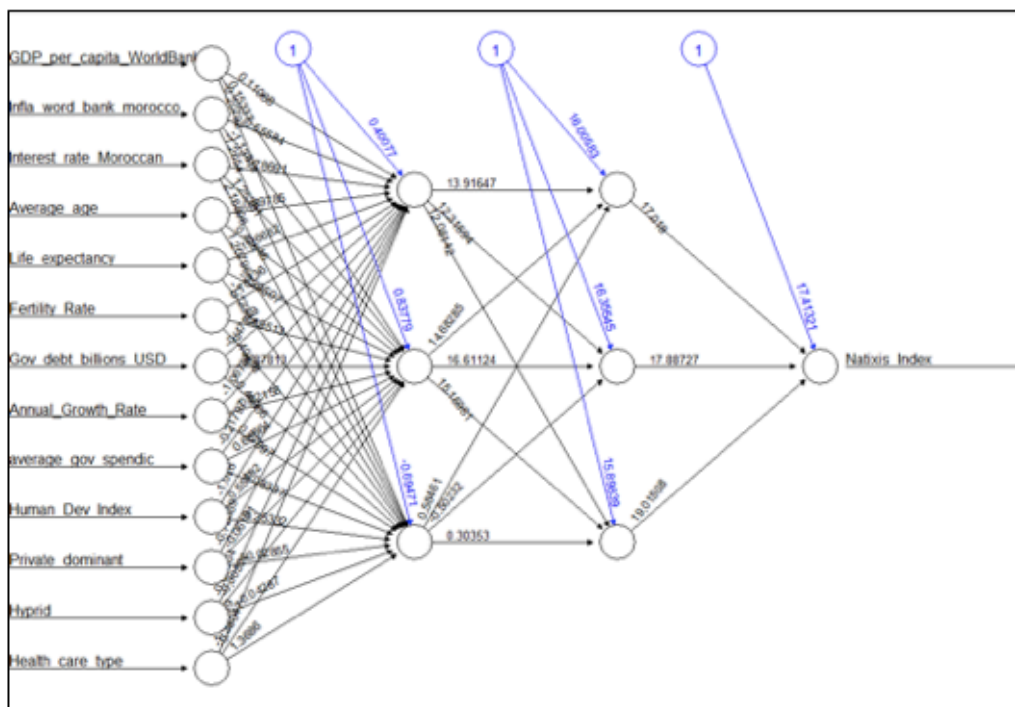


```
R  R 4.1.3 · ~/
> predicted <- compute(fit,testing)
> cor(predicted$net.result,testing$Natixis_Index)^2
      [,1]
[1,]  0.7
```

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