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Generativity is a Core Value of the ESJ: A Decade of Growth

Erik Erikson (1902-1994) was one of the great psychologists of the 20th century[1]. He explored the nature of personal human identity. Originally named Erik Homberger after his adoptive father, Dr. Theodore Homberger, he re-imagined his identity and re-named himself Erik Erikson (literally Erik son of Erik). Ironically, he rejected his adoptive father's wish to become a physician, never obtained a college degree, pursued independent studies under Anna Freud, and then taught at Harvard Medical School after emigrating from Germany to the United States. Erickson visualized human psychosocial development as eight successive life-cycle challenges. Each challenge was framed as a struggle between two outcomes, one desirable and one undesirable. The first two early development challenges were 'trust' versus 'mistrust' followed by 'autonomy' versus 'shame.' Importantly, he held that we face the challenge of **generativity** versus **stagnation in middle life**. This challenge concerns the desire to give back to society and leave a mark on the world. It is about the transition from acquiring and accumulating to providing and mentoring.

Founded in 2010, the European Scientific Journal is just reaching young adulthood. Nonetheless, **generativity** is one of our core values. As a Journal, we reject stagnation and continue to evolve to meet the needs of our contributors, our reviewers, and the academic community. We seek to innovate to meet the challenges of open-access academic publishing. For us,

[1] Hopkins, J. R. (1995). Erik Homburger Erikson (1902–1994). *American Psychologist*, 50(9), 796-797. doi:http://dx.doi.org/10.1037/0003-066X.50.9.796

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generativity has a special meaning. We acknowledge an obligation to give back to the academic community, which has supported us over the past decade and made our initial growth possible. As part of our commitment to generativity, we are re-doubling our efforts in several key areas. First, we are committed to keeping our article processing fees as low as possible to make the ESJ affordable to scholars from all countries. Second, we remain committed to fair and agile peer review and are making further changes to shorten the time between submission and publication of worthy contributions. Third, we are looking actively at ways to eliminate the article processing charges for scholars coming from low GDP countries through a system of subsidies. Fourth, we are examining ways to create and strengthen partnerships with various academic institutions that will mutually benefit those institutions and the ESJ. Finally, through our commitment to publishing excellence, we reaffirm our membership in an open-access academic publishing community that actively contributes to the vitality of scholarship worldwide.

Sincerely,

Daniel B. Hier, MD

European Scientific Journal (ESJ) Natural/Life/Medical Sciences

Editor in Chief

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Decoupling and EKC in European Union countries: A shift-share decomposition of air emissions

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Abstract

This paper examines the non-linear effect of per capita GDP growth rate, trade openness, physical and human capital endowments on air pollution in the EU region over the period 2008-2016 by decomposing air emissions into scale, composition and technique effects. Results show a negative non-linear relationship between greenhouse and acidifying gases emissions and per capita GDP growth rate, with more open economies tending to reduce emissions both directly and indirectly through investment in physical capital. The determinants mainly affect the scale component, although the environmental improvement due to capital investment works through the technique component. There are heterogeneous effects across countries, with more pronounced environmental benefits for countries in the higher deciles of GDP and trade growth rates.

Keywords: EKC, air emissions, trade openness, factors endowments, decoupling, non-linear estimation

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Introduction

In recent decades, environmental issues have become a global concern, prompting countries to implement green policies aimed at conserving resources and biodiversity through sustainable development. In this context, several key aspects have been emphasised.

Firstly, air pollution has become a priority for nations due to its detrimental impact on human health and society. In this regard, the United Nations Environment Programme (UNEP) recommended in 2018 that global greenhouse gas (GHG) emissions be reduced by at least 25% below 2017 levels by 2030 to meet the targets outlined in the Paris Agreement. The effects of air pollution are particularly harmful in regions where significant quantities of GHGs and acidifying gases (AGs) are emitted. Consequently, numerous environmental policies aim to mitigate emissions of these pollutants.

Secondly, the European Union (EU) has played a pivotal role in raising awareness of global emissions. Since 1973, with the launch of the first European Environmental Action Programme, the EU has developed a comprehensive environmental policy framework through the implementation of numerous directives, thereby gaining global influence in the sustainability process. Among the most recent and significant initiatives are the European Green Deal of 2019, the Fit for 55 initiative, the expansion of the Emissions Trading System, and the Renewable Energy Directive. Through these directives, the European Commission has proposed measures to align the EU's climate, energy, transport, and tax policies with the objective of reducing net GHG emissions by at least 55% by 2030 compared to 1990 levels, with the ultimate goal of achieving net-zero emissions by 2050. Furthermore, these policies, particularly the EU Green Deal, aim to decouple economic growth from resource use, fostering socio-economic well-being while protecting, conserving, and enhancing the EU’s natural capital, as well as boosting technological skills and innovation.

Given this context, this paper seeks to examine the role of various economic factors associated with globalised economies, such as GDP growth, trade openness, and physical and human capital endowments, in influencing GHG and AG emissions intensity. It also investigates the scale, composition, and technique effects that characterise the relationship between economic growth and environmental degradation in EU countries during the period 2008–2016. Additionally, our analysis offers insights into the EU countries' decoupling trajectories.

Regarding existing literature, it has highlighted that environmental degradation, in terms of increasing air pollution, has diverse causes. Research begins with the recognition of an inverted U-shaped relationship between per capita income and CO2 emissions, commonly known as the Environmental Kuznets Curve (EKC). Since 1991, economists have conducted numerous

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studies on the potential drivers of this relationship, finding that changes in emissions depend on several economic factors tied to a country's level of development, such as trade openness, innovation, and environmental regulation [Shafik and Bandyopadhyay (1992); Selden and Song (1994); Andreoni and Levinson (2001)]. During the same period, Grossman and Krueger (1991) decomposed total emissions into three effects: scale, composition, and technique. The scale effect pertains to a country's economic activity; as economic output increases, emissions tend to rise, all else being equal, a trend exacerbated by free international trade. The composition effect relates to shifts in sectoral composition; increased economic activity can lead to specialisation in advanced, greener sectors, with the net impact on emissions being contingent on the sources of comparative advantage driving trade. For example, under the Pollution Haven Hypothesis (PHH), countries with stringent environmental regulations may specialise in less polluting sectors, exporting pollution-intensive production to nations with weaker regulations, thereby reducing domestic emissions. Conversely, capital-rich countries tend to specialise in capital-intensive, more polluting sectors, while labour-rich nations gravitate towards less polluting, labour-intensive industries. Lastly, the technique effect concerns technological progress; countries with sustained economic growth are more likely to invest in cleaner technologies, a process further encouraged by higher living standards and trade liberalisation. Increased demand for green products, driven by wealthier populations and trade, often translates into stronger political will for stringent environmental policies, thereby accelerating the adoption of abatement technologies.

The shape of the EKC is closely tied to stages of economic growth, particularly changes in industrial structure and economic development [Baldwin (1995)]. During the initial phase of industrialisation (transitioning from agriculture to industry), environmental degradation intensifies, driven by scale and composition effects. However, as growth advances, technological development (shifting from industry to services) begins to mitigate environmental harm, lowering emissions through composition and technique effects.

Quantitative methods, such as the Log Mean Divisia Index (LMDI), have been used to decompose emissions for various countries. De Bruyn (1997) analysed data from the Netherlands and West Germany; Viguier (1999) studied Eastern European countries (Hungary, Poland, and Russia) alongside France and the United Kingdom; and Bruvoll and Medin (2003) focused on Norway. These studies largely agree on the critical interplay between technology adoption and economic growth in shaping emission levels.

On the other hand, the seminal publication *The Limits to Growth* (1972) by Meadows et al. argued that finite natural resources cannot sustain

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unchecked economic and population growth. UNEP (2011) and the European Parliament stress the importance of technological innovation, integrated urban infrastructure, and systemic changes in production, consumption, and trade to improve resource productivity and reduce material intensity. UNEP further correlates the EKC's stages with decoupling levels: emissions increase during the EKC's upward trajectory, weak decoupling occurs at the turning point, and strong decoupling is observed during the decline.

Many studies, including those by Jiang et al. (2019), Naqvi (2021), Wang and Lv (2022), and Caporin et al. (2024), have explored these dynamics. This paper contributes to the literature by employing innovative methodologies, such as LMDI Method II and Non-Linear Least Squares (NLLS) estimation, to analyse the drivers of the EKC's components (scale, composition, technique effects) and test for decoupling. We further consider heterogeneous coefficients to assess the variability in factors driving emissions. Our findings underscore the significant influence of GDP per capita growth, trade openness, and capital endowments on total emissions, identifying these variables as critical drivers of scale, composition, and technology effects. Given the study's 2008–2016-time frame, we also explore how the 2008 international financial crisis impacted the interplay between emissions and economic factors, noting that emission declines in EU countries are largely attributed to the technique effect, particularly in highly globalised nations investing in green technologies.

Finally, much of the existing research on the EKC and decoupling focuses on China [e.g., Jiang et al. (2019); Zhao et al. (2017); Wang and Lv (2022); Wang and Kim (2024)], with other studies targeting specific regions such as Central Asia [Caporin et al. (2024)] or the United States [Wang and Kim (2024)]. Relatively few articles, including ours, address these mechanisms within the EU, employing diverse methodologies [e.g., Naqvi (2021); Sanyé-Mengual et al. (2019); Papież et al. (2022); Bianco et al. (2024)].

The paper is structured as follows. Section 2 presents the decomposition methodology. Section 3 provides a detailed analysis of results about air emissions decomposition. Section 4 describes the econometric framework for the analysis of scale, composition and technique effects and data description. Section 5 reports the results. Section 6 provides a discussion of the results and Section 7 concludes.

2. Decomposition Methodology

Total emissions can be decomposed into scale, composition and technique effects using the Index Decomposition Analysis (IDA). Due to the nature of our data and the objective of the research, we have implemented the LMDI Method II with the multiplicative decomposition proposed by Ang and

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Choi (1997)[1] (2015). We have opted for this kind of methodology given that the weights in the formulae summed to unity which is a desirable property in index construction. The basic idea of this approach is to decompose the change in emissions into three different drivers: economies of scale, sector composition and technological differences. The LMDI has three important properties that make it a suitable decomposition method. First, it satisfies the factor reversal test, i.e. the index gives a decomposition without residuals, so the interpretation of results is not biased. Second, it also satisfies the time reversal test: given two periods, the result does not change whether the index is measured forward or backward. Third, LMDI allows for zero values in the dataset. As suggested by Ang and Choi (1997), zeros are replaced by a small positive number[2].

In practice, a difference that one will encounter is in result presentation, since the decomposition results are given in a physical unit in the additive case while in indexes in the multiplicative case. In the end, the decision is arbitrary.

The method is constructed by considering the following set of variables:

Y_{it}	Real Gross Value Added (GVA) in country *i* in year *t*
Y_{ijt}	Real GVA in country *i* in sector *j* in year *t*
E_{it}	Total volume of emissions in country *i* in year *t*
E_{ijt}	Volume of emissions in country *i* in sector *j* in year *t*
$S_{ijt} = \frac{Y_{ijt}}{Y_{it}}$	Share of sector *j* real GVA on total real GVA in country *i* in year *t*
$I_{it} = \frac{E_{it}}{Y_{it}} = \sum_j \frac{E_{ijt}}{Y_{it}}$	Total emissions intensity in country *i* in year *t*
$I_{ijt} = \frac{E_{ijt}}{Y_{ijt}}$	Emissions intensity in country *i* in sector *j* in year *t*

Changes in total emissions between base period $t = 0$ and any period t in country *i* are calculated using the following multiplicative form:

$$\frac{E_{it}}{E_{i0}} = Scale_{it} * Composition_{it} * Technique_{it} \quad (1)$$

[1] For a complete guide for implementation of LMDI, see Ang (2015).

[2] In our dataset, zero values for some sectoral emissions are replaced by 0.01 if the observation is equal to 0 every year, by the average of the previous and following year's values, and by the average of the last three years if the zero value refers to the last year of the analysis.

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where $Scale_{it}$ is the scale effect in year *t* in country *i*, which describes a *ceteris paribus* variation in economic activity, holding all the other factors constant. $Composition_{it}$ identifies the composition effect in year *t* in country *i*. This variable isolates the effect of changes in the economic weight of the sector on environmental emissions, holding all other factors constant. Finally, $Technique_{it}$ measures the technique effect in year *t* in country *i* as the change in emissions when the real GVA and sector economic weight are held constant at their initial values [EC (2016)]. The multiplicative decomposition approach allows to express the emissions change ratio as an index; moreover, since we have implemented a panel dataset, which has a time-series component, multiplicative procedure is more suited[3].

The three terms in equation (1) can be expressed as follow:

$$Scale_i = \exp\left\{\sum_j \alpha_{ijt}\, ln\frac{Y_T}{Y_0}\right\} \quad (2)$$

$$Composition_i = exp\left\{\sum_j \alpha_{ijt}\, ln\frac{S_{ijT}}{S_{ij0}}\right\} \quad (3)$$

$$Technique_i = exp\left\{\sum_j \alpha_{ijt}\, ln\frac{I_{ijT}}{I_{ij0}}\right\} \quad (4)$$

where $\alpha_{ijt} = \frac{(E_{ijt}-E_{ij0})/(lnE_{ijt}-lnE_{ij0})}{(E_{it}-E_{i0})/(lnE_{it}-lnE_{i0})}$ is the log average rate of change of sector emissions.

3. Empirical decomposition of air pollutants

We use Eurostat data for EU countries from 2008 to 2016 to examine the contribution of scale, composition and technique effects to the overall variation in air emissions[4,5]. The data cover 19 NACE Rev. 2 manufacturing industries at the 2-digit level[6]. Focusing on emissions of air pollutants, the decomposition analysis is carried out for two pollutants: the total volume of GHG (carbon dioxide (CO2), methane and nitrous oxide) and AG (sulphur dioxide (SO2), nitrous oxide and ammonia) in thousand tonnes[7]. GHG

[3] Using an additive approach is more informative if quantity indicator is applied.
[4] Excluded countries due to several missing observations in the period analysed are Cyprus, Czech Republic, Ireland, Luxembourg and Malta.
[5] Given Eurostat data on GHG and AG emissions, in 2008, GHG from manufacturing sectors are responsible for the 27.64% of total GHG emissions in EU. This share slightly decreases to 26.19% in 2016. Considering the share of manufacturing AG emissions in the same periods and area, 11.89% and 10.08% respectively.
[6] See Table A1 in Appendix for a detailed description of the sectors.
[7] Data on emissions are from Eurostat "Air emissions accounts by NACE Rev. 2 activity".

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emissions are expressed in CO2 equivalents, while AG emissions are expressed in SO2 equivalents.

Real GVA has been obtained as the ratio of nominal GVA at current prices to the implicit price deflator by the Nace Rev.2 sector in 2010[8].

We first describe the overall change in GHG and AG in the post-crisis period (2008–2016). Figure 1 shows that the level of EU emissions, represented by the solid line, has decreased for both GHG and AG. The most drastic decrease in emissions was concentrated in 2009 for all countries, which is probably related to the 2008 recession. There was a limited increase in air pollution in 2010, but then the data show a decreasing trend since 2014. This result is in line with EC (2016), who performed a similar analysis for a shorter period (2008–2012).

Looking at the three components obtained by the decomposition described in Section 2, we can see that for GHGs, the scale effect caused a decrease in total air emissions immediately after the crisis, after which a new increase started. The composition effect caused an increase in emissions between 2008 and 2009 and then a decrease until 2012. In addition, as suggested by the literature, the technique effect contributed to the reduction in GHG emissions. Similar trends are also observed for AG. As the decomposition results are presented in the form of indices, we cannot make a direct comparison between countries but can only describe each country's contribution to emissions in terms of variation. Looking at the ranking results, there are differences between countries in the total emissions of GHG and AG. Table 1 shows that for GHG, the lowest variation in total effect is for Lithuania in 2010 (0.480), while the highest is for Latvia in the same year (1.122). For AG, these values are 0.416 for Greece in 2016 and 1.094 for Bulgaria in 2011. In terms of GHG, the EU countries can be divided into three groups when looking at the time trends. As can be seen from the ranking in Table 1, a first group includes those countries that show a low overall impact throughout the period, such as Bulgaria, Croatia, and Lithuania; a second group shows a decrease in this value, such as Finland, France, Italy, Spain, and the United Kingdom. A third group worsened their situation in terms of emissions: Estonia, Greece, Hungary, and Poland. The other countries are still the most polluting in the EU or show an irregular trend in emissions. Focusing on AG, only Italy and the United Kingdom showed a decrease in total emissions, while the other EU countries are similarly ranked.

[8] Data on Nominal GVA and prices come from Eurostat "National accounts aggregate by industry (up to NACE A*64)". Eurostat defines GVA as the "*output (at basic prices) minus intermediate consumption (at purchaser prices); it is the balancing item of the national accounts' production account. The sum of GVA over all industries or sectors plus taxes on products minus subsidies on products gives Gross Domestic Product"*.

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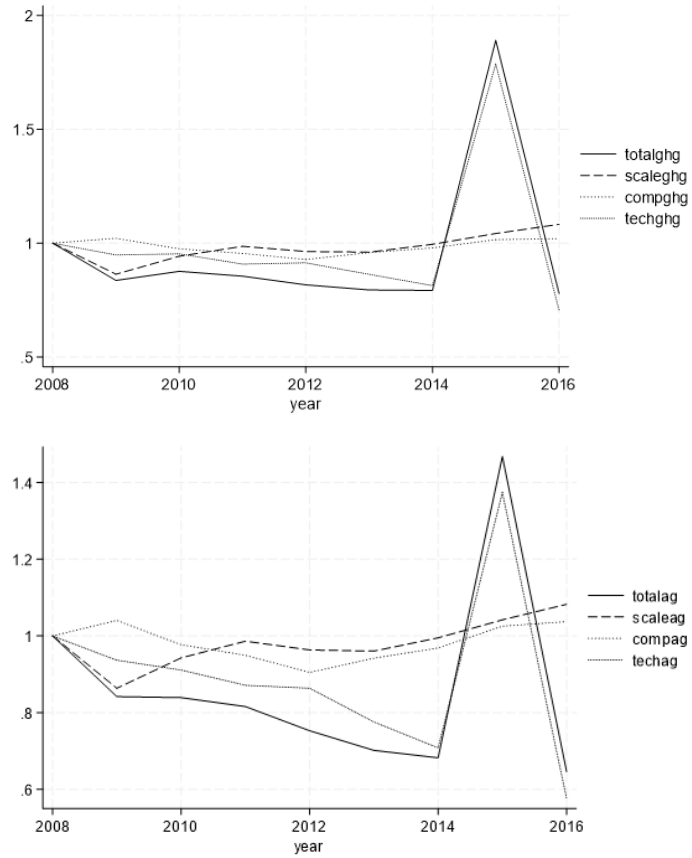

Figure 1. GHG and AG emissions decomposition for EU28, 2008-2016

By analysing the three components, some important conclusions can be drawn. Regarding the scale effect on GHG emissions, all countries showed a decrease between 2008 and 2009 due to the economic crisis, but from 2010 to 2016, the countries behaved differently. Austria, Belgium, Denmark, Estonia, Lithuania, and Poland show a steady increase in emissions due to the crisis. This result is in line with empirical evidence showing that an increase in economic activity in a country is associated with an increase in emissions, ceteris paribus. Greece and Spain show a decrease in emissions. The economies of scale of the remaining group of countries do not show a constant trend over the period, but all of them recorded a decrease in GHG emissions between 2011 and 2013. This is also confirmed for AG emissions.

A second result concerns the composition effect. GHG emissions depend strongly on the sectoral composition of GHG emissions, and the composition effect shown in the figure increases in the first year. This pattern is mainly due to an increase in the economic weight of capital-intensive sectors (manufacture of basic metals, coke, and refined petroleum products), which

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have contributed to an increase in total emissions. For some countries, a decreasing composition effect is observed for the whole period (Hungary and Slovenia) or for a large part of it (Estonia and Portugal). . The results are quite similar for AG emissions.

Finally, some conclusions can be drawn about the technique effect. For GHG emissions, many countries show a decreasing trend (Belgium, France, Finland, Italy, Bulgaria, and Lithuania). This may be due to the introduction of new or improved environmentally friendly technologies. Other European countries (Greece, Hungary, Germany, Portugal, and Spain) show a negative trend in the technique effect. This increase in emissions depends on the higher emission intensity of some sectors.

Concerning the technique effect on GHG emissions, some differences can be observed. Some of the above-mentioned countries show an irregular trend between 2008 and 2016, with only the Netherlands and Croatia showing a constant decrease in GHG emissions. These patterns seem to be related to the economic activity of some sectors; in fact, some polluting industries (basic metals, motor vehicles, trailers, and machinery) have increased their GVA level.

In order to quantitatively identify the main drivers of the three effects, we carry out an econometric analysis in the following sections.

Table 1. Ranking of countries by overall effect, GHG and AG emissions 2009-2016

	GHG								AG							
	2009	2010	2011	2012	2013	2014	2015	2016	2009	2010	2011	2012	2013	2014	2015	2016
Austria	20	21	21	21	23	21	23	21	19	23	21	21	21	21	20	20
Belgium	5	13	1	10	9	9	11	12	4	4	4	4	6	6	6	7
Bulgaria	2	3	1	1	1	6	2	6	22	19	23	22	23	22	23	23
Croatia	9	7	6	4	3	3	5	2	8	3	2	3	3	1	3	3
Denmark	13	9	16	16	16	13	15	17	5	9	6	5	4	4	5	5
Estonia	3	2	3	6	11	23	22	23	3	5	15	18	20	19	21	21
Finland	8	10	14	8	7	4	3	4	9	14	13	10	11	11	11	11
France	18	15	13	12	10	10	8	9	14	10	11	8	8	8	7	8
Germany	21	19	18	19	20	17	18	18	15	20	18	17	16	17	18	19
Greece	14	6	2	5	17	19	12	16	1	1	1	1	1	2	1	1
Hungary	12	8	15	14	12	16	19	20	13	16	17	16	13	14	15	15
Italy	11	11	12	7	4	2	4	3	12	15	10	6	5	5	4	4
Latvia	10	23	23	23	13	18	16	10	23	6	5	15	19	16	16	14
Lithuania	1	1	4	2	2	1	1	1	21	13	22	23	22	23	22	22
Netherland	23	22	22	20	22	20	21	22	6	7	7	9	7	7	8	9
Poland	15	17	20	22	21	22	20	19	18	18	20	20	18	20	19	17
Portugal	16	16	8	11	18	14	17	13	11	12	8	7	9	9	10	10
Romania	4	4	7	9	5	5	6	5	2	2	3	2	2	3	2	2
Slovakia	22	18	19	17	19	15	13	15	10	8	9	12	12	13	13	16
Slovenia	7	5	5	3	6	7	7	7	7	11	14	13	15	15	12	12
Spain	19	14	10	15	8	8	10	11	17	17	12	11	10	10	14	13
Sweden	6	20	17	18	15	12	14	14	20	21	19	19	17	18	17	18
United Kingdom	17	12	9	13	14	11	9	8	16	22	16	14	14	12	9	6

Note: Countries are ranked from the lowest to the highest overall effect. The year 2008 has been removed from the table as it is the reference period.

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4. Econometric Methodology

A large body of literature shows that the relationship between economic growth and environmental degradation is generally represented by the EKC inverted U-shaped curve.

As highlighted by existing studies, the shape of the EKC can be influenced by many factors that affect the scale, composition and technique effects; by allowing heterogeneous coefficients we can improve our knowledge of the forces behind GHG and AG emissions over time. By testing econometrically these effects allows to overcome a limit of the use of decomposition analysis. Specifically, since we have expressed emissions in terms of index, a change in these values, sometimes, is hard to understand due to results which are cumbersome to interpret; the econometric analysis helps in this direction.

The econometric analysis is carried out in two steps. In the first step, we estimate the EKC model expressed in terms of rates of change as follows:

$$g_{it}^{E} = \gamma + f(\boldsymbol{X_{it}\beta}) + \theta_{it} \quad (5)$$

where $\boldsymbol{X}_{it}$ is the vector of a vector of panel type independent variables and γ is the time trend coefficient of the EKC model in levels. Estimates are obtained using an OLS estimator for a linear specification of the function $f(X_{it}\beta)$ and a NLLS estimator when $f(X_{it}\beta)$ is a non-linear function of regressors. Non-linear effects have been found in the previous literature on EKC (Davidson and MacKinnon, 1993; Churchill et at., 2018).

In the second step, we estimate the decomposed model by emission components (scale, composition and technique effects). Since emissions in country *i* in year *t* can be written in terms of the decomposition equation (1), $lnE_{it} - lnE_{i0}$ corresponds to the sum of the logarithms of each component, so it can be written as $lnE_{it} - lnE_{i0} = lnScale_{it} + lnComposition_{it} + lnTechnique_{it}$. All effects (overall, scale, composition and technique) are expressed in terms of indices. Therefore, direct comparisons between countries are not possible, so by taking the natural logs and time differences of (1), we obtain the identity of emissions expressed in terms of rates of change:

$$g_{it}^{E} = g_{it}^{s} + g_{it}^{c} + g_{it}^{T} \quad (6)$$

where $g_{it}^{k} = \ln k_{it} - \ln k_{it-1}$ is the time difference between period *t-1* and *t* for each component, with

$k_{it} = \{EmissionTot_{it}, Scale_{it}, Composition_{it}, Technique_{it}\}$.

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Given the EKC model expressed in terms of change rates (5) and the identity (6), we also estimate the following three-equation model where dependent variables are the change rates of all components:

$$(7) \quad g_{it}^{S} = \gamma_1 + f(\boldsymbol{X_{it}\beta_1}) + \varepsilon_{1it}$$
$$(8) \quad g_{it}^{C} = \gamma_2 + f(\boldsymbol{X_{it}\beta_2}) + \varepsilon_{2it}$$
$$(9) \quad g_{it}^{T} = \gamma_3 + f(\boldsymbol{X_{it}\beta_3}) + \varepsilon_{3it}$$

$\gamma_1, \gamma_2, \gamma_3$ are time trend components (of emissions in levels); $\gamma_1 + \gamma_2 + \gamma_3 = \gamma$. $\boldsymbol{X}_{it}$ is the vector of regressors corresponding to the set of panel-type variables included in (5); $\boldsymbol{\beta_1}, \boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ are the vectors of estimated coefficients that are component-specific; $\varepsilon_{1it}, \varepsilon_{2it}$ and ε_{3it} are cluster robust disturbances at country level. We implement a Non-Linear Seemingly Unrelated Regression (NLSUR) estimator proposed by Gallant (1975).

4.1 Data Description

Our sample covers 23 EU countries and 8 years from 2008 to 2016. GHG and AG emissions data were obtained from Eurostat. The corresponding change rates in terms of overall, scale, composition and technique effects have been obtained following the methodology presented in Section 2. Explanatory variables are taken from the Penn World Table and is expressed in logs and first differences: GDP per capita (GDPpc), physical capital endowment (K/L), human capital index (H), share of total imports and exports on GDP (Trade). We use the two-year lagged rate of change in real GDPpc ($\Delta GDPpc_{t-2}$), so the estimates cover the period 2009-2016, while other variables are taken at *t-1*. To allow for a non-linear relationship between income and emissions, the squared and cubic terms of the GDPpc growth rate are also included. As regards factor endowments, we introduce the K/L ratio using data on capital stocks and the number of persons employed, and the H index based on years of schooling and returns to education. As far as international trade is concerned, it is important to assess the effect of trade openness, measured as the sum of the export and import shares of goods in real GDP at current purchasing power parity. See Table A2 in Appendix for a detailed description of variables.

The main variable of interest in this paper is trade. According to Antweiler et al. (2001), the impact of trade on EKC is twofold. On the one hand, it increases emissions through the scale effect, because it expands a country's economic activity, which in turn increases pollution. On the other hand, trade has a positive impact on the environment through the technique effect. As incomes rise, consumers are more likely to pay attention to environmental issues, so governments have a greater incentive to introduce stricter regulations, which in turn encourage producers to adopt cleaner

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technologies. The introduction of environmental policies could also positively affect the EKC through the composition effect. The composition effect captures the reduction in emissions associated with the relocation of production from more polluting sectors to countries with lax policies. This mechanism usually reduces emissions, but the net effect of trade on pollution also depends on other factors of comparative advantage that could contribute negatively to pollution [Grossman and Krueger (1993), Copeland and Taylor (1994), Cole and Elliott (2003)]. Since trade could have an indirect effect on pollution through endowments on scale, composition and technique components (trade-induced effects), two interaction terms have been included by multiplying the trade variable by those for human and physical capital.

5. Results

We first test the impact of all EKC drivers on the rates of change of total GHG and AG emissions change rates using the econometric model (5). We have estimated two model specifications. The first model (M1) is a linear model using first differences for both the dependent and independent variables and is estimated by including $\Delta GDPpc_{t-2}$,$\Delta K/L_{t-1}$,$\Delta H_{t-1}$and $\Delta Trade_{t-1}$. A second model (M2) is estimated by adding squared and cubic $\Delta GDPpc_{t-2}$ to account for non-linearities in the spirit of the EKC model, and trade interaction variables with physical and human capital.

The two sets of explanatory variables are also used to estimate a three-equation model of emission change rates related to scale, composition and technique effects.

Overall Effect: Taking the total emissions change rate as the dependent variable, OLS and NLLS estimates are reported in Table 2. As we can see from columns GHG-M1 and AG-M1, all economic variables have a significant and negative effect on the emissions change rate, leading to environmental improvements. The constant coefficient is positive (GHG) and negative (AG) but not statistically significant, so there is no time trend in emissions levels. Regarding the M2 model, the columns GHG-M2 and AG-M2 show non-linear effects of GDPpc growth and interactions between factor endowments and trade only for GHG emissions. For a better interpretation of the results, Figures 1-8 show the marginal effects at different deciles of the reported variables with confidence intervals. A negative non-linear relationship between the rate of change of total GHG emissions and GDPpc growth is highlighted in Figure 1 (top left graph) in terms of marginal effects. This implies that economic growth has a negative effect on emissions for all countries, which is stronger for higher deciles of GDP growth. Regarding trade determinants, we can identify both indirect effects of international trade, related to variations in factor endowments, and direct effects, through changes in export and import flows. The indirect effect is negative, so that a unit

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increase in physical (or human) capital tends to reduce air pollution. Physical capital investment reduces emissions in countries with trade change rates in the high deciles (Figure 2, top left graph), while human capital leads to environmental improvements in countries with trade change rates in the low deciles (Figure 3, top left graph). As for the direct effect of international trade (Figure 4, top panels), countries with large differences in openness tend to emit less, especially those with factor endowments in the higher deciles. This evidence is consistent with recent literature suggesting that a growing economy invests more in environmentally friendly sectors, for example, through investment in green technologies. This could imply that the declining phase of the EKC is mostly related to the technology effect, so the existence of decoupling cannot be rejected. Most of the results are also verified for AG emissions (Figures 6 to 10).

Table 2: OLS and NLLS estimates of EKC, overall effect.

	GHG-M1	**GHG-M2**	**AG-M1**	**AG-M2**
$\Delta GDPpc_{t-2}$	-1.32***	-0.29	-0.52 ***	-0.21
	(0.370)	(0.390)	(0.147)	(0.253)
$\Delta K/L_{t-1}$	-0.54***	-0.63***	-0.59***	-0.70***
	(0.180)	(0.220)	(0.089)	(0.144)
ΔH_{t-1}	-5.99**	-3.720	-5.54*	-4.02
	(2.280)	(2.260)	(2.625)	(2.582)
$\Delta Trade_{t-1}$	-0.4***	-0.29**	-0.12	0.02
	(0.060)	(0.140)	(0.074)	(0.245)
${\Delta GDPpc_{t-2}}^2$		-10.19**		0.225
		(4.290)		(2.401)
${\Delta GDPpc_{t-2}}^3$		-124.85*		-25.77
		(66.150)		(21.240)
$\Delta Trade_{t-1} * \Delta H_{t-1}$		14.380		-6.27
		(19.560)		(29.730)
$\Delta Trade_{t-1} * \Delta K/L_{t-1}$		-5.27*		-3.94
		(2.750)		(3.330)
constant	0.020	0.010	-0.011	-0.016
	(0.010)	(0.010)	(0.017)	(0.016)
R-squared	0.341	0.432	0.166	0.188
Obs	184	184	184	184

*Note. Standard errors in brackets. Significance level: *** 0.01, ** 0.05, * 0.1*

The analysis is repeated for the three emission components. Looking at the decomposed effects (Appendix, Table A3), there is a positive time trend in the scale component for GHG and AG emissions and a negative time trend in the technique effect for AG emissions, both of which are statistically significant. For M2, the negative trend in the technique equation for AG emissions is the only common result with the previous specification. For the other estimates, the null hypothesis is not rejected.

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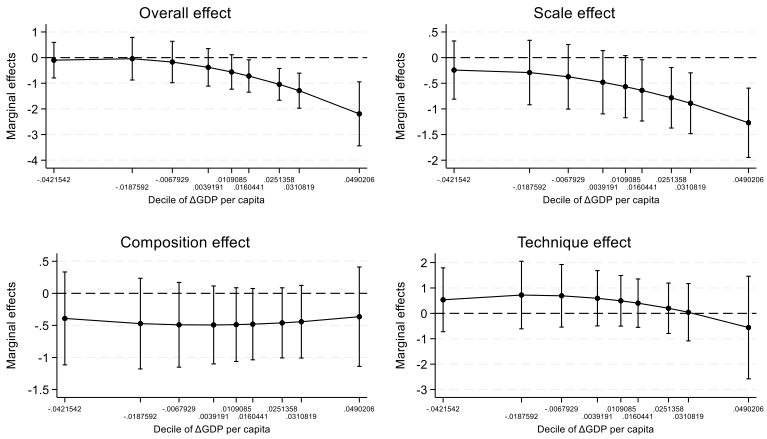
Figure 1: Marginal effects of GDP growth, GHG emissions



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

Scale Effect: The linear SUR estimates (GHG-M1 and AG-M1 columns of Table A3) show that economic growth and trade appear to have a negative effect on emissions, leading to environmental improvements. This is confirmed for both types of air pollutants, but the results are only statistically significant for GHG. We cannot reject the null hypothesis for physical and human capital. When analysing model M2, i.e. the NLSUR estimates, most of the comments reported for the rate of change of total emissions are confirmed for the scale effect. See Figure 1 (top right graph) for the effect on GDP growth and Figure 4 (bottom graphs) for the direct effect of trade on GHG emissions. Figure 6 (top right graph) and Figure 9 (bottom graphs) show similar results for AG emissions. Note that, in contrast to the overall estimates, for countries in the lower deciles of investment in physical and human capital, the rate of change in trade reduces emissions in terms of both GHG and AG, so that being more open to trade *per se* is not sufficient to achieve lower emissions through the scale effect.

Composition Effect: Focusing on the composition effect, the M1 results suggest that there is no relationship between ΔGDPpc and changes in GHG emissions, and no trade-related variables (except physical capital) have a statistically significant effect. However, when examining the marginal effects of the M2 specification, we find a (statistically significant) negative relationship between the rate of change in GHG emissions and ΔGDPpc for countries in the lower deciles of GDP growth rate (Figure 2, top left panel). As for the trade-related determinants, there is no direct effect of international trade on the composition component, as shown in Figure 5 (upper panels). This result contradicts the PHH. The trade-induced effect of factor

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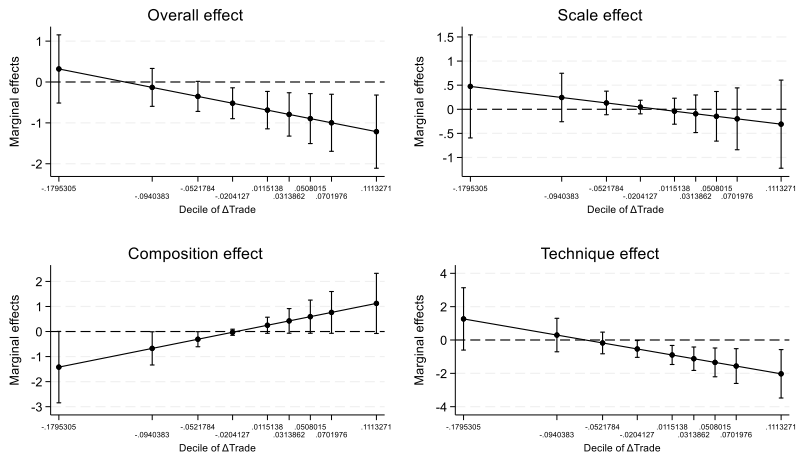
endowments is partly negative. A unit increase in physical capital reduces air pollution in response to trade in countries in the lower deciles of the openness change rate (Figure 2, top middle panel), but this effect is not verified for human capital investment. This evidence suggests that sectors investing in physical (green) capital improve the environment. For AG emissions, there are no statistically significant effects on the composition component (Figures 6-10).

Technique Effect: Analysing the M1 results on the technique effect, we can see from Table A3 that no variables have a significant effect, except for physical capital, which has a negative coefficient. Regarding the M2 marginal effects, we find a statistically insignificant negative relationship between the rate of change of GHG emissions and the rate of GDP growth (Figure 1, bottom right-hand panel), so that GDP growth does not affect the technology effect and consequently the reduction of emissions. Regarding the direct effect of trade, we find that more open countries tend to emit less in higher deciles of investment in human and physical capital, as shown in Figure 5 (bottom panels). The indirect effect of trade through factor endowments is negative only for physical capital, so that a unit increase in physical capital reduces air pollution in response to trade in countries in higher deciles of trade change rates (Figure 2, bottom right graph). The marginal changes in human capital are not statistically significant. All results for GHG emissions are partially verified for AG emissions (see Figures 6-10). The indirect effect of physical capital investment is confirmed for AG emissions, while the relationship between the rate of change of AG emissions and the rate of GDP growth for countries is positive (and not negative) at higher deciles of GDP growth. All other effects are not statistically significant.

Figure 2: Marginal effects of investment in physical capital, GHG emissions



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

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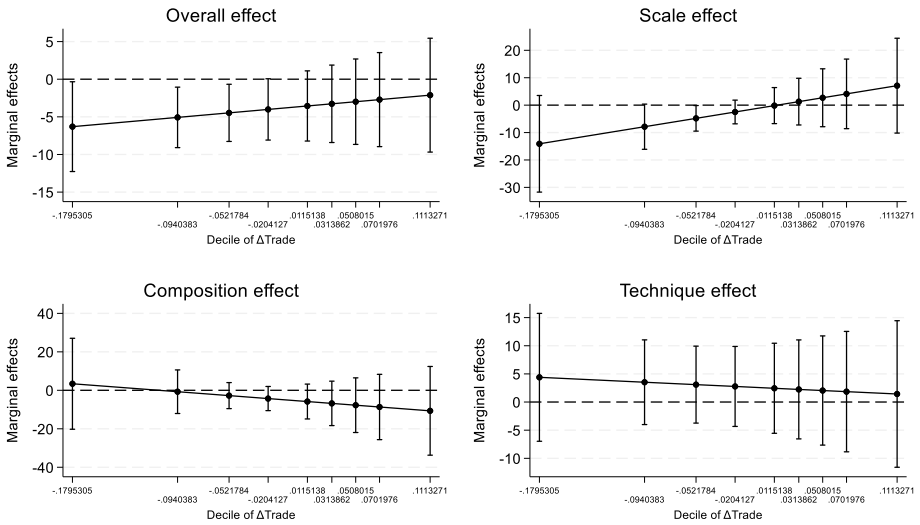
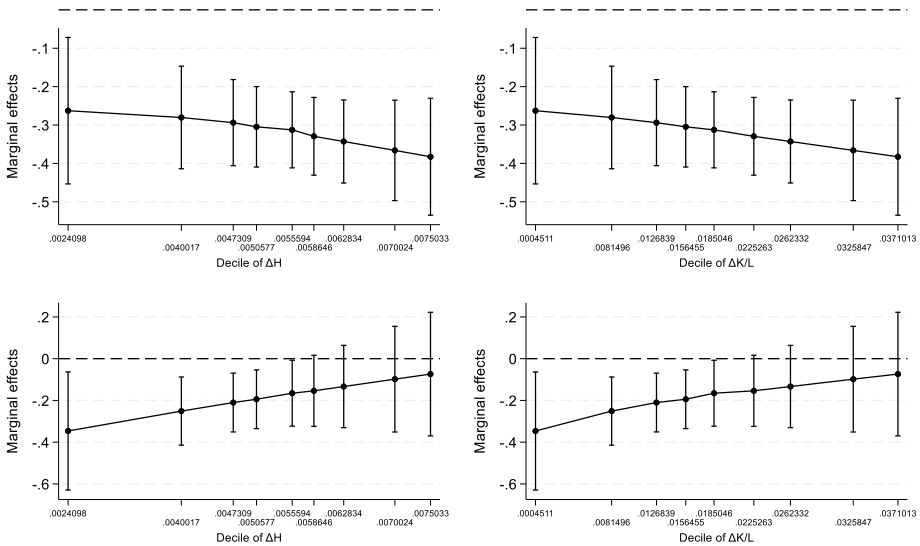
Figure 3: Marginal effects of investment in human capital, GHG emissions



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

Figure 4: Direct effects of trade openness, overall (top graphs) and scale (bottom graphs) GHG components



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

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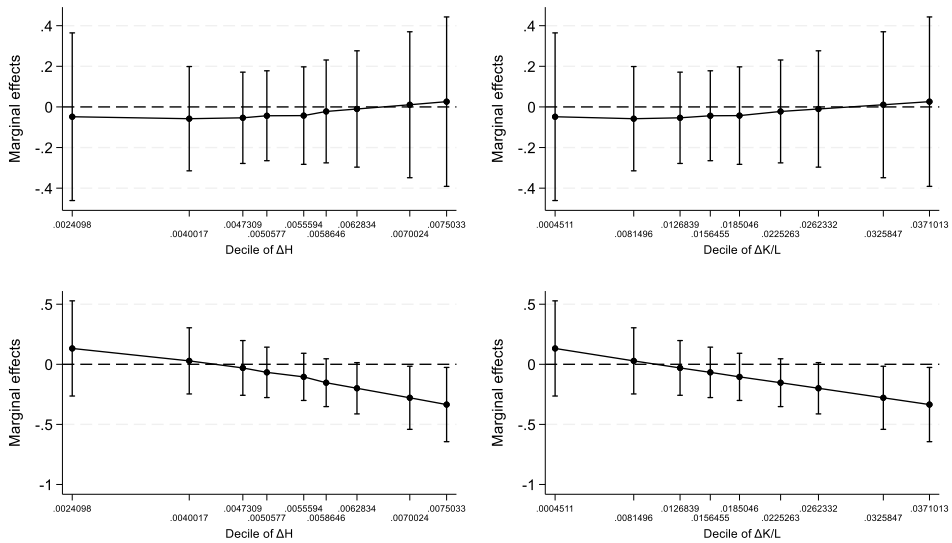
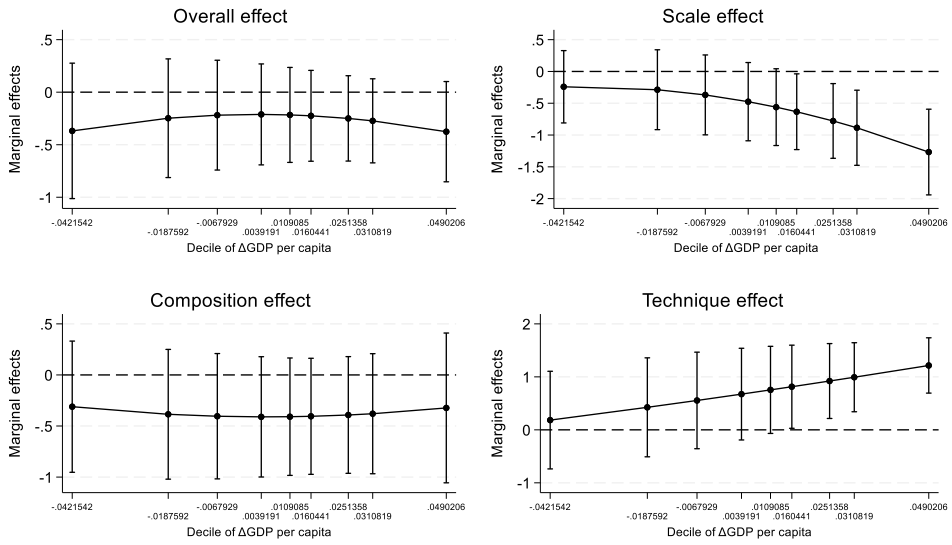
Figure 5: Direct effects of trade openness, composition (top graphs) and technique (bottom graphs) GHG components



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

Figure 6: Marginal effects of GDP growth, AG emissions



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

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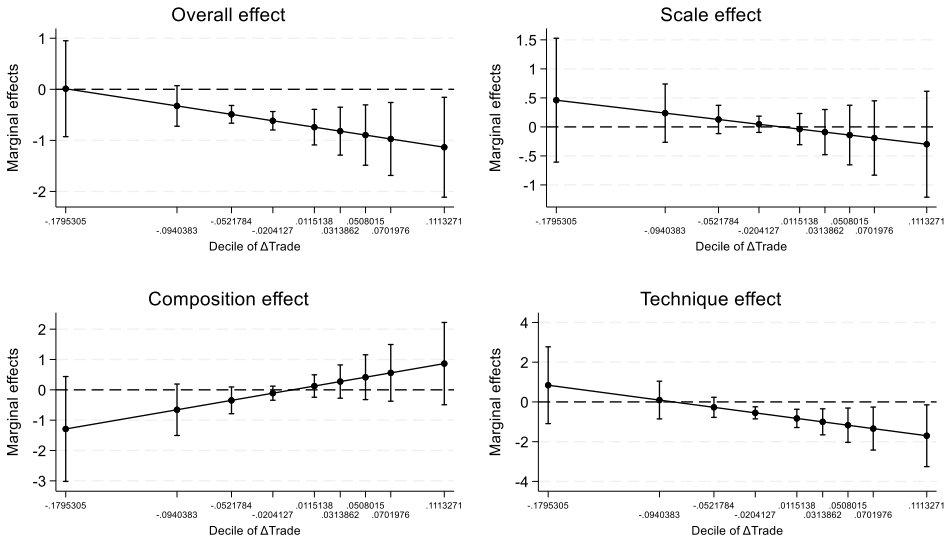
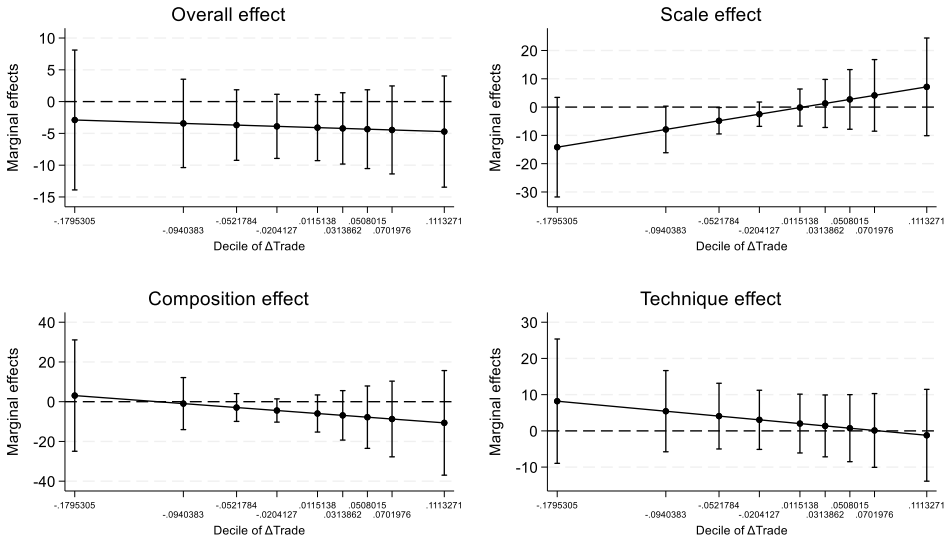
Figure 7: Marginal effects of investment in physical capital, AG emissions



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

Figure 8: Marginal effects of investment in human capital, AG emissions



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

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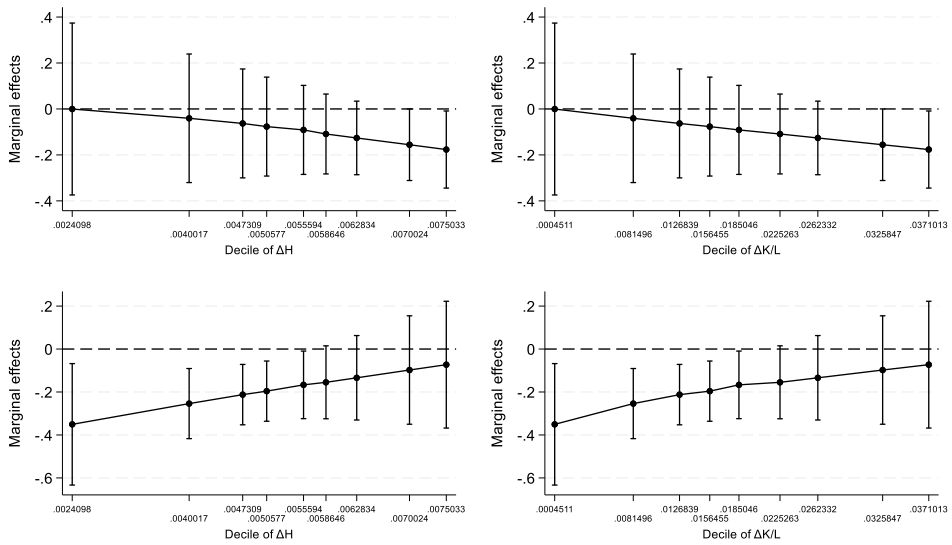
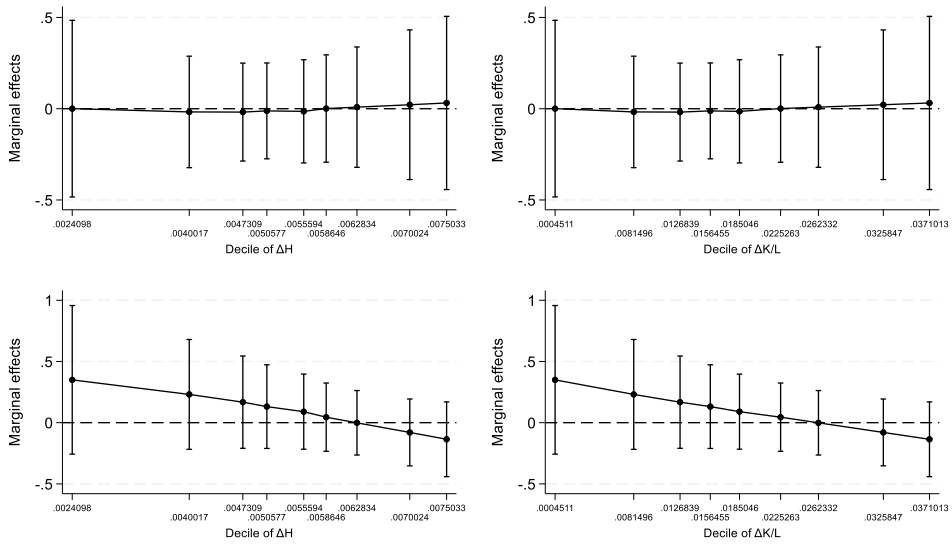
Figure 9: Direct effects of trade openness, overall (top graphs) and scale (bottom graphs) AG components



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

Figure 10: Direct effects of trade openness, composition (top graphs) and technique (bottom graphs) AG components



Note: Marginal effects at each decile of the reported variable on the x-axis from M2 model estimated by NLLS

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6. Discussion

The LMDI decomposition of GHG and AG emissions for EU countries for the period 2008-2016 showed that the overall level of emissions in the EU countries stays constant, but heterogeneous effects are recorded. Some of them reported a decrease in air pollution, while others showed an increase in air pollutants emissions. The common decrease recorded between 2008 and 2010 is likely linked to the economic crisis of 2008, which led to a decline in the real GVA of countries. Regarding the three effects, emissions generally increased due to the scale effect and decreased due to the technique effect. The composition effect behaved differently from country to country.

The results on the EKC underlined that GHG and AG emissions are driven in a non-linear way by GDP per capita growth and trade, both directly and indirectly through the interaction with factor endowments.

Table 3. Emissions (GHGs and AGs) and GDPpc growth by country and median value

		ΔGDPpc	
		High growth countries	*Low growth countries*
ΔGHG	*High Polluter*	Bulgaria, Estonia, Hungary, Lithuania, Netherland, Poland, Slovakia	Austria, Belgium, Denmark, Germany, Greece
	Less polluter	Latvia, Romania, Sweden	Croatia, Finland, France, Italy, Portugal, Slovenia, Spain, United Kingdom
ΔAG	*High Polluter*	Bulgaria, Estonia, Hungary, Lithuania, Netherland, Poland	Austria, Belgium, Denmark, Germany, Greece
	Less Polluter	Latvia, Romania, Slovakia, Sweden	Croatia, Finland, France, Italy, Portugal, Slovenia, Spain, United Kingdom

Through our empirical analysis on the overall effect, we have not rejected the hypothesis that a decoupling exists. To support this result, we have constructed Table 3. It is obtained by calculating the median values of emissions and growth rates for each country and of the all sample. If the country median values of ΔGHG (ΔAG) is higher than the sample median, the country is classified as "High Polluter" otherwise it is a "Less Polluter". Referring to ΔGDPpc, if the median value of the country is higher than the sample median value, the country lies among the "High growth countries" otherwise among the "Less growth countries". Table 3 shows that the decoupling results are related to less polluter country with a high growth rate, so Latvia, Romania and Sweden, in terms of GHGs, and Latvia, Romania, Slovakia and Sweden, concerning AGs.

By combining the results on the three effects, some important conclusions can be drawn. First, the estimates have shown that economic factors have different impacts on each component and that the results are qualitatively similar across air pollutants. Second, the scale effect appears to be significantly driven by the growth rate of GDP per capita through a non-

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linear relationship, but the effect is opposite to that found in the literature. This could be explained by the fact that EU countries are advanced economies linked by a common trade market and can be interpreted as evidence in favour of decoupling. This result is confirmed by the evidence that countries that are highly dynamic in international trade reduce emissions. Moreover, the composition effect does not seem to be very relevant, except when countries make investments in physical capital that contribute to reducing GHG and AG emissions. Third, estimates of the technique component suggest that investment in physical capital can play a key role in achieving environmental improvements. However, more effort is needed in terms of resources invested to offset the scale effect.

Conclusions

Given the increasing importance of environmental issues and their impact on human health and natural degradation, researchers have examined some economic factors such as GDP, energy consumption and trade-related determinants of air emissions to find possible solutions for sustainable development. As emissions can be decomposed into three specific effects - scale, composition and technique - this paper has qualitatively and quantitatively analysed the impact of GDP growth, trade openness and factor endowments on these effects separately. Emissions were driven by GDP per capita growth in a non-linear way and by trade openness, both directly and indirectly through the interaction with factor endowments. The determinants of the scale component mainly influenced the rate of change of total emissions, but physical capital investment played a key role in reducing emissions mainly through the technique component.

From a policy point of view, institutions should manage air pollutants by concentrating resources on new investment in physical capital to expand the composition and technique effects with respect to the scale component and to consider the heterogeneous impact of investments on them. This is also in line with a decoupling pattern. Policies should encourage a rethinking of the sectoral composition by promoting investments in green capital and pay more attention to eco-innovation and technological progress with the aim of reducing emissions through a lower dependence on raw materials and the environment in general. Furthermore, concerning resource decoupling, EU, since the enacting of the European Green Deal and following corollary directives, is fostering a just and inclusive ecological and digital transition but challenges due to economic, structural, and social disparities among Member States make the adoption difficult. Different transposition times lead wealthier countries to adapt more easily, while less developed states reliant on resource-intensive industries must bear higher costs, risking competitiveness and regional inequalities. Different absorption capacity, public support, economic

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structures and uneven access to green technologies make transitioning harder for some nations. Administrative gaps and limited monitoring capacity hinder consistent enforcement. Finally, having diverse environmental baselines make uniform targets harder to achieve so higher flexibility is required. Not to be underestimated cross-border effects risk, which implies a shift of environmental pressures between countries. Towards solving these problems, possible solutions could refer to EU funding, differentiated timelines (short-term and long-term), collaboration among countries, which can also help ensure equity and cohesion while advancing decoupling goals.

Further research could be undertaken. First, a longer time horizon should be considered, as the implementation of an environmental regulation and the adoption of new green technologies require a longer-term perspective to allow for a complete structural change of the economy. Second, a robustness analysis of the results could be carried out by allowing for the existence of zero emissions at the sectoral level (Wood and Lenzen, 2006). Third, as there are many differences between pollutants, further studies could be carried out by applying the same analysis to other types of pollutants, such as water pollutants. Finally, it might be useful to find an appropriate variable to measure environmental regulation to capture the direct impact of specific policies on emissions.

Despite our work could contribute to the current discussion about possible drivers of emissions and insights to policymakers, it is not spurious by limitations that could be treated in further researchers. Firstly, the adoption of a LMDI II approach requires that the involved variables have constant elasticities, so the relationships between these measures and their respective outcomes remain unchanged over time. In other terms, it has been assumed that these relationships are not likely to evolve due to technological progress, changes in economic conditions or policy shift (Ang, 2004). Furthermore, since we are dealing with data that varies across countries, sectors, or time periods, LMDI II treats the changes in factors as though they have the same influence regardless of the context (Ang and Wang, 2000).

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Data Availability: All data are included in the content of the paper.

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Appendix A

Table A1. Manufacturing sectors by Nace Rev. 2 classification

Nace Code	Description
C10_C12	Manufacture of goods, products, beverage, tobacco products
C13_C15	Manufacture of textile, wearing apparel, leather and related products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_C32	Manufacture of furniture and other manufacture
C33	Repair and installation of machinery and equipment

Table A2. Data Description

Variable	Description
Dependent Variables	
g_{it}^{E}	Total emission change rate
g_{it}^{S}	Emission change rate due to the scale effect (scale component)
g_{it}^{C}	Emission change rate due to the composition effect (composition component)
g_{it}^{T}	Emission change rate due to the technique effect (technique component)
Independent Variables (in logs and first differences)	
$\Delta GDPpc_{t-2}$	Expenditure-side real GDP per capita
$\Delta K/L_{t-1}$	Ratio of capital stock to number of engaged workers
ΔH_{t-1}	Human capital index, based on years of schooling and returns to education
$\Delta Trade_{t-1}$	Share of total exports and imports of goods at current PPPs, (EXP+IMP)/GDP

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Table A3: SUR and NLSUR estimates of emission components

	Scale				Composition				Technique			
	GHG-M1	**GHG-M2**	**AG-M1**	**AG-M2**	**GHG-M1**	**GHG-M2**	**AG-M1**	**AG-M2**	**GHG-M1**	**GHG-M2**	**AG-M1**	**AG-M2**
$\Delta GDPpc_{t-2}$	-0.81***	-0.440	-0.81***	-0.430	-0.150	-0.49*	-0.120	-0.410	-0.36	0.64	0.4*	0.630
	(0.170)	(0.290)	(0.160)	(0.290)	(0.170)	(0.290)	(0.130)	(0.280)	(0.480)	(0.530)	(0.230)	(0.410)
$\Delta K/L_{t-1}$	0.040	-0.01	0.040	-0.010	-0.08*	0.150	-0.15**	0.040	-0.5**	-0.77***	-0.47***	-0.73***
	(0.070)	(0.100)	(0.070)	(0.100)	(0.040)	(0.110)	(0.080)	(0.130)	(0.200)	(0.240)	(0.120)	(0.170)
ΔH_{t-1}	-2.79	-1.01	-2.79	-1.01	-3.830	-5.270	-4.100	-5.400	0.630	2.560	2.360	2.390
	(2.160)	(2.580)	(2.150)	(2.570)	(2.760)	(3.610)	(2.570)	(3.590)	(3.140)	(3.520)	(3.920)	(3.710)
$\Delta Trade_{t-1}$	-0.19**	-0.52**	-0.19**	-0.53**	0.010	0.060	0.020	0.110	-0.21*	0.160	0.050	0.430
	(0.080)	(0.250)	(0.080)	(0.250)	(0.110)	(0.340)	(0.130)	(0.390)	(0.110)	(0.250)	(0.140)	(0.360)
$\Delta GDPpc_{t-2}{}^2$		-5.17**		-5.16**		-0.040		-0.220		-4.980		5.6**
		(2.09)		(2.100)		(2.860)		(2.600)		(6.480)		(2.330)
$\Delta GDPpc_{t-2}{}^3$		-45.19**		-45.66**		18.520		14.990		-98.190		4.900
		(19.240)		(19.160)		(23.150)		(19.610)		(78.350)		(27.490)
$\Delta Trade_{t-1} * \Delta H_{t-1}$		72.91		73.31		-48.34		-47.20		-10.19		-32.370
		(53.97)		(53.870)		(71.7)		(84.48)		(32.040)		(39.700)
$\Delta Trade_{t-1} * \Delta K/L_{t-1}$		-2.69		-2.61		8.75**		7.410		-11.32**		-8.740
		(3.120)		(3.110)		(4.150)		(4.850)		(5.030)		(5.450)
constant	0.02**	0.02*	0.02**	0.02*	0.01	0.02	0.01	0.020	-0.02	-0.03	-0.05**	-0.06***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.020)	(0.010)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
R-squared	0.144	0.203	0.144	0.203	0.011	0.051	0.013	0.041	0.053	0.121	0.021	0.069
Obs	184	184	184	184	184	184	184	184	184	184	184	184

Note. Significance level: *** 0.01, ** 0.05, * 0.1

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Enhancing E-Government Proactive Services Through Advanced Data Processing Technologies

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Abstract

The approach of citizens to the digital world allows the public sector to provide services that cross the frontiers of traditional citizen-administration relationships. Anticipating consumer needs, fostering more satisfying relationships, and reducing resolution times are some of the goals for a new era of electronic public sector services. A concise set of proactive systems is compiled to illustrate and analyse these options. This paper focuses on analysing the key role of Big Data and Digital Twin in public administrations as tools for providing Proactive Services (PAS). It is common for government administration to consider the use of disruptive technologies to enhance services designed to improve relationships with citizens. This paper explores the use of innovative technologies to increase the number of proactive services available within public administration (Proactive Public Services - PPS), the challenges they face, and the technical limitations that arise. A change in mindset is necessary. Paraphrasing an illustrious United States president in his inaugural address: "*Ask not what citizens can do for administration – ask what administration can do for its citizens*."

Keywords: Big Data, Government services, Proactive, Decision making

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Introduction

Life is full of events that require administrative services, such as being born, going to school, graduating, obtaining a driver's license, starting a job, getting married, having a child, or starting a new activity or company. Sometimes, public administration creates services to assist citizens with these life events.

A primary goal is to provide an overview of how data-driven public services could become a source of knowledge for policymaking. Another goal is to justify the use of proactive services as the best way to communicate with citizens, based on big data usage. Digital governance has improved public service provision over several years. The first era focused on transferring paper-based system into digital domain using holistic solutions. A second era of digital governance era is currently underway, enabling more effective policies. Data-driven policies in this era implement better individualized, tailor-made services with improved process efficiency and higher citizen satisfaction.

In the first era, it was common for public administrations to offer services through reactive tasks, improving public services by replacing paper-based systems. Managers created digital forms as a direct replacement for physical ones. While this digitalization sometimes helped with form completion, it also increased the amount of information required. The new era of digital governance enables individualization and tailor-made services, yielding better process efficiency and greater citizen satisfaction. Authors such as Tan and Crompvoets (2022) discuss the transition from e-government to a new era of digital governance. However, interactive services have not yet fully realized their potential. In some cases, the concept of “Digital Neo-Weberianism" has been suggested as a new approach to shaping interactions between citizens and governments This concept mirrors the first era but utilizes more advanced forms.

A data-driven government capable of proactively using and delivering information to its clients represents the next generation of governance. Lemke et al. (2020) argue that “designing proactive services of e-governance should be seen as the next stage in service design for e-governance."

Organizational and cultural condition are evolving from an “electronic government” paradigm to a “digital governance” paradigm (Omar et al., 2020). Strategies for implementing digital governance include transitioning from a reactive to a proactive approach in public policy and service provision (Dias & Gomes, 2021). This shift also involves moving from an information-centric government to a data-driven public sector and toward a user-driven administration.

There are also regulatory limitations to consider. Certain legislative guarantees restrict data processing possibilities, such as those in the European

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Union. Legal challenges may arise with proactive services based on automated decision-making. For instance, European legislation recognizes the right not to present the same documentation multiple times, though in practice, data is still frequently requested repeatedly.

According to Velasco (2020), Article 22 of Regulation (EU) 2016/679 of the European Parliament and of the Council states, "The data subject shall have the right not to be subject to a decision based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her." This requires human intervention in decision-making, allowing individuals to challenge such decisions or make allegations.

Efforts to promote openness and collaboration with Trans-Atlantic countries, such as the data processing agreements between the US and Europe, are ongoing. While attempts like Safe Harbour (2000) and Privacy Shield (2016) have not produced satisfactory results, negotiations continue with the EU-US Data Privacy Framework (EU-US DPF) to establish a robust data processing framework.

Some authors have emphasised the need to design public services around citizens rather than providers. Tailoring services to meet the needs of citizens, businesses, and other actors involved in e-government is critical. Henriques et al. (2019) present a clear list of twelve life events in the context of public services that can be monitored, including birth, marriage, divorce, issuance/renewal of a citizen's card or passport, enrollment in public school, parental benefits/family allowances, associating a household with a family doctor, vaccination/family planning, issuance/renewal of a driver's license, registration of vehicles or buildings, taxes, unemployment, and retirement.

Public services must adapt to changes brought by new generations and increased mobility. In the European Union, only 6% of proactive public services (PPS) are supplied proactively compared to 81% of government services accessible online (Barasa & Iosad, 2002). A proactive governance model has the potential to transform the relationship between citizens and governments. Speed and simplicity, key benefits of proactivity, improve perceptions of government services (Baig et al., 2014).

Proactive services have long been used in sales systems. Strategies like cross-selling and up-selling, based on product data and history, aim to enhance sales and improve the buyer experience. A new stage of government is emerging to meet the increasing demand for e-services on mobile devices and for data-driven governance capable of proactively serving citizens and enterprises. This transition requires a new framework to define the maturity of governments moving from e-government (eGov) to smart government (sGov) (Lemke et al., 2020). Foundational frameworks for analysing stage models have been presented by various authors, including Hiller and Bélanger (2001),

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Andersen and Henriksen (2006), and Klievink and Janssen (2008). These models have shaped the understanding needed to develop stage model extensions for novel and innovative governance that is primarily data-driven and proactive.

Proactive services benefit not only citizens but also businesses, organizations, and society by reducing administrative burdens.

Laney (2001) defined Big Data by its volume, velocity, and variety. Governments view Big Data as a means of addressing national challenges in areas like the economy and healthcare (Kim et al., 2014). Big Data revolutionizes public administration through systems for producing, collecting, storing, and analysing vast amounts of data (Clark & Golder, 2015). Big data methods include data aggregation, extraction, pattern detection, network analytics, and predictive modeling. Public administrations are still learning to harness Big Data as a development tool (Isaza & Zarate, 2021). Challenges arise when integrating public services with data to create innovative solutions. Leoni et al. (2023) highlight the importance of collecting non-traditional data sources, such as digital interactions, remote sensing, satellite data, tollbooth cameras, and open data sources.

Digital twins have been proposed for technology governance (Husni et al., 2022; Proper et al., 2021). Kopponen et al. (2022) proposed a digital twin model for citizens, while Lasse (2020) presented classifications of digital twins along lifecycle phases, common uses, and hierarchical levels. Proactive services could accommodate various digital twin models.

Temkin Goup (2011) introduced the "Six Levels of Proactive Support" (Ignore, React, Alert, Self-Heal, Pre-Empt, Avoid), which categorize proactive support and integrate multiple criteria. This framework has since been adapted for public services.

What is Proactive Service?

Proactive Computing is not a new area, Tennenhouse (2000) described proactive computing, but nowadays, scientific researchers have not yet provided dedicated PAS literature (Hhasmammadli & Erlenheim, 2022). One way to reduce this gap is to create a comprehensive taxonomy. Services can be categorized into two types based on who makes the first move: Proactive or Reactive.

Reactive customer service, as described by Brown (2022), "is when a customer has to reach out to a company representative." The same author defines proactive service as "anticipating customer needs and actively reaching out with a solution, whether by communicating a potential problem that has cropped up or allowing customers to self-service their issue." Henriques et al. (2019) define proactive services as "... an automatic provision of services, without the need to wait for a citizen." Another definition by

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Khasmammadli (2023) refers to a service provision model in which governments anticipate citizens' needs and provide a service before citizens request it. This must occur at the exact moment -not too early or too late- anticipating events or responding after an event.

Perfect customer service must ensure perfect timing with proactive customer service. This does not imply personalization for every customer: "Proactivity and customization are independent and do not necessarily go hand in hand" (Andersen & Henriksen, 2006).

Not only customer or citizen relations can be classified, but sharing data with other organizations or notifying changes within one's organization can also be proactive. In this context, data interchange/communication must be initiated by the producer, while the consumer only waits to receive the data.

Proactive models react to various stimuli. Instead of reacting to citizens' request, they react to regulations, policies, or changes in data. Depending on the perspective, services can be classified as reactive or proactive from the citizen's viewpoint. However, from another viewpoint (such as that of analysts or politicians), they are conditioned to events. These events could include increases, changes, or stability. They do not act independently but are triggered by data changes, not citizens' actions.

A new definition is proposed: Proactive services are those that flexibly react to data changes, while reactive services respond only to citizens' action. Proactive services might be more efficient compared to reactive services.

Proactive services must be periodically evaluated due to the changing characteristics of data. Consequently, data volume increases dramatically when settings must be evaluated at multiple time points.

Some authors such as Lemke et al. (2020), have written about a new state of e-government (eGov) proactive government decision-making maturity, which has emerged "due to the involvement of Big Data and data analytics."

Are proactive services better than reactive services? The following tips may help balance reactive and proactive approaches. The first tip is based on higher productivity in processes designed proactively. The next tip is a higher service revenue, which, in public administrations, must be interpreted as citizen satisfaction. Lastly, there is an increase in satisfaction and loyalty scores.

Martinez et al. (2020) propose a classification for the degree of personalization, but a new classification is proposed based on the following categories:

- **Duties-based:** Assistance with various types of duties, such as tax obligations, labour obligations, contractual duties, or financial liabilities.

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- **Procedures-based:** Periodic reporting on the status of procedures or matters of concern.
- **Profile-based:** Automated granting of social benefits or aid based on the profile of a person, family, or community.

The existence of authenticated means of communication with sufficient guarantees is necessary (e.g., email, WhatsApp, Telegram, Signal, citizen's boxes, etc.). While many entities consider a cell phone or email sufficient for communications and administration, this is not yet the case in public administration. Proactive services not only involve external stakeholders but can also benefit internal stakeholders. Alarm or advisory systems can be implemented using similar approaches to notify public servants to take appropriate measures.
Reactive services suffer from long lead times due to the numerous steps required before resolution or conclusion. Focusing on an event (customer request or event trigger), a figure with multiple cases of services is proposed.

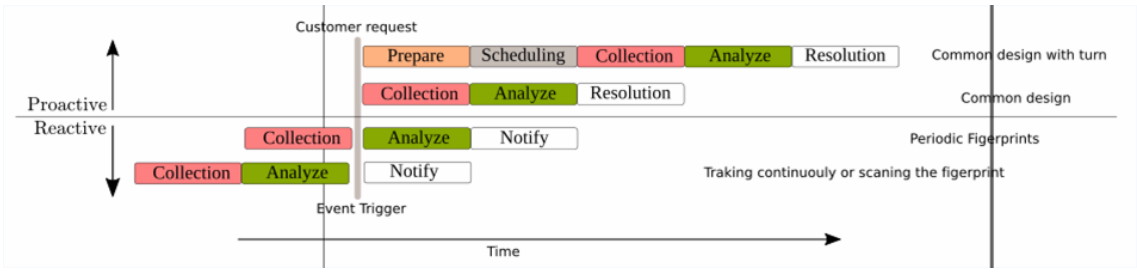

Figure 1. Proactive and Reactive services steps

The process begins by preparing the creation of laws and regulations necessary to achieve government goals. Scheduling involves setting aside time in the day to make presentations. Collection entails gathering the necessary data for the intended purpose. Next, the collected data is analysed, and any identified issues are subsequently resolved. Notification, similar to resolution, involves informing relevant stakeholders about the outcomes; however, this step focuses solely on delivering notifications.

Certain administrative functions must be defined for proactive services: supervision, regulation, or service delivery (Laney, 2001). Services categorized as proactive typically have no endpoint. Processes or tasks involve testing a condition or waiting for an event to trigger a response. Processes designed to run only once are executed as a response to a political event (see topology in planner strategy criteria).

For instance, assisting homeless individuals does not require evaluating personal profiles or examining social exclusion profiles. Instead, it entails providing proactive citizen services based on public administration

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data. As long as this approach is not the sole method for obtaining benefits, it should not pose a legal problem.

At times, the passage of legislation mandates include information regarding the economic expenditures necessary to carry out the actions outlined within the regulation. To create this economic assessment, it is essential to evaluate the quantity and target nature of the projected consequences. Previously, such an assessment needed to be published compulsorily alongside the draft act. This approach enhances the effectiveness of lawmaking and improves the outcomes of law production.

Implementing proactive services presents a new challenge for government structures. Legal and technological teams must approach this area carefully, as a mistake could lead an organization into unexpected situations. Developing regulations to authorize proactive services requires experienced personnel in law. Meanwhile, analysing historical data to provide insights for drafting laws is the responsibility of skilled data analysts.

Examples

The effectiveness of proactive services can best be understood through examples. Below are several cases illustrating proactive and reactive services, along with ways to transition between them. Some proactive services may also incorporate reactive elements.

- PAS#1: As described by Khasmammadli (2023) and Hhasmammadli and Erlenheim, (2022), various user cases demonstrate the potential for these types of services. Advanced data analytics, for example, can identify citizens at risk of poverty or financial distress, enabling proactive e-service to assist them before difficulties arise. Another example involves analysing housing data to identify citizens facing housing instability or homelessness and providing proactive assistance such as rental subsidies or support services. Lastly, improving the lives of parents by creating a proactive service for childbirth allowances has been exemplified in Azerbaijan, as shown in Figure 2.

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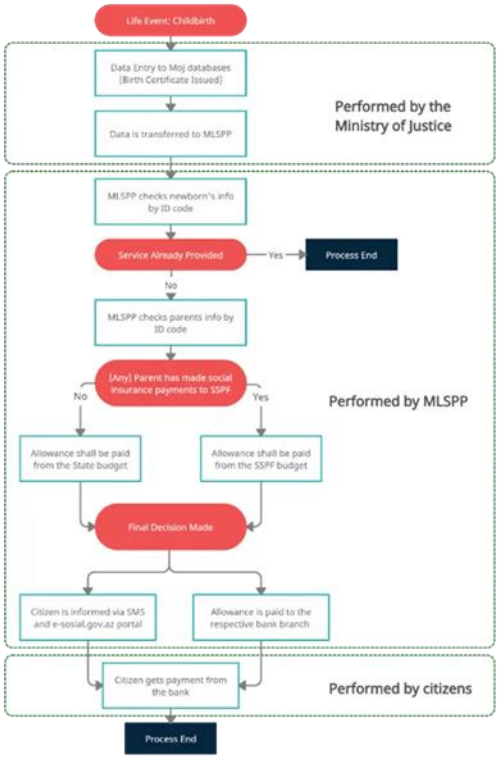

Figure 2. From the Ministry of Labour and Social Protection of Azerbaijan (Khasmammadli, 2023; Hhasmammadli & Erlenheim, 2022)

- PAS#2: The Spanish government has introduced a cultural wallet initiative for young individuals who turn 18 in 2023. This service promotes access to cultural services in Spain. Currently, young people must actively apply for the wallet by filling out a web form and waiting for it to be processed, a process that may take several months or even years. A proactive service would automatically provide wallets ready for use to all individuals born in 2025, eliminating the need for an application.
- PAS#3: The Portuguese government offers a Social Energy Tariff by integrating data from energy companies, tax authorities, and the social security system. By combining data from these sources, the government can automatically provide eligible individuals with an energy tariff tailored to their social circumstances.
- PAS#4: In multiple countries, such as the UK, the Netherlands, and Spain, annual tax returns are pre-filled with existing information. Citizens are required only to review, accept, or correct the information before submitting their return.

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- PAS#5: A recommendation system is a proposal for a reactive service where, based on a user's profile, a web platform proactively recommends products or services tailored to their preferences and characteristics.

Proactive Services Taxonomy

Building on the work of Lasse (2020) and the Temkin Group (2011) mentioned in the introduction, a new taxonomy is proposed based on multiple criteria. This taxonomy aims to be simple and clearly defined, providing an accessible framework for both users and developers. It fosters better understanding and clarity in defining and implementing proactive services.

Table A. Taxonomy for proactive services

Relationship	Criteria	Options
Related to trigger	Decision position on time	Anticipate, Recognize
	Planner strategy	Continuous, Periodically, Sometimes, Triggered by event
	Trigger type	Data, time, location, status, revenue, etc.
Related to data	Data used	Citizen data, External data, Mixed
	Personalization level	Personalized, Grouped
	Facts	Duties, Procedures, Profiles
Related to Results	Outcomes	Solve, Notice
	Profits	For citizen, for service provider, third person
Related to Technology	Processing	Emulated, simulated, IA, Digital Twin, etc...
	Notify system	Mail, SMS, messaging app, etc.
Related to entitlement	Authorized by law	Laws, directives, Decisions, Recommendations, Regulation, etc.
	Company Strategic alignment	Goals, targets, objectives, corporative aims, aspirations

- Related to the Moment to Start the Event
  - Based on the Decision Position on Time: Refers to the timing of decision making. This can involve either anticipating a decision with a predictive model or waiting for an event to occur and recognizing previously defined options (Anticipate or Recognize).
  - Based on the Planner's Strategy: Includes continuous evaluation, periodic evaluation that runs after an earlier cycle, or actions executed by human intervention or triggered by specific conditions (Continuous, Periodically, Sometimes, Triggered byan event).
  - Based on the Trigger Type: A trigger based on a specific date activates when the designated day arrives. Other triggers may rely on planner strategies, such as data, time, location, status, or revenue (Data, Time, Location, Status, Revenue, etc.).
- Related to Data Used in the Process

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- Based on Data Used: Refers to the type of information employed in the procedure. Citizen data involves information directly provided via forms or administrative relations. External data refers to information not directly supplied by individuals, such as open data or purchased datasets. The mixed approach combines all available data (Citizen Data, External Data, Mixed).
- Based on Personalization Level: Determines whether the service is designed for a single individual or a group of people (Personalized, Grouped).
- Based on Facts: Refers to the previously mentioned categories (Duties, Procedures, Profiles).

- Related to Results or Effects
- Based on Outcomes: Indicates whether the service resolves the issue or simply notifies the relevant parties of a possible situation (Solve, Notice).
- Based on Profit: Identifies the primary beneficiary of the service—citizens, the service provider (e.g., the administration), or a third party (For Citizen, For Service Provider, Third Party).
- Related to Technology
- Based on Technologies: Observe the technologies employed in implementation (Emulated, Simulated, IA, Digital Twin, etc.)
- Based on the Notification System: Refers to the method used to communicate with citizens (Mail, SMS, Messaging Apps, Feeds, etc.).
- Related to Entitlement
- Authorized by Law: Involves regulations or legal rules permitting the implementation of the service (Laws, Regulations, etc.).
- Company Strategic Alignment: Refers to internal decisions aimed at achieving a common objective (Goals or Targets).

These twelve alternatives encompass nearly all proactive services deployed and help to explain the characteristics of their implementation.

Creating Interactive E-services

At first glance, proactive services and the data universe are closely related concepts. Running proactive services requires substantial amounts of data, which can be obtained from government services, open sources, or purchased datasets. Before acquiring data, it is essential to define a model to assemble each component. After data acquisition, phases for creation must be clearly defined. A new model and a four-phase guide are proposed for this purpose.

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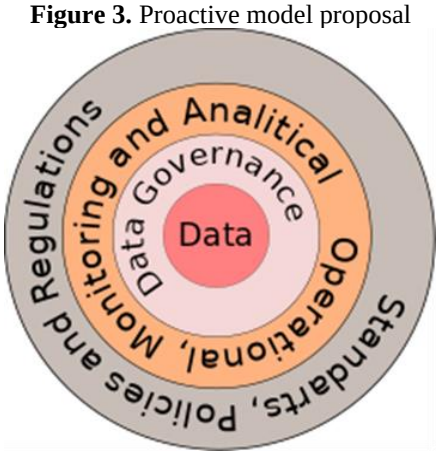
Proactive Services Model

The proposed model for proactive services consists of four well-established layers:

- Data – Incorporates all data sources and methods of data interchange.
- Data Governance – Establishes standards for the ethical and efficient use of data.
- Use of Data – Applies data for operational, monitoring, or analytical purposes.
- Use Governance – Implements standards, policies, and regulations to ensure effective data utilisation.

The four-level model, illustrated in Figure 3, offers a concise framework connecting proactive services with non-proactive services.

Figure 3. Proactive model proposal



1. Data is the core of PAS. Data-driven analysis relies on information gathered from various sources.
2. Data Governance: Several crucial requirements associated with proactive services, alongside many other domains, include Data Governance to improve data quality for service delivery. Establishing effective communication channels for reporting, notifying, or advising citizens about relevant issues is also necessary. Ensuring data quality is imperative, with features such as Interoperability and consistent records (e.g., digital IDs) being indispensable. However, challenges arise when collecting data from multiple sources, such as a lack of homogeneity.
3. Operational Monitoring and Analytics: This involves using data for operational purposes, monitoring, and analytical processing.
4. Standards, Policies, and Regulations: These encompass all work carried out to ensure that proactive services are governed effectively.

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Proactive Services Creation Phases

Some proposals have been made to create interactive e-services. One such proposal, by Erlenheim (2019), outlines a step-by-step process for proactive service creation: defining stakeholders, clarifying requirements, prototyping solutions, and finally launching the service. A four-stage definition for creating proactive services is proposed:

1. Establishing the Terms: Define the terms, laws, rules, conditions, and regulatory frameworks that will enable beneficiaries to receive the service.
2. Data Gathering: Collect data from various sources.
3. Technology Utilization: Use technology to define and combine data through an intelligence engine, employing advanced techniques such as analytics, data mining, digital twin, and AI.
4. Service Utilization: Implement the service, ensuring it is useful and usable.

In public administration environments, the first phase is particularly important. Points 2 and 3 can be repeated until a solution is obtained. The final phase involves informing stakeholders.

Joining Proactive Service and Data Universe

As noted by the authors, decision-making based on Big Data will allow proactive service to citizens (Sun et al., 2020; Lemke et al., 2020). A comprehensive suite of technologies to facilitate the creation of proactive services is proposed. This approach leverages key data technologies in two critical areas, both of which have demonstrated efficacy:

- Big Data Frameworks: Technologies such as Apache Hadoop (Hadoop, 2023), Apache Storm (Storm, 2024), and Apache Spark (Spark, 2024) are essential. Whether using batch or streaming processing, these frameworks are effective in achieving proactive services.
- Digital Twin and AI: Creating a digital twin of a citizen allows for the evolution of physical status and evaluation of future conditions, needs, and feasible solutions. With the current state, a digital twin can assess potential future states for an individual.

A definition of the digital twin, proposed by Kopponen et al. (2022) is "*a virtual representation that serves as the real-time digital counterpart of a physical object or process.*" While digital human twins (HDT) in healthcare focus on disease prevention and medical image processing, the goal is to develop a digital citizen twin. However, this area is beyond the scope of this document.

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Certain behaviour of digital twins must be guided by Influence Engineering (IE) (Sajid, 2023). This involves developing algorithms using behavioural science techniques to automate aspects of digital life. Common techniques include sentiment analysis, which categorizes user data as positive, negative, or neutral, facial expression recognition, and voice analysis to detect emotions.

Implementing Big Data in this context presents challenges, particularly regarding security and privacy. Government agencies must apply measures to manage security and privacy while sharing data, a concept known as smart governance (Sarker et al., 2018).

Threats

Addressing the risks involved in using proactive services is critical. Every project encounters risks that can be mitigated. The risk of error in Big Data models is high and context-specific. A case in the Netherlands illustrates this risk. Thousands of families were wrongly profiled as fraudulent and instructed to repay child welfare subsidies for a PAS, leading to the Cabinet's resignation (Roobeek et al., 2021).

The use of proactive services (PAS) may lead to the following risks, among others:

- Privacy concerns: Public administration functions aim to create and improve a fair society.
- Software errors: These can have dramatic consequences due to the proactive nature of the services.
- Data quality: Issues such as incorrect phone numbers, the number of intermediaries, etc., are common concerns. Significant investment in data quality is essential.
- Misinterpretation of data.
- Barriers to entry: Disadvantaged groups may lack access.
- Resistance to change: Habits are difficult to break, and vested interest persist.
- Political and religious challenges: These create additional barriers.
- Economic considerations: Low-cost technologies may not always be attractive to firms.
- Potential discrimination: There is a risk of discriminatory practices from the use of such services.

Conclusion

First and foremost, a fundamental question must be addressed: While the government can create proactive e-services, are citizens ready for this transition? Many citizen initiatives focus on privacy and data protection.

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Public administration should align its goals with the public will. Developing legislation to facilitate the creation of proactive e-services is crucial for enabling innovation while minimizing adverse effects on citizen data privacy.

Developing a predictive business model entails inherent challenges. Designing one tailored for use with vast datasets and deployable within a Big Data framework is vital for proactive citizen services and introduces an even greater level of complexity. It is not just about fixing or empowering technicians; significant investment in IT infrastructure is needed to complete these tasks. A new way to solve day-to-day problems must be accepted and promoted within the organization.

Indeed, ethical risks are associated with predictive business models, particularly concerning potential discrimination due to inaccuracies or biases in data profiling. New developments must align with political concerns and advancements in citizens' daily lives, ensuring that proactive measures mitigate any adverse effects on individuals or communities. Ethical considerations should be paramount in the design and implementation of such models to uphold fairness, transparency, and social responsibility.

Economic requirements are needed in the legislative approval process. Showing the total expenses required to approve official rules and providing information about the total number of members exposed or affected by new legislation enhances the clarity of lawmakers' actions.

Incorporating economic requirements into the legislative approval process and delineating the total expenses required to implement official rules is paramount. Additionally, disclosing the total number of individuals exposed or affected by new legislation enhances the clarity of lawmakers' actions. This transparency not only bolsters accountability but also ensures that legislative decisions are informed by both financial considerations and their potential impact on constituents.

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Sustainable Tourism Supported by Drafting of the Cross-border Sustainable Mobility Plan (CBSMP) between southern Italy and Greece: Connections among Gallipoli, Brindisi, Thesprotia, and Igoumenitsa

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Abstract

The development of a Cross-Border Sustainable Mobility Plan (CBSMP) under the European Interreg Greece-Italy Cooperation Programme (2014-2020) highlights the critical need for a synergistic and systemic approach to creating sustainable accessibility models. These models are vital at both international and local levels for fostering environmentally, socially, and economically responsible tourism development. This research addresses the urgent need to design comprehensive sustainability solutions, with transportation playing a pivotal role. The CBSMP was meticulously developed by integrating international, national, and local transport plans and

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programmes, with particular emphasis on existing Sustainable Urban Mobility Plans (SUMPs). The plan not only proposes alternatives to highly polluting transport options but also lays the foundation for establishing new maritime connections between southern Salento (Italy) and Epirus (Greece), thereby enhancing cross-border mobility and fostering regional integration.

Keywords: Sustainable tourism, Regional development, Environmental planning policies, Sustainable transport, Spatial planning, Connectivity

Introduction

Although the past few years have been challenging in terms of liveability in Europe and globally-first due to the COVID-19 pandemic and more recently because of the war in Ukraine, which has deeply affected many-Europe and the world now, more than ever, need to feel connected and united. Sustainable mobility plays a crucial role in fostering this connection. As noted by Fusté-Forné (2021), the COVID-19 pandemic has significantly impacted global travel, posing challenges for sustainable tourism. The economic, sociocultural, and psychological effects on tourism systems are likely to disrupt businesses for years to come. Moreover, environmental considerations are becoming increasingly critical in the tourism sector (Pacheco et al. 2024). The sustainability of tourism systems depends on all elements of their broader environment. This underscores the need for governments and stakeholders to reshape their understanding of tourism, emphasizing ethical, responsible, and sustainable management and marketing strategies (Baloch, 2023). The uneven impacts of climate change across different regions and the crucial role of local responses further highlight the importance of understanding ports and their unique local contexts (Manios et al., 2024). Connective infrastructures that span sovereign borders take on unique characteristics, becoming more than just motorways or high-voltage lines; they function as shared utilities (Khanna, 2016). Regarding the impact of the Ukraine war, the UNWTO reports that Russia and Ukraine accounted for 3% of global spending on international tourism in 2020. Prolonged conflict could result in a loss of up to $14 billion in global tourism receipts by 2022.

More than one-third of EU citizens live and work in EU border regions (European Commission, 2015). Over the past two decades, border regions have gained prominence (Fadigas, 2010, 2015; Castro & Alvarez, 2015; Castanho et al., 2016), with cross-border cooperation (CBC) achieving numerous political, economic, environmental, and sociocultural successes (Nave & Franco, 2021). The concept of cross-border regions and cooperation has become increasingly significant in political and academic discussions across fields such as management, geography, sociology, international relations, and political economy (Medeiros, 2015; Nave & Franco, 2021).

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However, while the permeability of borders facilitates cultural and commercial exchange, it also requires careful management to ensure environmental sustainability, particularly concerning how movements occur between more or less homogeneous areas. A sound conceptual foundation for the methodological approach to connectivity lies in recognizing that transportation systems, as integrated networks at various scales, are transforming their operations and influencing urban and regional development patterns (Castanho et al., 2017; Salov & Semerikova 2024).

Several authors have investigated the impact of transport infrastructure on regional development. However, despite these efforts, no definitive conclusions have been reached (Freiria & Sousa, 2024). Simultaneously, ongoing economic and social crises are encouraging collaborative approaches between countries (IGCC, 2020), influencing policies and processes related to trade and investment, migration, peace and security, regional integration, climate change, food security and the private sector (ECDPM, 2022). Many countries are striving to remove barriers associated with borders to foster integration and territorial cohesion through exponential cross-border movements (Nave & Franco, 2021). Therefore, countries must urgently adopt new strategies and approaches to achieve territorial cohesion and cooperation. Nonetheless, Cross-Border Cooperation remains a complex challenge (Castanho et al., 2016). Recent geopolitical events have revived lingering tensions from the Cold War and the Second World War (Dale, 2016; Holmes, 2016; Wall Street Journal, 2022). Factors such as linguistic, cultural, and socioeconomic differences further hinder cross-border cooperation (European Commission, 2015).

In recent years, countries have increasingly focused on enhancing sustainable mobility, particularly by: (1) Avoiding unnecessary transportation volume (2) Shifting transportation norms and practices (3) Improving the carbon efficiency of transportation systems (Griffiths et al., 2021). Administrative borders also create barriers to cross-border mobility. Efficient cross-border transport is crucial to reducing these barriers, improving citizens' mobility, and increasing the territorial integration of the European Union (EU). Various limitations impede this progress. According to Nijkamp et al. (1990), these include: physical barriers (e.g., mountains, rivers, artificial walls), technical barriers (e.g., incompatibility between railway systems of different countries), cultural, linguistic, and information barriers (e.g., discrepancy between supply and demand), fiscal barriers (e.g., visa costs), and institutional barriers (e.g., costs associated with crossing borders between different jurisdictions).

McGahern (2023) highlights the role of cross-border mobility in addressing diverse travel motivations and gender issues, particularly in the context of Israel. This analysis underscores the importance of the complex

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interconnections between mobility and the capital allocated to transport infrastructure, demonstrating how eliminating these gaps can promote equal and safe mobility. In this sense, sustainable tourism becomes inherently more socially inclusive and culturally open. Tourism development also induces sociocultural and environmental changes in local communities (Ap, 1992; Stylidis et al., 2014). Such transformations underline the need for responsible approaches to tourism that balance its growth with the well-being of host communities.

Literature Review and Hypotheses

Many scholars and institutions have recognized that Cross-Border Cooperation (CBC) projects offer numerous benefits to member states (Yigitcanlar et al. 2015; Castanho et al., 2016). First, they enhance opportunities to improve the quality of life. Second, CBC projects help mitigate the economic decline that many developed countries have faced in recent years (Roy & Ciobotaru, 2023). Third, they facilitate the development of resilient and collaborative border cities (Yang & Guangcheng, 2023).

To build resilient and sustainable cities, urban planners and policymakers have proposed new policy models for greener mobility worldwide (Tammaru et al., 2023). Additionally, scholars identified critical factors for successful CBC projects: (i) the definition of clear, common objectives and master plans; (ii) the promotion of political transparency and commitment to CBC-related decisions; and (iii) the encouragement of connectivity and movement between cities (Castanho et al., 2016). The third factor has guided this research, particularly in developing systemic sustainability solutions in which transport and sustainable mobility play central roles (Yejin & Sugie, 2025). Mobility is generally defined in geographical terms as a “crossing or displacement in space” (Kaufmann 2014; Beylier & Fortuné, 2022). Therefore, the quality and quantity of cross-border (CB) accessibility and transport options are crucial in shaping CB mobility, as they directly influence the number of CB commuters (Medeiros 2019). Although both regions fall within EU jurisdictions, facilitating the movement of people, joint planning—such as the adoption of a Sustainable Mobility Cross-Border Plan—can provide essential guidelines and regulations for fostering economic, environmental, and social sustainability in transport systems. In this context, Rietveld (2012) emphasized the importance of both direct costs (e.g., transport, taxes) and indirect costs (e.g., cultural, institutional, and fiscal differences) associated with border crossings. Schiebel et al. (2015) identified several travel characteristics—such as travel purpose, cost, departure time, distance, duration, travel chain, weather conditions, and interchanges between different modes of transport—as factors influencing citizens' behaviour and choices when crossing borders. Similarly, Rosselló-

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Nadal and Santana-Gallego (2024) analysed the impact of geographical distance on tourism flows, while Errico et al. (2024) highlighted the role of network effects in cross-border mobility.

Medeiros (2010) proposed subdividing the barrier effect into five main dimensions: (i) accessibility; (ii) cultural-social; (iii) environmental-hereditary; (iv) institutional-legal; and (v) economic-technological. Similarly, Wassenberge and Reitel (2015) categorized existing barriers as legal, political, economic, or cultural. This article considers the concept of barriers in terms of accessibility—not to suggest that the analysed areas are currently inaccessible, but to evaluate the potential for achieving more-sustainable accessibility that can contribute to sustainable economic, social, and environmental development. To analyse which barriers persist across EU borders after more than 25 years of EU cross-border cooperation Programmes, the online public consultation on border obstacles (2015–2016) conducted by DG REGIO (EC) revealed that EU citizens consider "legal and administrative" barriers as the primary obstacles to their daily lives when crossing borders. These are followed by language barriers and physical accessibility barriers, including transportation (Medeiros, 2019). The survey highlighted concerns regarding the lack and/or poor quality and security of physical cross-border (CB) infrastructure, the absence of integrated public transport systems at borders, differing rules and standards in transportation, the inadequacy of existing physical CB connections to meet current traffic flows, the low frequency of services, and excessive prices for CB transport connections in many EU border regions (EC, 2016). A Eurobarometer survey on barriers in EU-funded CBC programmes indicated that respondents in Italy reported accessibility-related barriers most frequently.

Keeble et al. (1982) also emphasized the connection between regional accessibility and economic competitiveness. From a governance perspective, the EU has recognized that a well-functioning transport system linking EU member states and neighbouring countries is vital for sustainable economic growth and citizen well-being. According to Dühr et al. (2010), EU transport and infrastructure policy is driven by three main goals: competitiveness, cohesion, and sustainability. Similarly, Knippschild (2011) highlighted that successful cross-border cooperation can drive development in areas such as economic clusters, labour markets, education and training, transport, tourism, and public services. The METIS study (2015) identified six main analytical components related to obstacles in cross-border transport, including road passenger transport and inland waterway ferry services (e.g., transport system quality, connection density).

Sustainable mobility is defined as "achieving an overall volume of physical mobility, modal splits, and transport technologies that efficiently meet basic mobility needs while supporting ecosystem integrity and limiting

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greenhouse gas (GHG) emissions to levels consistent with international sustainable development" (Griffiths et al., 2021). Cars, as part of a socio-technical mobility system, account for approximately 7% of global GHG emissions and more than 50% of total transportation emissions (Victor et al., 2019). Tang et al. (2023) explored the role of air transport in post-pandemic challenges, noting that air routes have a decreasing but positive impact on inbound tourism demand from long-haul markets, though they are less significant for short-haul markets. This analysis underscores the importance of factors beyond transportation in shaping tourism demand (Mazzola et al., 2022).

COVID-19 mitigation measures, such as restrictions on movements and reduced car usage, led to a significant reduction in global CO_2 emissions (Le Quéré et al., 2020). These changes have also influenced social behaviours, transportation patterns, and consumption habits (Wang & Wells, 2020). Many institutions have adopted strategies and green initiatives to promote long-term sustainable urban mobility (Ibold et al., 2020). Several approaches have been proposed to reduce transport demand and car use, improve road networks and vehicle technology, and promote alternative transport modes (Bakker et al., 2014; Marcucci et al., 2019). Holden et al. (2020) presented three "grand narratives" for sustainable mobility:

- Electromobility: Replacing fossil fuel-based vehicles with electric vehicles powered by clean energy.
- Collective Transport 2.0: Expanding public transportation and shared mobility options.
- Low-mobility Societies: Reducing the number and length of trips by cars and planes.

Literature on accessibility performance and indicators, as well as theoretical approaches to interspatial and disaggregated accessibility models, has been further developed by Gattuso and Malara (2018), Thiede et al. (2023), and Hidalgo (2024).

Theoretical Foundation and Hypotheses

Global data suggests that mobility is a significant contributor to CO2 emissions (approximately 25% of the total) and energy consumption (around 20%). However, public authorities and mobility operators often lack the necessary expertise to integrate energy efficiency into mobility planning and investment strategies. Consequently, CO2 emission reductions are frequently excluded from mobility strategies and services. The planning processes often fail to involve key stakeholders—such as service and energy providers, transport operators, and SMEs—or end users directly. Although frameworks like Sustainable Energy Action Plans (SEAPs) and Sustainable Mobility Plans

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(SUMPs) aims to address these criticalities, their practical application and integration into implementation processes remain limited. This results in inadequate promotion and adoption of sustainable mobility models and restricted utilization of related services. This challenges are particularly pronounced in cross-border regions, characterised by fragmented transport systems, poor cooperation, and a lack of synergistic transport planning. There is a pressing need for systemic, integrated, and efficient mobility services along the Adriatic seacoast to mitigate the environmental impacts of mobility activities. This article presents findings from the Cross-Border Sustainable Mobility Plan (CBSMP), developed under the Interreg Greece-Italy cooperation Programme (2014–2020). The CBSMP seeks to enhance public-private cooperation to create a multimodal transport system, particularly for tourism. The plan focuses on improving connections between ports, airports, roads, and cycle paths to cultural and environmental destinations, ensuring service continuity across geographical and temporal dimensions. Stoffelen (2018) highlights the potential of tourism routes—such as hiking and cycling trails—as tools for fostering cross-border cooperation. These routes can utilize existing infrastructure, repurpose abandoned railway tracks, and bring together local stakeholders in collaborative projects, thereby enhancing mobility for both tourists and locals. Tourism, in general, is recognized as one of the most accessible means of establishing cross-border contact.

The starting point of this research is the urgent need to provide systemic sustainability solutions, emphasizing cross-border integration and collaboration, with transport as a central focus. While this challenge exists globally, localized action is essential to guide policies and implement tools effectively. Stoffelen (2018) further emphasises that tourism routes anchored in inclusive decision-making networks can stimulate cooperation and establish linkages between local communities, the tourism industry, and broader economic development.

The research underscores the potential for alternative tourism in the studied areas (Gallipoli in Italy and Thesprotia in Greece), promoting travel as a sustainable experience. However, assessing these destinations currently requires road travel to airports (Brindisi in Apulia and Corfu in Greece) before reaching the final destination, which is both environmentally and economically unsustainable. Encouraging transport intermodality through joint planning is critical in these small but densely populated regions. These areas, despite their sizes, attract significant seasonal tourism, impacting sustainability and liveability.

This article does not aim to innovate the accessibility model but to demonstrate that established models, when applied within a transport convention, can promote sustainable transport in tourist-oriented regions. The Cross-Border Sustainable Mobility Plan facilitates the movement of people

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through sustainable transport modes, highlighting the importance of long-term planning in a sector sensitive to climate change, natural environments, and socio-economic development (Hyytiäinen et al. 2022). The CBSMP aligns with the recommendations of Karim et al. (2024), who stress incorporating natural elements to achieve sustainable goals.

The European Commission recognised this case study's significance, financing it under the Interreg Cooperation Programme. Stoffelen (2018) similarly underscores the role of Interreg projects in enhancing cross-border communication and social cohesion in European borderlands.

The Cross-border Sustainable Mobility Plan (CBSMP) spans South Salento (Apulia region, Italy) and Thesprotia (Epirus region, Greece), drawing from international, national, and local transport plans, particularly SUMPs (Sustainable Urban Mobility Plans). The CBSMP is built on coordinated actions with a focus on tourist mobility, meeting EU, and national regulatory criteria, including:

- A clear vision of objectives shared by European project partners
- A participatory approach involving citizens and stakeholders
- Balanced and integrated transport development favouring sustainable modes such as walking, cycling, and public transport
- A sustainability perspective encompassing economic, social, and environmental dimensions
- Integration with existing spatial and transport planning tools
- Comprehensive assessment of the plan's impacts, particularly its environmental and social benefits.

Theoretical Background

The scenario planning analysis utilized a network model and territorial accessibility indicators, related to the planning area's unique characteristics and the restructured interregional transport services. Although inspired by the principles of Sustainable Urban Mobility Plan (SUMP), the methodology for developing the Cross-Border Plan diverges significantly. Unlike SUMP, which primarily focuses on urban areas, this plan encompasses a broader spatial dimension, targeting the integrated interregional area of South Salento (Apulia Region, Italy) and the province of Thesprotia (Epirus Region, Greece). This model was constructed using context analysis, established transport models, scenario design, and impact assessment.

The scenario design specifically aims to enhance cross-border relations, with particular focus on the tourism sector. Its formulation drew from insights obtained through targeted surveys, communication, and participation activities. The design seeks to offer an alternative transport supply that fosters cross-border effects by addressing the following: facilitating intermodal exchanges via sea routes, improving accessibility to

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urban areas and key tourist sites, and enhancing connections to tourist accommodations. Tourism, as an economic driver, generates a dual on local communities. Positively, it stimulates the development of hotels, transportation networks (both road and air), electricity and internet infrastructure, banking, and other essential services. However, tourism also has adverse social consequences, including: unequal access to essential services, the proliferation of negative societal issues such as prostitution, theft, and illicit trade in cultural heritage, and the uncritical adoption of tourists' lifestyles by local residents, leading to cultural homogenization (Alamineh et al., 2023). Sustainable tourism policies are vital for mitigating these negative effects while maximizing the benefits. The COVID-19 pandemic underscored the need for robust research into the impact of crises on tourism policies, emphasizing the importance of balanced and resilient strategies (Schönherr et al., 2023).

The scenario design was informed by a comprehensive analysis of existing tourist mobility flows and a systemic organization of data regarding the transport supply across the Greek-Italian border. Specific areas of focus included: intermodal transport supply (rationalizing and improving existing transport services, upgrading service quality to meet evolving demands, establishing guidelines and adopting best practices for sustainable transport solutions, etc.), potential demand estimation (assessing the projected demand for passenger mobility, with an emphasis on tourism), and investment cost assessment (conducting approximate evaluations of required investments to implement the proposed scenarios). The cross-border planning area’s structure is illustrated in Figure 1, which presents the road network and the traffic zones, offering a clear depiction of the interregional transport connections and their integration.

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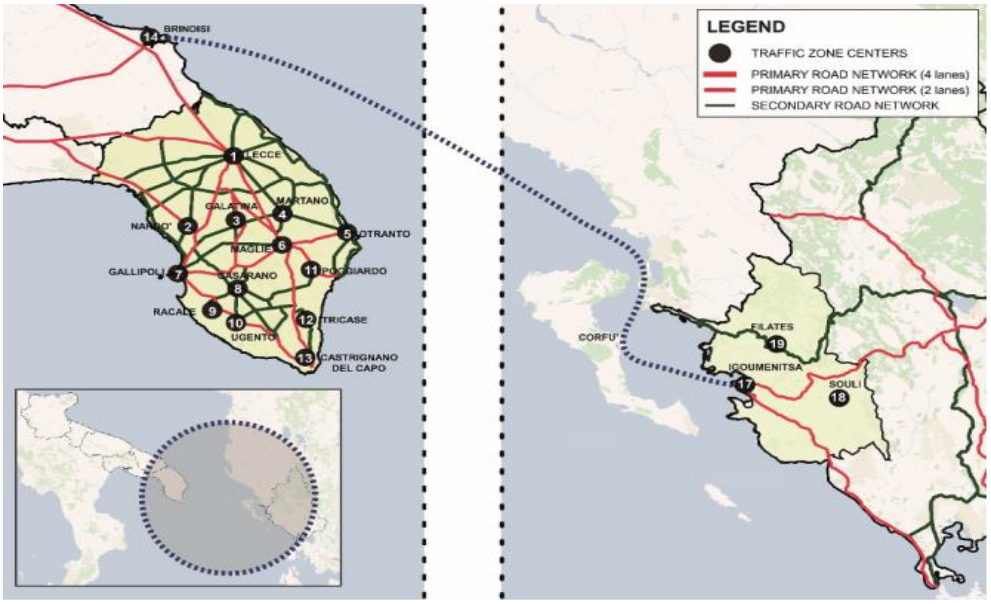

Figure 1. Cross-border Planning Area

Table 1 illustrates some sociodemographic data from the context of the plan. Apulia covers an area approximately twice of Epirus. Its population is much larger (with a ratio of 12:1), resulting in a density five times higher than that of Epirus. A similar ratio is observed at the sub-regional level: South Salento is 1.8 times larger than the regional unit of Thesprotia, but in terms of population, it is 18 times larger. The population density of South Salento is higher than that of the entire Apulia Region, while that of Thesprotia is even lower than that of Epirus.

Table 1. Land use data for the study area

	Area (Km²)	POPULATION (inhabitants)	DENSITY (inh./km²)	MUNICIPALITIES N.
APULIA	19.541	3.991.140	204,25	257
EPIRUS	9.203	336.856	36,60	18
SOUTH SALENTO	2.799	791.122	282,66	96
THESPROTIA	1.515	43.857	28,95	3

Source: 2019 data from the National Institute of Statistics, Italy

To build the current structure of the transport system in the analysis area, the existing plans were analysed, and the main elements were extrapolated and re-elaborated with reference to passenger transport.

Method

The scenario design is based on performance and accessibility indicators. As performance indicators, travel times and monetary costs are

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computed in relation to the network supply. As an accessibility indicator, a mathematical model has been adopted, consisting of generalised cost functions associated with a transport network. Given a spatial system divided into *n* zones and a road network, the matrix of the minimum number of routes can be considered the starting point for accessibility measures.

In interspatial models, mathematical measures of accessibility express the potential of the transport system as functions solely of the travel cost variable. However , experience shows that other factors, linked to the system of local activities, contribute to determining the possibility of travelling between two zones i and j. In this analysis, in addition to various cost factors, accessibility is a key and relevant element that characterises the construction of the impedance function.

Transport impedance is expressed as a linear combination of times and monetary costs, and accessibility takes the following form:

$$A_i = \Sigma_j K_j^{\delta} \exp(\Phi(c_{ij})) \quad (1)$$

Here, $\Phi(c_{ij})$ is an impedance function that usually decreases with the cost c_{ij}. Over the years, different expressions have been used, depending on the author. Among these expressions are the following:

Hansen's expression (1959): $\Phi(c_{ij}) = c_{ij}^{-\alpha}$ (2)

Wilson's expression (1967): $\Phi(c_{ij}) = \exp[-(\beta_1 t_{ij} + \beta_2 cm_{ij})]$ (3)

Ingram's expression (1971): $\Phi(c_{ij}) = \exp(-d_{ij}^2/\Upsilon)$ (4)

Where:
A_i is the weighted accessibility for people living in zone *I* and is related to zones *j* in region *D*;
K_j is a measure of activities and services located in zone *j*;
d_{ij} , t_{ij} , cm_{ij} are measures of costs (distance, travel time, monetary cost);
β, Υ are calibration parameters.

A possible impedance cost function (average utility function) associated with a user departing from zone *i* towards a destination *j* on an interregional transport network (see Figure 2) can be expressed as:

$$V_j = b_0 \log K_j - b_1 c_{ik} - b_2 t_{ik} - b_3 cp_k - b_4 t_{kl} + b_5 f_{kl} - b_1 cf_{kl} - b_1 c_{lj} - b_2 t_{lj} \quad (5)$$

or $$V_j = \log[K_j^{b0} \exp(-b_1 c_{ik} - b_2 t_{ik} - b_3 cp_k - b_4 t_{kl} + b_5 f_{kl} - b_1 cf_{kl} - b_1 c_{lj} - b_2 t_{lj})] \quad (6)$$

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Where:
K_j is an expression of the attractiveness of destination j (e.g., population or touristic accommodation attributes of the destination);
c_{ik} = monetary cost to reach the main node k (e.g., port, airport, or station) of departure (fuel, tolls, public transport fares, etc.);
t_{ik} = travel time to the port/airport/station of origin k (e.g., by private vehicle, public transportation, or multimodal combinations);
c_{pk} = parking fare for a private vehicle adjacent to a port/airport/station at origin k;
f_{kl} = average frequency of flights, ships, or trains between the origin k and destination l (e.g., daily or weekly);
cf_{kl} = average fare for sea/air/rail transport from k to l;
c_{lj} = average fare for maritime/air/rail transport moving from k to l;
t_{lj} = travel time from node l to final destination j (e.g., private vehicle, public transport, or multimodal combinations);
β_n = model parameters.

The travel time components can include penalties for modal transfers, waiting times, and early departures to reduce the risk of missing a connection (e.g., ship, plane, or train).

Accessibility measures that account for multiple transport modes (e.g., car, train, or bus) must weigh the accessibility of individual modes. This can be achieved using the *LogSum formula* (Ben-Akiva et al., 1985):

$$LogSum = log \sum_m exp^{Vm} \tag{7}$$

Where the summation considers all available modes m.

For practical applications of this methodological approach, data collection is necessary, focusing on user times and costs for tourist travel. These data are obtained through typical transport supply analyses (e.g., distances, speeds, energy consumption, parking costs, public transport fares), based on spatial and temporal network designs and information from public and private transport companies. Tourists may travel as single users or as families, which influences the model parameters. Specific values for these parameters can be adopted based on a review of specialized literature.

A Case Study: Gallipoli – Paramythia Accessibility

An application of the modelling tools for accessibility analysis was proposed as a case study in the context of the transborder planning area (Apulia-Epirus), focusing on different multimodal mobility alternatives across

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the Otranto Channel. For computational simplicity, the generalised cost function (average utility function V_j) was adopted as the accessibility measure. The cities of Gallipoli, as the origin, and Paramythia, as a cross-border destination, were used as references, and accessibility was calculated considering the following seven route alternatives (Figure 2) for an ordinary user (a single adult or member of a family of four):

- By car from Gallipoli to Brindisi's port, on a ferry to the port of Igoumenitsa, and by car to Paramythia;
- By car from Gallipoli to Brindisi's port, parking at the port, taking a ferry to the port of Igoumenitsa, and traveling by bus to Paramythia;
- By bus from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and traveling by bus to Paramythia;
- By train from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and traveling by bus to Paramythia;
- By bus from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and traveling by rental car to Paramythia;
- By train from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and traveling by rental car to Paramythia;
- By bike from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and biking to Paramythia.

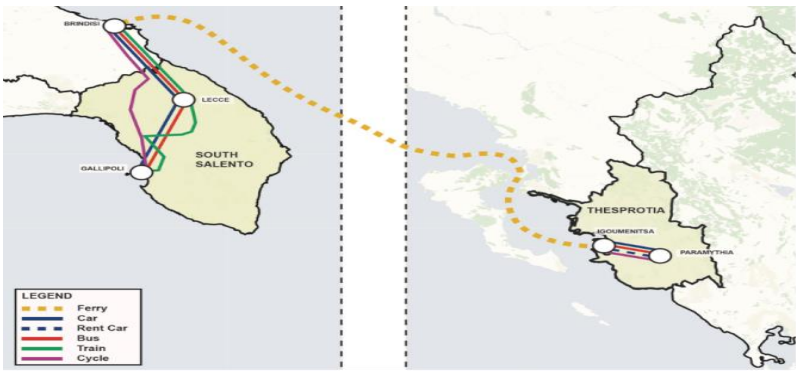

Figure 2. Outline of multimodal routes: Case study on cross-border routes

The results obtained form the basis for subsequent scenario analyses aimed at improving network connections. The following notation has been assumed, with reference to Figure 2, for travel simulation from Gallipoli (Italy) to Paramythia (Greece):
Gallipoli (GAL) = node *i*
Brindisi Port (BRI) = node *k*
Igoumenitsa Port (IGO) = node *l*
Paramythia (PAR) = node *j*
C_{xy} = monetary cost associated with moving from node *x* to node *y*

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T_{xy} = time to move from node *x* to node *y*
$T_{tot} = T_{xy} + T_a$ (where T_a is waiting time)
C_{pk} = parking cost

Assumed Departure Data:

- Distances: Gallipoli-Brindisi 79.8 km; Igoumenitsa - Paramythia 31.9 km
- Partial travel time: Gallipoli-Brindisi 1h 6min, Igoumenitsa - Paramythia 27min
- Average speed: Gallipoli-Brindisi 72.5 km/h, Igoumenitsa - Paramythia 70 km/h
- Energy consumption (litres of fuel): Gallipoli-Brindisi 5.8 L; Igoumenitsa - Paramythia 2.5 L;
- Parking time at the port: 1 week
- Transfer time from the car park to the port: 5min
- Train fare: €7.30 per person
- Gallipoli-Lecce: Salento by bus 52 min, €2.90 per person
- Lecce-Brindisi 40 min, €8.69 per person
- Car rental: € 135 for a week
- Fuel costs: Igoumenitsa - Paramythia € 3.27
- Routes: Suitable for cycling

Summary Overview

The monetary costs and travel times for the Gallipoli-Paramythia route, considering different travel alternatives, are presented in Table 2.

Table 2. Monetary costs and travel times for the Gallipoli-Paramythia route, with different travel alternatives

Travel alternatives	People n.	C_{ij} (€)	T_{ij} (hh:mm)
Travel by own car (small car) for the whole route	1	76,83	12:32
	4	169,83	12:32
2. Gallipoli - Brindisi by car/Igoumenitsa - Paramythia by bus	1	130,56	12:45
	4	238,56	12:45
Gallipoli - Brindisi by train/Igoumenitsa - Paramythia by bus	1	52,20	13:48
	4	181,80	13:48
Gallipoli - Brindisi by bus/Igoumenitsa - Paramythia by bus	1	56,59	13:12
	4	199,36	13:12
Gallipoli - Brindisi by bus/Igoumenitsa - Paramythia by rental car	1	189,86	12:59
	4	317,63	12:59
Gallipoli - Brindisi by train/Igoumenitsa - Paramythia by rental car	4	317,63	12:59
	1	189,86	12:59
Whole journey by bike	1	45,00	17:12
	4	180,00	17:12

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It follows that family (of 4 persons) travel is cheaper in terms of overall impedance, since the monetary cost associated with the use of a shared car is significant. It is also generally more convenient to use public transport (train and bus) for inland travel. The travel time is not significantly different for motorised travel (range of 12:30 - 13:50 hours), as the travel times inland are fairly comparable. The penalties related to the advanced departure times of the ships are of the same order of magnitude. The trip by bike is certainly the cheapest option, but the travel time increases significantly (about 4–5 hours).

The accessibility function is assumed as follows:

$$V_j = b_0 \log K_j - b1\ c_{ik} - b2\ t_{ik} - b3\ cp_k - b4\ t_{kl} + b5\ f_{kl} - b1\ cf_{kl} - b1\ c_{lj} - b2\ t_{lj}$$

With parameters $b0 = 1$, $b1 = 1$, $b2 = 15$ €/h, $b3 = 1$, $b4 = 5$ €/h, $b5 = 5$

With the attractiveness parameter set to the population of the destination city (Thestroptia), where Kj = 7,900 inhabitants, the resulting utilities (accessibility levels) for each alternative multimodal travel to destination j (Paramythia) are calculated. The daily ferry frequency is assumed to be 2, and the accessibility values are expressed in euros.

Table 3. Accessibility for single traveller

Multimodal travel alternatives	V_j
By car for all travel	-141,322
Gallipoli - Brindisi by car, Igoumenitsa - Paramythia by bus	-200,452
Gallipoli - Brindisi by train, Igoumenitsa – Paramythia by bus	-135,152
Gallipoli – Brindisi by bus, Igoumenitsa - Paramythia by bus	-130,092
Gallipoli - Brindisi by bus, Igoumenitsa - Paramythia by rental car	-260,212
Gallipoli - Brindisi by train, Igoumenitsa - Paramythia by rental car	-265,272
Gallipoli - Brindisi by bike, Igoumenitsa - Paramythia by bike	-193,302

Table 4. Accessibility for a traveller as a component of a 4-person family

Multimodal travel alternatives	V_j
By car for all travel	-114,622
Gallipoli - Brindisi by car, Igoumenitsa - Paramythia by bus	-191,452
Gallipoli - Brindisi by train, Igoumenitsa – Paramythia by bus	-128,402
Gallipoli – Brindisi by bus, Igoumenitsa - Paramythia by bus	-123,342
Gallipoli - Brindisi by bus, Igoumenitsa - Paramythia by rental car	-149,752
Gallipoli - Brindisi by train, Igoumenitsa - Paramythia by rental car	-154,810
Gallipoli - Brindisi by bike, Igoumenitsa - Paramythia by bike	-193,302

Looking at Tables 2 and 3, it can be underlined that accessibility values are generally higher for a user travelling with their family, due to the distribution of some monetary cost items (e.g., shared car). Accessibility is greater for users who use public transport or their own car when traveling with their family (Table 4), and for those who use only public transport as well. However, the gap between the values in the tables shows a smaller

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discrepancy, especially in the combination characterised by the use of a train together with the bus. The use of a rental car drastically reduces the accessibility values, especially in Table 3. The use of a car is convenient because travel costs are reduced, particularly in the case of family travel, where the monetary cost is shared. The bike trip occurs in an intermediate position; the lower accessibility compared to the private car is due to the longer travel times (4–5 hours longer).

Special attention should be given to bicycle travel. In both tables, the accessibility value is identical, and from a sustainability perspective, action should be taken on the components that most affect accessibility values. Obviously, the choice of a sustainable means of transportation is influenced by a tourism demand and supply strongly characterised by sustainability features. In summary, the use of rental cars significantly reduces accessibility for both an individual's trip and a family of four individuals (Table 4). This suggests that, in the pursuit of a sustainable vision, policies founded on the empowerment of public transportation and mobility aimed at reducing greenhouse emissions, such as the construction of bicycle lanes, could be key strategic choices.

Two planning scenarios were considered:
A. Same alternative routes to Brindisi-Igoumentisa ferry
B. Alternative routes to Otranto-Igoumentisa ferry

Scenario A, with strengthened connections, reduced the travel times of the same paths:

- The upgrade of the Lecce - Brindisi link (on highway features) translates into a consequent reduction in the travel time by car from 51 to 37 minutes.
- The upgrading of the railway network, in particular the Gallipoli - Lecce section, and the provision of fast regional trains (elimination of 4 stops with low demand) translates into a reduction in travel time from 2 hours and 8 minutes to 1 hour and 52 minutes.
- The improvement of the regional road network travelled by buses (Gallipoli - Lecce section) increases the average transit speed from the current 45.2 km/h to 55 km/h, with a consequent reduction in travel time from 52 to 42 minutes (-10 minutes).
- The use of cycling paths in reserved lanes is considered an improvement proposal, with an average speed increase of 4 km/h (from 14 to 18 Km/h), with a relative reduction in travel time from 5 hours and 12 minutes to 4 hours and 3 minutes.

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Scenario B involves a maritime link by ferries between Otranto and Igoumenista:

- Distance Otranto - Igoumenitsa = 186 km
- Navigation speed = 25 knots (46.3 km/h)
- Travel time at sea = 4 hours
- Average boarding waiting time = 2 hours
- Time for access/egress, modal shift = 1 hour
- Total time: 7 hours
- Rate: 30 €/person; 100 €/car

It is also assumed that the Gallipoli - Otranto connections will be strengthened, leading to a consequent reduction in travel times.

- Gallipoli-Maglie section (32.1 km in 38 minutes): hypothesis of a fast and direct connection of about 34 km with an increase in the average speed from 51 to 90 km/h.
- Cycling lanes in separate lanes, with an increase in average speed from 14 km/h to 18 km/h, and a reduction in travel time from 3 hours and 25 minutes to 3 hours.
- In relation to the strengthening of the direct section between Gallipoli and Maglie (34 km), which is covered in about 29 minutes, and considering the Maglie - Otranto section (16.8 km) which is covered in 14 minutes, this results in a bus travel time of 43 minutes in total.

Table 5 presents the total travel costs and times between the two terminal sites. Compared with the current scenario, monetary costs are slightly reduced in the first scenario (range of 4-12%), substantially in the second scenario (range of 8-37%). The greatest reductions in percentage terms were found on routes with bicycles and cars.

Time costs are reduced by the order of 2-10% in Scenario A, and by a range of 25-37% in Scenario B. In the first, the biggest reductions are related to alternatives 5 (with bus in Apulia and car rental in Thesprotia) and 7 (travel by bike). In Scenario B, alternatives 5 (with bus in Apulia and car rental in Thesprotia), 4 (bus in both regions), 1, and 2 (use of own car) are registered.

Table 5. Monetary costs and travel times for the Gallipoli-Paramythia route, with different travel alternatives

		Current Scenario		**Future Scenario A**		**Future Scenario B**	
ALT.	**People**	**C_{ij} (€)**	**T_{ij} (hh:mm)**	**C_{ij} (€)**	**T_{ij} (hh:mm)**	**C_{ij} (€)**	**T_{ij} (hh:mm)**
1	1	76,83	12:32	70,83	12:19	48,32	8:07
	4	169,83	12:32	150,83	12:19	108,32	8:07
2	1	130,56	12:45	125,56	12:31	100,05	8:20
	4	238,56	12:45	225,56	12:31	205,05	8:20

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3	1 4	52,20 181,80	13:48 13:48	47,20 168,80	13:32 13:32	40,00 160,00	9:40 9:40
4	1 4	56,59 199,36	13:12 13:12	51,59 186,36	12:57 12:57	41,00 164,00	8:23 8:23
5	1 4	189,86 317,63	12:59 12:59	184,86 304,63	11:44 11:44	174,27 282,27	8:10 8:10
6	1 4	189,86 317,63	12:59 12:59	180,47 287,07	13:19 13:19	173,27 278,27	9:27 9:27
7	1 4	45,00 180,00	17:12 17:12	40,00 160,00	16,03 16,03	30,00 120,00	12:17 12:17

Table 6 lists the synthetic "generalised cost" indicator of travel between Gallipoli and Thesprotia. The greatest reductions in generalized cost are recorded for an average family user.

In Scenario A, the greatest benefits are observed for: Alternative 5 (46.2%) with a bus in Apulia and car rental in Thesprotia; Alternative 6 (41.5%) with a train in Apulia and car rental in Thesprotia; Alternative 2 (37.9%) with a car in Apulia and a bus in Thesprotia. In Scenario B, the following alternatives show reduction in generalized cost: Alternative 5 (59.5%) with a bus in Apulia and car rental in Thesprotia; Alternative 4 (55%) with a bus in both regions; Alternative 1 (54.9%) and 2 (55, 9%) with the use of their own car, and generally, the values stand at high levels (47-60%).

Table 6. Generalised transport cost

		Current Scenario (C)	**Future Scenario (A)**	**Future Scenario (B)**		
ALT.	**People**	**GC_{ij} (€)**	**GC_{ij} (€)**	**GC_{ij} (€)**	**Δ % (C-A)**	**Δ % (C-B)**
1	I FC	139,33 104,96	132,33 99,21	88,87 47,32	5,02 5,48	36,22 54,92
2	I FC	194,31 123,39	188,06 76,60	141,70 54,47	3,22 37,92	27,08 55,86
3	I FC	117,60 110,85	109,85 73,20	88,35 58,40	6,59 33,96	24,87 47,32
4	I FC	122,59 115,84	116,34 76,40	82,90 52,15	5,10 34,05	32,38 54,98
5	I FC	254,86 144,41	243,51 77,69	215,12 58,49	4,45 46,20	15,59 59,50
6	I FC	254,86 144,41	247,02 84,49	220,52 64,64	3,08 41,49	13,47 55,24
7	I FC	131,00 131,00	120,25 90,25	91,40 68,90	8,21 31,11	30,23 47,40

I = Individual; FC = Family component

In terms of accessibility, Scenario A shows a slight improvement compared to the current state, with gains ranging from 3% to 12%, particularly in the case of mobility by bike (alternative 7). In Scenario B, the

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accessibility gain becomes much more significant, ranging between 21% and 38%. The most effective alternatives are 1 (own car) and 4 (all bus), while alternative 7 (bike trip) shows a significant improvement (+32.6%).

Table 7. Accessibility (V_j) of scenario alternatives: Family component

Alternative	Current Scenario (C)	Future Scenario (A)	Future Scenario (B)	Δ % (C-A)	Δ % (C-B)
1.	-114,62	-107,42	-71,22	6,3	37,9
2.	-191,45	-185,30	-136,10	3,2	28,9
3.	-128,40	-121,25	-97,00	5,6	24,5
4.	-123,34	-116,79	-77,80	5,3	36,9
5.	-149,75	-143,20	-104,21	4,4	30,4
6.	-154,81	-147,66	-122,41	4,6	20,9
7.	-193,30	-170,30	-130,30	11,9	32,6

Ultimately, it can be concluded that:

a. In both scenarios of the plan, the accessibility of cross-border route increases.
b. The most significant results for accessibility are found in the plan scenario with greater investment commitment (Scenario B, strategic), with increases between 21% and 38% compared to the current state.
c. In terms of generalised transport cost, results similar to points a) and b) are found; but with more marked percentage variations, particularly with percentage variations compared to the current scenario in a range between 47% and 60%.
d. The most effective alternatives in terms of both generalised cost and accessibility are 1 (own car) and 4 (all bus), especially with group travel (family).
e. The competitive advantage of travel alternatives 1 and 4 is amplified in Scenarios B; however, the cycling alternative gains importance.

Discussion

It is recognized that both the transport and tourism sectors and their interactions are problematic. Each sector has rising emissions, weak responses reliant on technological innovation, and is locked into mind sets that perpetuate business-as-usual, characterised by exponential growth. Coupled with issues of global climate change are more localised issues such as urban air pollution, with some research suggesting that while tourism-transport contribute to emissions, air pollution might also reduce tourism activities as destinations become less appealing (Hopkins, 2020; Rosselló-Nadal & Santana-Gallego, 2024). Nevertheless, some solutions can be implemented, and the following suggestions are provided for policy makers.

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Transport Field

Concerning connectivity and multimodal transport, the following actions could be considered.

- Enhancement of the current connectivity. This will aim at increasing the flow of passengers among the areas, which can be achieved by increasing the number of scheduled trips that can operate for more months of the year. This can also apply to the operations of the ports and airports in the area. This factor will work together with other actions to promote tourism and other forms of tourism that can occur year-round, as mentioned in more detail below. This can be achieved using the following actions:
  - Increased frequency of ferry lines among project areas (GR-IT).
  - Increased frequency of flights from neighbouring airports of Ioannina and Aktio (also seek the potential of seaplane flights among the project areas).
  - Use of neighbouring sea and land Trans-European Transport Networks (connection of Italian ports with neighbouring Greek ports).
  - Seek the potential of seaplane flights within the project areas.
  - Creation of cycling routes linked to a cross-border network of cycling routes planned based on common specifications for the Plan areas (linked to the project).

- Enhance multimodal transport in project areas. This can be achieved through several actions and activities, including the following:
  - Activities that reduce the transport intensity of the economy.
  - Promote better organisation of transport services (e.g., the degree of use of logistics and intelligent technologies, especially traffic management technologies, and the organisation of last-mile transport).
  - Modernisation and creation of new railways, especially in Thesprotia, to connect the area to the rest of the network and to waterways.
  - Reductions in train journey times increase the competitiveness of rail transport compared to other less environmentally friendly modes of transport.
  - Improving the technical solutions for vehicles (powertrain and fuel) and infrastructure.

Tourism and the Environment

Concerning tourism and the environment (promotion of sustainable tourism destinations), the following actions have been considered:

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- Promotion of alternative forms of tourism enables increased tourist flow throughout the year. Such actions are also aligned with national policies and will contribute to the economic growth of the planning area in a sector that remains important and has considerable potential. Nature offers the opportunity to develop forms of tourism such as cycling, hiking, horseback riding, boating, and canoeing.
- Measures to protect the natural environment and areas of cultural importance. This can also be achieved through various projects or related actions. RDP programmes and other related sources offer significant potential.
- Promoting sustainable tourism enhances the idea of safe destinations. Sustainable tourism is also linked to safe experiences. Additionally, the promotion of tourist destinations will be linked to alternative forms of tourism, as previously mentioned. The role of tourist accommodation and services is crucial at this stage. It will not only include monuments and sites of touristic importance but also the services provided by the hotel sector, restaurants, and coffee shops in terms of safety regulations.
- Enhanced use of digital technologies. Digitalisation and the wider use of social media and apps will continue to play a key role in this context. Considering the previous case, it is assumed that passengers have learned to manage their trips in detail, with all the tools and information needed to do so.
- Networking among stakeholders in the planning area and sharing of best practises. Sustainable tourism development requires informed participation by all relevant stakeholders and strong political leadership to ensure broad participation and consensus building. Achieving sustainable tourism is a continuous process that requires constant monitoring of impacts, and the introduction of necessary preventive and/or corrective measures whenever necessary.

Conclusion

In the context of the Interreg cooperation programme Italy-Greece (2014-2020), one of the objectives was the development of a cross-border plan for sustainable mobility. Travel alternatives between southern Italy (Salento) and Greece (Epirus) were analysed to verify more sustainable travel modes between the two areas. The aim was to stimulate a sustainability sphere related to transport, one of the most polluting assets globally, and to assess the potential of an agreed and shared cross-border plan.

The results present accessibility indices and multimodal travel alternatives between the two areas for a single traveller and an average family of four, outlining three different development scenarios for the multimodal

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transport system in the planning area (passive, proactive future, and reactive future scenarios). The proactive scenario is seen as the most realistic and immediate solution, while the reactive scenario is considered the most innovative and ambitious.

To stimulate the development of sustainable tourism in the identified areas, more concerted actions should be envisioned, both in terms of transport and tourism. Specifically, it would be beneficial to increase the current multimodal connectivity between the areas by strengthening maritime and seaplane connections. The creation of cycling routes on both sides, linked to a cross-border network of cycling routes, should also be considered, with common specifications for the plan areas. In this regard, the modernisation and creation of new railways, especially in the Thesprotia area, should be planned, with the goal of connecting the area to broader network and waterways, supported by advanced technological solutions. These measures should be complemented by the promotion of alternative forms of tourism to encourage deseasonalisation. Increased accessibility fosters mobility, translating into social and economic benefits for local communities. Being more easily accessible from the outside and more connected to each other, the regions can expect more incoming tourism and increased reciprocal exchange flows. The future perspective of the research recommends a systemic vision, considering the most recent results from the Adriatic-Ionian Macro-regional Strategy and the latest projects financed by directly managed programmes. These should be integrated with tools for mainstream and local planning to provide operational support to local policymakers in the fields of tourism and sustainable transport.

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Inteligencia artificial y la gestión del talento humano en Chihuahua, su impacto y consecuencias

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Resumen

El máximo potencial de la inteligencia artificial (IA) se logra fusionando la creatividad y la empatía del talento humano, con la innovación tecnológica. El objetivo del estudio fue analizar la forma en que se puede integrar la inteligencia artificial (IA) en la gestión del talento humano, con especial atención a las pequeñas y medianas empresas (PyMEs) en Chihuahua, Chih. México. Fue una investigación cualitativa, transeccional-descriptiva, con fuerte enfoque documental. Se enmarca en el contexto de la Industria 4.0, caracterizada por la adopción de tecnologías avanzadas como el Internet de las Cosas (IoT), el *Big Data* y las medidas de ciberseguridad, que han transformado los procesos de negocio; a pesar de los desafíos relacionados con recursos limitados, barreras culturales y altos costos de implementación, la inteligencia artificial (IA) es una herramienta estratégica para optimizar la eficiencia y optimizar la toma de decisiones. Entre los principales resultados, se destaca que la integración conjunta entre tecnología y talento humano es clave para promover la competitividad y la sostenibilidad, destacando la importancia de la capacitación de los empleados y el diseño de estrategias que equilibren la innovación tecnológica y la estabilidad laboral.

Palabras clave: Industria 4.0, inteligencia artificial (IA), Talento Humano

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Artificial intelligence and human talent management in Chihuahua, its impact and consequences

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Abstract

The maximum potential of artificial intelligence (AI) is achieved by merging the creativity and empathy of human talent with technological innovation. The aim of the study was to analyze how artificial intelligence (AI) can be integrated into human talent management, with special attention to small and medium-sized enterprises (SMEs) in Chihuahua, Chih. Mexico. It was a qualitative, cross-sectional-descriptive research, with a strong documentary focus. It is framed in the context of Industry 4.0, characterized by the adoption of advanced technologies such as the Internet of Things (IoT), Big Data, and cybersecurity measures, which have transformed business processes; despite the challenges related to limited resources, cultural barriers and high implementation costs, AI is a strategic tool to optimize efficiency and optimize decision making. Among the main results, it is highlighted that the joint integration between technology and human talent is key to promoting competitiveness and sustainability, highlighting the importance of employee training and the design of strategies that balance technological innovation and job stability.

Keywords: Industry 4.0, Artificial Intelligence, Human Talent

Introduction

El máximo potencial de la inteligencia artificial (IA) se logra fusionando la creatividad y la empatía del talento humano, con la innovación tecnológica El objetivo del estudio fue analizar la forma en que se puede integrar la inteligencia artificial (IA) en la gestión del talento humano, con especial atención a las pequeñas y medianas empresas (PyMEs) en Chihuahua, Chih. México. El eje principal se centra en detectar estrategias que maximicen las habilidades de ambos, creando sinergias que favorezcan el desarrollo sostenible y competitivo de las pequeñas y medianas empresas (PyMEs) en Chihuahua, Chih., México.

Mediante un análisis exhaustivo, se pretende no solo entender los retos que surgen de la incorporación de la inteligencia artificial (IA) en los procedimientos organizacionales, sino también presentar observaciones y

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recomendaciones prácticas para un uso eficiente de los recursos disponibles. La investigación discute aspectos fundamentales como la formación del personal, la adaptación cultural a tecnologías emergentes y el impacto social y económico de la inteligencia artificial (IA) en las PyMEs; asimismo, determinar cómo estas interacciones pueden impulsar la innovación, mejorar la toma de decisiones y aumentar la productividad, contribuyendo a la consolidación de las PyMEs como pilares esenciales de la economía local y regional.

Así, la investigación busca no solo proporcionar soluciones viables a corto plazo, sino también establecer las bases para un modelo sostenible de adopción de tecnología que tenga en cuenta las características del entorno empresarial de Chihuahua y fomente un equilibrio entre el avance tecnológico y el desarrollo humano.

Los avances tecnológicos han provocado cambios drásticos en el ámbito empresarial, destacando la Industria 4.0 como un modelo que incorpora el Internet de las Cosas (IoT) y la inteligencia artificial (IA); estas innovaciones han transformado globalmente los procesos, haciendo que la inteligencia artificial (IA) evolucione de ser una herramienta hipotética a una realidad concreta que desempeña un papel crucial en los negocios; presentando tanto retos como oportunidades para las pequeñas y medianas empresas (PyMEs). En este contexto, las PyMEs del sector servicios en Chihuahua también deben adaptarse a una economía digitalizada, donde la innovación y la eficiencia son esenciales para mantener su competitividad y alcanzar sus metas.

En México, el proceso de adopción de tecnologías basadas en inteligencia artificial (IA) se halla en una fase de transición, con un crecimiento en sectores como el turismo, el comercio minorista y la agricultura (Duran Mena, 2024). A pesar del claro potencial de estas tecnologías, su implementación trae consigo desafíos, sobre todo en la interacción entre la inteligencia artificial (IA) y el talento humano. Siendo pilares esenciales de la economía, las PyMEs del sector servicios tienen que lograr un equilibrio que permita integrar la automatización junto con la conservación y desarrollo del capital humano (Canossa Montes de Oca & Peraza Villarreal, 2023).

Métodos

La investigación tiene un enfoque cualitativo, lo que conlleva una interpretación y análisis sistemático de información extraídos de las fuentes seleccionadas dentro del periodo mencionado. Se dio prioridad a la inclusión de artículos científicos y estudios académicos publicados en los últimos cinco años, complementando el proceso con la lectura detallada y el rastreo de las referencias bibliográficas incluidas en dichos documentos, con el fin de enriquecer y ampliar la comprensión de los temas tratados.

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La revisión de la literatura llevada a cabo en esta investigación es de tipo descriptivo, enfocándose en identificar, organizar y analizar información relevante sobre los temas investigados. Para su desarrollo, se consultaron varias bases de datos de artículos científicos, incluyendo plataformas reconocidas como Google Scholar, Scopus y otras fuentes confiables, durante el periodo de enero a octubre de 2024.

Este enfoque metodológico garantiza una revisión minuciosa y confiable, proporcionando un marco teórico sólido para abordar las preguntas de investigación y establecer las bases para el análisis de la interacción entre inteligencia artificial (IA) y talento humano en el contexto de la Industria 4.0. La combinación de diversas fuentes, métodos y un marco temporal definido permitió no solo identificar tendencias actuales, sino también resaltar las brechas de conocimiento y oportunidades de investigación futuras.

Discusión y Resultados

Industria 4.0

El término Industria 4.0, introducido por el gobierno alemán en 2010, se refiere a un modelo de producción en el que todos los procesos están conectados a través del Internet de las cosas (IoT) (Sniderman & Cootteleer, 2017); esta revolución se fundamenta en la digitalización de los procesos mediante la interacción entre la inteligencia artificial (IA) y el talento humano, optimizando recursos a través de métodos eficaces (Sniderman & Cootteleer, 2017).

Desde la primera revolución industrial, la tecnología ha sido clave para la industria manufacturera, transformando la producción, haciendo más eficientes los procesos y generando empleo en diversos sectores. Ideas como *Business Intelligence, Big Data, RFID* (Identificación por Radiofrecuencia) y técnicas de *merchandising* en puntos de venta han tenido un impacto considerable, sobre todo en las áreas automotriz y de distribución. Estos sectores han adoptado la filosofía de "adaptarse o morir" para cumplir con las crecientes demandas de los consumidores (Quiroga Peralta et al., 2024).

La Industria 4.0 abarca actividades como: automatización de procesos, optimización de la cadena de suministro y control de calidad, entre otras; todo ello con el objetivo de garantizar la profesionalización de los servicios y la satisfacción del cliente, fomentando la integración económica y la creación de nuevos nichos (Ramirez Silva, 2021).

México, como parte de esta transformación, alberga más de cuatro millones de PyMEs, que representan el 72% del empleo y contribuyen con el 52% del Producto Interno Bruto (PIB) nacional. Estas empresas son fundamentales para la competitividad del país, atrayendo inversiones y fortaleciendo diversas industrias; sin embargo, enfrenta desafíos para avanzar

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en esta evolución, lo que motiva a las PyMEs a implementar estrategias de innovación y mejora.

De acuerdo con la Encuesta Nacional sobre Productividad y Competitividad de las Micro, Pequeñas y Medianas Empresas, elaborada por el INEGI, el INADEM y Bancomext, más del 40% de las medianas compañías en México consideran realizar mejoras en sus procesos como una forma de prepararse adecuadamente y aumentar su competitividad (INEGI, INADEM, Bancomext. 2017).

Las pequeñas y medianas empresas (PyMEs) en México se enfrentan a diversos retos que complican su desarrollo y capacidad para competir a nivel internacional; entre los principales obstáculos se destacan (Manyika et al., 2017):

- **Acceso restringido al financiamiento**: Muchos emprendedores enfrentan dificultades para conseguir crédito y recursos financieros, lo que limita su habilidad para invertir en innovación y expansión.
- **Carencia de infraestructura y tecnología:** La infraestructura deficiente en distintas regiones del país y la escasa adopción de nuevas tecnologías afectan la eficiencia y la competitividad de las PyMEs en México.
- **Burocracia y regulaciones:** La complejidad y los costos elevados relacionados con el cumplimiento de las normativas fiscales y laborales representan desafíos significativos para las PyMEs, en particular para las más pequeñas, que a menudo carecen de los recursos necesarios para satisfacer todos los requerimientos.
- **Competencia internacional:** La globalización y la apertura de mercados han expuesto a las PyMEs mexicanas a una competencia más intensa a nivel mundial, especialmente de empresas extranjeras que pueden ofrecer productos a precios más bajos gracias a economías de escala.

Para enfrentar estos retos, las PyMEs en México han comenzado a implementar estrategias de innovación y mejora; estas abarcan (Secretaría de Economía de México 2020):

- **Digitalización de procesos:** Un gran número de PyMEs está dedicando recursos a la digitalización de sus operaciones, desde la adopción de software de gestión empresarial hasta la creación de plataformas de comercio electrónico; esto les ayuda a ser más eficientes, reducir gastos y acceder a un mercado más amplio.
- **Mejora continua y capacitación:** La formación continua de su personal y la optimización de los procesos internos son cruciales para aumentar la competitividad; en este ámbito, la aplicación de modelos

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como Lean *Manufacturing* o la metodología *Six Sigma* ha permitido a muchas empresas mejorar la utilización de sus recursos y reducir desperdicios.

- **Innovación en productos y servicios:** Las PyMEs están enfocándose en desarrollar nuevos productos o en optimizar los ya existentes, atendiendo así las cambiantes demandas de los consumidores; la innovación también puede incluir la diversificación de productos, lo que facilita a las empresas entrar en nuevos segmentos de mercado.
- **Alianzas estratégicas:** Algunas PyMEs han optado por establecer alianzas estratégicas con otras empresas, universidades o centros de investigación para obtener acceso a nuevas tecnologías y mercados; estas colaboraciones les permiten compartir riesgos y recursos, así como ampliar su potencial de innovación.

Inteligencia Artificial

La tecnología ha jugado un papel crucial en las actividades humanas, sobre todo en el sector empresarial, donde su relevancia se encuentra en la capacidad de hacer que las organizaciones sean más eficientes y competitivas; entre estas herramientas, la inteligencia artificial (IA) resalta como una de las más importantes, aplicándose incluso en campos como la gestión del talento humano, no obstante, su definición ha sido motivo de discusión. Jerry Kaplan, en su libro "*La Inteligencia Artificial. Lo que todo el mundo debe saber"*, resalta las dificultades para definir el término debido a su ambigüedad (Kaplan, 2017).

El concepto de inteligencia artificial (IA), que fue introducido en 1965 por John McCarthy en una conferencia en la Universidad de Dartmouth, hace referencia al diseño de máquinas capaces de realizar tareas que serían consideradas inteligentes si las llevara a cabo un ser humano. La IA es la capacidad de un sistema para replicar procesos mentales humanos, abarcando la creatividad y el análisis complejo, mediante procesos de aprendizaje y autocorrección (López de Mántaras, 2018).

Russell y Norving (2008) caracterizan la inteligencia artificial (IA) como un sistema creado para pensar y llevar a cabo tareas específicas. Sin embargo, advierten que no siempre es posible llegar a inferencias correctas, especialmente en escenarios ambiguos, donde las decisiones deben basarse en diferentes perspectivas; estos autores subrayan el interés de la IA en responder eficazmente a variados estímulos.

McCarthy (2007) define la IA como la ciencia y la ingeniería que se dedica a la creación de dispositivos inteligentes, centrándose en emplear computadores para entender la inteligencia humana, sin limitarse a métodos que sean biológicamente observables.

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Por otro lado, Nilsson (2005) menciona que la inteligencia artificial (IA) investiga el comportamiento inteligente de las máquinas en tareas específicas, mientras que Minsky (1998) propuso que, aunque no se comprenda completamente el funcionamiento del cerebro humano, es posible desarrollar sistemas que imiten sus capacidades.

Otros académicos, como Shirai Tsujii (1987) argumenta que la finalidad de la inteligencia artificial (IA) es crear computadoras que puedan llevar a cabo funciones propias del ser humano. Por otro lado, la Comisión Europea la define como sistemas que tienen la capacidad de evaluar su entorno, operar de manera independiente y lograr objetivos concretos (López de Mántaras, 2018). Los especialistas en esta tecnología intentan alinear los diferentes conceptos de inteligencia artificial, detallando estas definiciones en la Tabla 1, donde se resumen las propuestas de los autores previamente mencionados.

Tabla 1. Definiciones de Inteligencia Artificial por diversos autores

AUTOR	DEFINICIÓN
John McCarthy (2007)	Hacer que una máquina se comporte de formas que serían llamadas inteligentes si un ser humano hiciera eso.
Russell y Norving (2008)	Sistema inteligente determinado por el enfoque de pensar racionalmente y construido para hacer inferencias correctas.
Nils Nilsson (2005)	Estudio del comportamiento inteligente en las máquinas.
Shirai & Tsujii (1987)	El objetivo de la investigación sobre inteligencia artificial es conseguir que un ordenador llegue a realizar las importantes funciones de la inteligencia humana.

Fuentes: Integración del autor de diversas fuentes

Es importante resaltar que la Inteligencia Artificial es el área científica de la informática que se enfoca en el desarrollo de programas y mecanismos que pueden demostrar procedimientos considerados inteligentes; en otras palabras, la inteligencia artificial (IA) es el concepto que establece que “las máquinas piensan como humanos” (Duran Mena, 2024).

Generalmente, un sistema de IA tiene la capacidad de analizar grandes volúmenes de datos *(big data)*, identificar patrones y tendencias, y así hacer predicciones de manera instintiva, rápida y precisa (Garcia Mogollon & Malagon Saenz, 2021).

Talento Humano

La administración del talento humano se considera una tarea esencial en las organizaciones, centrada en planificar, retener, supervisar y fomentar las habilidades de los miembros de la empresa: para ello, se llevan a cabo actividades como el análisis y definición de roles, procesos de reclutamiento, selección, contratación, inducción y estrategias de motivación, así como la evaluación del desempeño, incentivos y el fortalecimiento de la cultura

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organizacional, el liderazgo y el desarrollo de competencias blandas (Canossa Montes de Oca & Peraza Villarreal, 2023).

A diferencia de la administración, la gestión implica la aplicación práctica de estos conceptos en las actividades diarias; en este contexto, la gestión del talento humano engloba un conjunto de procesos que buscan optimizar el capital humano de las organizaciones, mediante el desarrollo y fortalecimiento de las habilidades y capacidades tanto blandas como técnicas de los colaboradores (Canossa Montes de Oca & Peraza Villarreal, 2023).

La inteligencia artificial (IA), al permitir que las máquinas reproduzcan ciertas habilidades humanas, ha demostrado ser una herramienta clave para las empresas. Su implementación en la gestión del talento humano aumenta la productividad, el control y la seguridad, además de mejorar flujos de trabajo y optimizar diversas actividades que pueden beneficiarse de tecnologías relacionadas con la inteligencia artificial (IA) (Canossa Montes de Oca & Peraza Villarreal, 2023).

La Revolución Industrial 4.0 ha acelerado el progreso y el uso de la inteligencia artificial (IA), que debe incorporarse en los procesos de negocio y educativos para facilitar el desarrollo del talento humano y sus habilidades; esto implica la combinación de conocimientos, destrezas, experiencias y actitudes necesarias tanto en la vida profesional como en el ámbito laboral; en este contexto, es fundamental ajustar los sistemas educativos y los modelos de formación a los desafíos de la era actual. Además, las empresas deben adaptarse a la Revolución 4.0 y la implementación de la inteligencia artificial (IA) para proporcionar elementos formativos que fomenten tanto la innovación como la preparación de los empleados ante los desafíos actuales (Rodríguez-Alegre et al., 2021).

Las principales barreras que impiden la aceptación de la inteligencia artificial son el desconocimiento que tienen las empresas sobre estos productos y servicios, la falta de inversión necesaria y el retorno de inversión a largo plazo; si bien existe interés por parte de las empresas en adquirir bienes y/o servicios basados en inteligencia artificial (IA) el elevado costo de estos productos resulta un obstáculo, especialmente para las micro y pequeñas empresas, lo cual limita su adopción y uso de la tecnología, así como la actualización comercial, la competencia, el manejo de la información y el costo de implementar servicios de inteligencia artificial (Sanchez Brito 2024).

La inteligencia artificial (IA) en Chihuahua presenta enormes oportunidades para el crecimiento, pero este debe ir acompañado del desarrollo del talento humano. Si se consigue unir la innovación tecnológica con una inversión en educación y bienestar laboral, podemos crear un entorno en el que la tecnología y el talento humano colaboren para mejorar la calidad de vida.

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Derivado del análisis sobre la implementación de la inteligencia artificial, el efecto en el talento humano y su conexión con teorías administrativas se puede concluir que:

- **Teoría General de Sistemas (TGS):** Todo está interconectado; si el *chatbot* optimiza la atención al cliente, los empleados pueden enfocarse en actividades estratégicas, lo que refuerza la competitividad del sistema en su totalidad.
- **Teoría de Sistemas:** Las empresas funcionan como flujos dinámicos de recursos: reciben insumos (tecnología, datos, habilidades humanas), son gestionados y producen productos o servicios mejorados; sin embargo, el ciclo no se detiene ahí: los resultados se evalúan y contribuyen a futuras mejoras.
- **Teoría de la Contingencia:** Cada empresa es diferente, y lo que funciona para una puede no ser lo más adecuado para otra. En este ámbito, las PyMEs enfrentan obstáculos culturales y económicos. No tiene sentido implementar una solución tecnológica compleja si la empresa no está preparada.
- **Teoría X-Y:** El éxito de cualquier cambio, incluida la digitalización, depende en gran medida de cómo los líderes perciben a sus empleados; esto genera un ambiente de desconfianza que provoca resistencia al cambio y, por lo tanto, fallos en las operaciones.
- **Teoría del Caos:** La adopción de nuevas tecnologías puede resultar confusa en un principio: pueden surgir problemas inesperados, algunos empleados pueden sentirse desubicados, y los clientes pueden tardar en adaptarse a estas nuevas herramientas debido a su falta de familiaridad; sin embargo, la teoría del caos nos enseña que, dentro de este aparente desorden, hay oportunidades para innovar y crecer.

Cada una de estas teorías reafirma que la integración de la inteligencia artificial (IA) no debe verse como una simple "solución tecnológica", sino como un proceso esencialmente humano que facilita las operaciones y procesos de las empresas, y que puede conducir a un gran desarrollo. Las empresas no son solo máquinas o números: están compuestas por personas que colaboran para lograr algo más productivo y, junto con la tecnología, llevar más allá del simple objetivo comercial.

Una de las principales preocupaciones de los trabajadores es el temor a la pérdida de sus empleos debido a la implementación de esta tecnología. Sin embargo, hay teorías sobre la interacción entre humanos y máquinas que resaltan la importancia de capacitar y preparar al personal para alcanzar una integración efectiva entre estos dos componentes vitales de las empresas, permitiendo así cumplir tanto con los objetivos empresariales como con las necesidades de las personas.

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Entidades Productivas en Chihuahua

Las micro, pequeñas y medianas empresas (MiPyMEs) constituyen el núcleo de la economía en Chihuahua. Según el DENUE, hasta 2024 se registraron aproximadamente 142,000 unidades económicas en el estado, clasificadas como sigue: Microempresas: 129,798 unidades (91.4%); Pequeñas empresas: 9,318 unidades (6.6%); y, Medianas empresas: 2,205 unidades (1.5%), quienes están distribuidas principalmente en actividades comerciales, de servicios y manufactura (INEGI Instituto Nacional de Estadística y Geografía 2024).

Según un estudio llevado a cabo por la Universidad Tecnológica de Chihuahua, la percepción del uso de herramientas de IA en las empresas es la siguiente: el 53% lo ve como una ventaja competitiva, el 41% considera que su impacto es moderado, y un 6% no nota ningún impacto. Además, un 34% de las empresas afirma que la implementación de inteligencia artificial les ayuda a aumentar su competitividad en el mercado, un 24% busca optimizar sus operaciones, el 22% cree que puede ser más eficiente en la utilización de sus recursos, y un 20% señala que logra mantener una mejor relación con sus clientes (Andew Sotelo et al., 2024).

Los beneficios que la inteligencia artificial ofrece a las empresas, según su clasificación, muestran que, en las medianas empresas, el 30% reporta un aumento en la competitividad en el mercado, un 23% indica la optimización de sus actividades, otro 23% destaca una mayor eficiencia en el uso de los recursos, y el 21% menciona una mejor relación con los clientes. En el caso de las pequeñas empresas, el 36% asegura que han mejorado su competitividad en el mercado, un 20% menciona ser más eficientes en el uso de sus recursos y otro 20% indica tener una mejor relación con los clientes (Andew Sotelo et al., 2024).

Algunas empresas muestran interés, pero debido al costo prefieren posponer la inversión y avanzar en la proyección e innovación de sus procesos de manera gradual en pasos pequeños; además, hay un grupo de PyMEs que se encuentran satisfechas con el servicio que ofrecen a sus clientes y el producto que elaboran les resulta eficiente y económico, por lo que no sienten la necesidad de adquirir un bien o servicio relacionado con la inteligencia artificial (IA). El riesgo es bastante alto en caso de que la implementación del servicio o producto no sea exitosa. Por otro lado, las microempresas no han mostrado interés en invertir en bienes o servicios con algún tipo de inteligencia artificial por la misma razón (Pangol Lascano, 2022).

De acuerdo con un informe de la Secretaría de Innovación y Desarrollo Económico de Chihuahua (2023), el 27% de las pequeñas y medianas empresas del estado ha expresado interés en implementar tecnologías vinculadas a la inteligencia artificial; sin embargo, el 65% señala que los elevados costos de implementación son el principal obstáculo. Este patrón se

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observa con mayor frecuencia en sectores como el comercio al por menor y los servicios, donde la inversión inicial y el retorno esperado son aspectos cruciales.

Un estudio realizado por CANACINTRA Chihuahua en 2022 reportó que alrededor del 12% de las PyMEs que ya han implementado soluciones de inteligencia artificial (IA) se consideran satisfechas con los resultados, destacando beneficios en áreas como la gestión de inventarios y atención al cliente. Estas empresas pertenecen principalmente a los sectores de manufactura y logística. (Cámara Nacional de la Industria de Transformación 2022).

Un caso emblemático es el de una empresa local del sector agroindustrial que implementó inteligencia artificial (IA) para optimizar sus procesos de riego y cultivo, logrando reducir sus costos operativos en un 15% en un periodo de 12 meses (INEGI, 2023). No obstante, también se documentaron desafíos, como la falta de personal capacitado para gestionar estas tecnologías y la necesidad de consultores externos.

La implementación de la inteligencia artificial (IA) en Chihuahua ha presentado resultados interesantes, tanto positivos como desafiantes. Por un lado, la tecnología ha permitido que sectores como la manufactura, la salud y los servicios mejoren en términos de eficiencia y productividad; sin embargo, también ha quedado claro que los miembros de la fuerza laboral deben adaptarse a estos avances tecnológicos y perder el temor al cambio.

El principal desafío consiste en garantizar que el talento humano no se quede rezagado. Es crucial que los empleados tengan acceso a programas de capacitación y formación continua, así como a incentivos y oportunidades de desarrollo laboral que les permitan utilizar las herramientas de inteligencia artificial (IA) en lugar de sentirse amenazados por ellas y temer la pérdida de sus empleos.

Conclusiones

Considerando que el objetivo del estudio fue analizar la forma en que se puede integrar la inteligencia artificial (IA) en la gestión del talento humano, con especial atención a las pequeñas y medianas empresas (PyMEs) en Chihuahua, Chih. México, a continuación, se señalan los principales hallazgos.

La implementación de la inteligencia artificial (IA) en Chihuahua representa una oportunidad transformadora que, aunque promete mejoras en productividad, eficiencia y competitividad, también presenta importantes desafíos en la gestión del talento humano. La automatización de procesos industriales, la optimización de cadenas de suministro y el análisis predictivo son algunos ejemplos del impacto positivo que la inteligencia artificial (IA) puede tener en sectores clave como la manufactura, la agroindustria y los

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servicios. No obstante, estas transformaciones también traen consigo retos significativos relacionados con la adaptación del capital humano.
En cuanto a las consecuencias, la inteligencia artificial (IA) podría reemplazar empleos rutinarios y repetitivos, generando incertidumbre laboral en sectores con menor especialización; esto resalta la necesidad de implementar estrategias de reentrenamiento y aprendizaje continuo que preparen a la fuerza laboral para desempeñar roles más complejos y creativos; asimismo, el desarrollo desigual en la adopción tecnológica entre empresas podría agravar las brechas económicas y sociales en la región.

Los principales desafíos incluyen la creación de un ecosistema educativo y empresarial que promueva habilidades como el pensamiento crítico, la resolución de problemas y la colaboración interdisciplinaria. Es crucial fortalecer la conexión entre universidades, centros de investigación y empresas para fomentar la formación de talento orientado al desarrollo e implementación de la inteligencia artificial (IA); también es fundamental establecer políticas públicas que regulen la adopción de esta tecnología de manera ética y equitativa, evitando sesgos y exclusión.

En conclusión, la inteligencia artificial no debe considerarse como un sustituto del talento humano, sino como un complemento que potencie sus capacidades. Para que Chihuahua se convierta en un estado competitivo en la era de la inteligencia artificial (IA), será necesario promover una visión integradora que combine innovación tecnología, crecimiento humano y políticas inclusivas. Solo de esta manera se podrá abordar las consecuencias inmediatas y convertir los desafíos en oportunidades para un desarrollo continuo.

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The Relationship between Constructivist Thinking and Academic Engagement among University Students in Light of Some Variables

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Abstract

This paper focuses on revealing the relationship between constructivist thinking and academic engagement among university students in light of some variables. To achieve the objectives, a sample of 697 male and female students was selected using available sample method at the Qasimi Academic College of Education. The correlational approach was used. The constructive thinking scale and measure of academic participation were applied. The results showed a statistically significant positive correlation between academic participation and constructive thinking dimensions. The results also showed a statistically significant negative correlation between academic participation and destructive constructive thinking dimensions. The results indicated that there were no significant differences in correlation factors between constructive thinking and academic engagement attributed to gender and specialization. Based on the findings, it is logical to conclude that the increase in constructive dimensions of constructive thinking contributes to achieving academic engagement, while the increase in destructive dimensions of constructive thinking reduces academic engagement.

Keywords: Constructive thinking, academic engagement, university students

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Introduction

All educational institutions, including universities and various colleges, seek to achieve the highest possible level of student engagement in the educational process. This engagement does not only stop at the behavioral aspect, but it also extends to the psychological, cognitive, and emotional aspects.

The university education stage is one of the most prominent educational stages, where students focus on their specializations through theoretical and practical coursework, as well as various extracurricular activities. Academic participation occurs at this stage when students delve into learning activities, and when they are cognitively, emotionally, and socially immersed into various courses in addition to academic activities and tasks. Academic engagement also occurs when students achieve positive social interactions with each other (Hattie, 2003).

Academic engagement refers to the quality of effort or involvement that students devote to academically and educationally meaningful activities, while academic engagement is directly related to academic course outcomes, academic achievement, as well as future job prospects and the career success of students (Karki et al., 2020).

Consequently, academic engagement is not merely about receiving and memorizing information; it also involves building knowledge, translating it, connecting it with prior experiences, and applying it in decision-making and problem-solving. The role of constructive thinking lies in integrating acquired knowledge with the individual's sensory, cognitive, and emotional side. When there is a conflict between what the individual has done previously and new experiences, this creates a state of imbalance that may push the student to learn and achieve academic engagement. This is relatively possible through constructive thinking, which focuses on the mind, body and spirit together, and it helps in solving daily problems with minimal effort and without harassment from others (Shaw, 2021).

Theoretical Literature

Constructivist Thinking

Constructivist thinking refers to a set of habitual, automatic, and cognitively productive thoughts that influence an individual's ability to think. This concept was coined by Epstein, who is considered the pioneer of constructivist thinking (Thayer-Bacon, 1998).

Constructivist thinking is seen as an outgrowth of cognitive experiential self-theory (CEST), a dual-operational model of cognition developed by Seymour Epstein. This theory assumes that individuals operate using two separate information-processing systems: the analytic-rational system and the intuitive-experiential system (Epstein, 2003).

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Individuals with an analytic-rational system are thoughtful, slow, and logical. Other individuals with an intuitive-experiential system are fast, spontaneous, and emotionally driven. These systems are independent, work in parallel, and interact to produce conscious behavior and thought. Self-experiential cognitive theory is unique in that it posits two systems that make up an individual's personality, rather than viewing personality as a single construct (Pacini & Epstein, 1999).

However, Epstein (2003) has argued that there is constant interaction between these two systems in the context of everyday life. The experiential system, being fast, guided by emotion and past experience, and requiring minimal cognitive resources, is particularly well-suited for managing most daily information processing—much of which occurs outside conscious awareness. The rational system, in light of the experiential system's operation, allows individuals to focus on the limited capacity of conscious awareness.

Thus, constructive thinking is a theoretical component of the experiential system. It is also defined as the degree of automatic thinking that an individual achieves without deliberate intention, such that it is easier for the individual to solve problems in daily life with the least possible cost under pressure (Epstein, 1998a). For example, constructive thinkers tend to interpret new situations as challenges rather than threats, and they view issues positively and with a certain degree of realism (Epstein, 2003).

It can also be said that constructive thinking is an indicator of intelligence associated with the individual's experience system, as it reflects the extent to which the individual is able to learn from past experiences and determine the way of thinking that increases his effectiveness in life. Thus, constructive thinking helps solve daily problems with minimal effort and without harassment from others (Thayer-Bacon, 1998).

It can also be said that individuals with positive constructive thinking are described as flexible and they are able to change and modify their behavior to suit the variables of the surrounding environment. Individuals adapt their behaviors and actions according to different academic situations and tasks, and it makes it easy for them to understand logical issues. Their optimism or pessimism is appropriate to the situation they are going through, and they focus on solving the problem more than focusing on the results. Individuals exhibit a high degree of emotional control, along with low levels of superstitious and categorical thinking. These characteristics collectively enable them to integrate effectively into the academic environment (Vizoso et al., 2018).

Shaw (2021) highlighted that the most prominent characteristics of constructivist thinking include its cooperative and collective nature, the integration of cognitive, emotional, and behavioral dimensions in the learning

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process, an emphasis on wisdom and obedience, a bottom-up approach, and a foundation of critical analysis supported by conclusive evidence.

Individuals with negative or destructive thinking are described as having an inability to self-regulate, a clear dispersion of thoughts, a lack of sufficient problem-solving skills, making incorrect judgments, superstitious thinking, and having high levels of unjustified optimism that may lead them to make exaggerated generalizations about the events they experience. In addition, their thinking is also described as narrow and may lead them to only two options either left or right, backward or forward (Epstein, 1998b).

It can be said that constructive thinking consists of two basic components; the first is the constructive component, and the second is the destructive component. The constructive components of constructive thinking that the researcher has adopted in this study can be described below:

1. Global constructive thinking, considered an automatic way of thinking in daily life, helps solve life problems and this solution is without pressure, tension, anxiety or causing pain to the individual or others (Epstein, 2001).
2. Emotional coping and behavioral coping, where emotional coping refers to the ability to avoid taking things personally, not being sensitive to others' disapproval and not worrying excessively about failure or rejection. Individuals who rate themselves highly in emotional coping are not overly sensitive, do not overreact when problems arise, and do not care excessively about things over which they have no control (Humphreys & Zettel, 2002).

Emotional coping includes four main components. The first component is self-acceptance, which refers to the positive attitude of the person towards himself and the subsequent self-respect, feeling, and development. The second component refers to the absence of negative overgeneralization. Basically, overgeneralization - even if it is positive - is completely unacceptable. So how about negative generalization? Therefore, the individual should avoid generalizing negative events, especially if they are in the past. The third component refers to insensitivity which indicates the extent of the individual's ability to tolerate the rejection of others, to be tolerant of them, and to tolerate the element of ambiguity and surprises in life events. The fourth component refers to the absence of elaboration in thinking and avoiding the control of negative events that the individual may experience over his thinking (Murad & Saber, 2021).

On the other hand, behavioral coping refers to individual's willingness to adopt thought patterns that encourage effective behavior and sustain an optimistic outlook on life. Those who rate themselves highly on behavioral

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congruence tend to be practical and approach problems with great energy (Epstein & Meier, 1989).
The destructive components can be addressed as follows:

- Personal superstitious thinking which is concerned with specific beliefs that the individual is convinced of without objective or scientific evidence, and it can be described as mental games that the individual practices to confront a state of failure or imbalance.
- Categorical thinking: This thinking is described as narrow thinking, which makes its owner see only two colors; black and white.
- Esoteric thinking, or what is known as limited thinking, is concerned with general beliefs that the individual is convinced of without objective evidence (Epstein, 1998b).

Additionally, naive optimism is an exaggerated generalization of the positive events that the individual experiences. Hence, it consists of three elements. The first is excessive optimism, which expresses the individual's belief that his success in his work makes him successful in everything. The second is stereotypical thinking, which indicates an exaggerated reaction such as the individual believing that the people of a certain region are more stingy or generous than others. The third is optimistic thinking, where the individual believes that all people are kind-hearted (Al-Huwaiji, 2016).

According to the hierarchical property, the most general constructive thinking is at the top of the pyramid, while emotional compatibility, behavioral compatibility, personal superstitious thinking, categorical or categorical thinking, introspection and naive optimism are in the middle of the pyramid. However, the manifestations of these main components represent the qualitative components of constructive thinking, which are at the bottom of the pyramid (Epstein, 2001).

Academic Engagement

Academic engagement is defined as the amount of physical, psychological, cognitive, social, and emotional energy that a student expends in the academic institution to which he belongs. This energy is invested in areas such as participation in classroom and extracurricular activities and in achieving positive social interaction with students and faculty members (Astin, 1993). Schaufeli and Bakker (2006) define it as a positive mental state in the student, such that this state makes the student characterized by vitality, cognitive flexibility, and effective participation in the classroom. Schreiber and Yu (2016) define it as the student's success in the activities provided by the academic institution, in addition to the circumstances surrounding the individual that enhance his continuity within the academic institution. Thus, this is determined through purposeful activities, positive interaction, and

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awareness of the educational environment. Academic engagement refers to the levels of effort or participation students devote to meaningful academic and educational activities. In addition, academic engagement is directly related to academic outcomes, future work orientation, and student career success (Karki et al., 2020).

It can be stated that there are three main dimensions of academic engagement, which are:

1. **Behavioral Engagement**: This dimension refers to an observable act whereby a student participates in various learning activities and the efforts made to perform academic tasks such as interacting with the teacher and peers and participating in activities within the classroom (Revee & Tseng, 2011).

   Behavioral engagement is usually defined as active participation in both academic and non-academic learning activities. Behavioral engagement is associated with a student's overall positive behavior, ability to follow rules in the classroom, and lack of disruptive or aggressive behavior. In addition, displaying academic behaviors, such as exerting effort, showing persistence, asking questions and maintaining focus, are also indicators of behavioral engagement (Finn & Voelkl, 1993).
2. **Cognitive Engagement**: This dimension represents the extent to which students are interested in the learning process and being able to take on its tasks, such as learning styles, cognitive styles, self-regulation strategies, and developed learning strategies (Revee & Tseng, 2011).

   Fredricks et al. (2004) confirmed that cognitive engagement means a general investment in learning. Students who show investment in learning have higher scores on tests and academic activities. Also, they are less likely to be disruptive, absent from school, or drop out of school. Cognitive engagement is a student's psychological investment, and it is an effort directed toward learning, understanding, and mastering knowledge and skills or crafts that academic work aims to enhance. Students in cognitive engagement show behavior that exceeds stated expectations and seeks academic challenges.
3. **Emotional Engagement:** This dimension refers to the student's emotions and feelings within the academic environment such as feeling excited, interested, happy, not anxious, stressed and bored (Revee & Tseng, 2011).

   Emotional engagement also reflects students' feelings and actions related to the academic institution and classrooms. It also provides an opportunity for students' emotional reactions to be seen, such as boredom, sadness, and anxiety. Emotional engagement can be assessed

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by measuring students' reactions to school and teachers. Students who are emotionally engaged in school show higher academic achievement than others (Lee & Smith, 1995).

Study Problem

The study problem emerged from the results of some previous studies (Miralles-Armenteros et al., 2019; Vizoso et al., 2018). These results showed the importance of achieving academic engagement for students within their different academic environments. They also showed the existence of variables that may positively affect academic engagement and may increase its different levels. The researcher, by virtue of his work as a school principal, noticed that students do not have characteristics of academic engagement such as vitality, cognitive flexibility, and effective participation within the classroom. Their interaction with the elements of the educational environment is very negative, and their awareness of it is at its lowest, which affects the outcomes of the educational process in a very negative way. Another justification for conducting this study is that the relationship between academic engagement and constructive thinking is unclear. Thus, it is based on the dimensions of constructive thinking related to emotional and behavioral coping only. Also, there is no direct relationship between the two variables in foreign studies to the best of the researcher's knowledge. Accordingly, this study came in an attempt to determine the relationships between constructive thinking and academic engagement among university students, by answering the following two questions:

1. **Is there a statistically significant relationship at the significance level (α=0.05) between constructive thinking and academic engagement among university students?**
2. **Does the strength of the relationship between constructive thinking and academic engagement differ according to gender and specialization among university students?**

Material and Methods

This study relied on the correlational approach.

Sample

The study sample comprised 697 undergraduate students from Al-Qasemi Academic College of Education, located within the Green Line in Baqa al-Gharbiyye. Participants were selected using the available sampling method. However, this method allow researcher to access participants who are readily available and willing to participate. Given that the target population consists of students at Al-Qasemi Academic College, this method is both time-efficient and cost-effective, ensuring timely data collection within the

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constraints of the academic calendar. The sample included 256 male and 441 female students. Of these, 148 were enrolled in scientific disciplines, while 549 were pursuing humanities disciplines. Data collection was conducted during the second semester of the 2022-2023 academic year using paper-based scales.

Study Tools

Academic Engagement Scale

The researcher used the Academic Engagement Scale of Afifi (2016), where the scale consisted of 61 items distributed over three dimensions: behavioral engagement (22 items), emotional engagement (21 items), and cognitive engagement (18 items).

To verify the validity of the scale, it was presented to a group of 9 jurors who are specialists in educational psychology, measurement and evaluation. They were asked to verify the linguistic formulation of the items and to judge the extent to which the items belong to the dimension, and any comments they deem appropriate. The consensus of 7 or more jurors was relied upon. The jurors indicated the deletion of the item stated as "I participate with my colleagues outside the lecture hall in performing the required assignments" from the behavioral engagement dimension due to its inappropriateness to the academic context and linguistic modifications were made to some items.

The reliability of the academic engagement scale was confirmed through the internal consistency coefficient (Cronbach's alpha), where it reached 0.90 for the behavioral dimension, 0.90 for the emotional dimension, 0.87 for the cognitive dimension, and 0.93 for the overall dimension, indicating that the scale has a high degree of reliability (Li et al., 1996).

Constructive Thinking Scale

The researcher used the constructive thinking scale developed by Epstein and Meier (1989), which was Arabized, developed, and modified by Morsi et al. (2020). The scale consisted of 78 items distributed over seven dimensions: global constructive thinking (7 items), emotional coping (18 items), behavioral coping (11 items), personal superstitious (6 items), categorical thinking (13 items), esoteric thinking (13 items), and naive optimism (10 items).

After presenting the scale to the jurors, they agreed to delete item stated as “I never learned to read” from the dimension of behavioral coping because it is not clear, and it does not belong to the dimension. Also, they agreed to delete item stated as “I care about others’ opinions of me” from the dimension of emotional coping because it is does not belong to the dimension. Furthermore, they also agreed to delete items stated as “There are two types

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of people: successful people and failures" and "Two + two = four" from the dimension of categorical thinking because it is unclear. They also agreed to delete item stated as "When I have many tasks, I make a plan to accomplish them and stick to it" from the dimension of esoteric thinking because it does not belong to the dimension.

Accordingly, the scale became composed of 73 items distributed over seven dimensions, which are: global constructive thinking (7 items), emotional coping (17 items), behavioral coping (10 items), personal superstitious thinking (6 items), categorical thinking (11 items), esoteric thinking (12 items), and naive optimism (10 items).

The reliability of the constructive thinking scale was also confirmed through the internal consistency coefficient (Cronbach's alpha), where it reached 0.88 for the global constructive thinking domain, 0.93 for the behavioral coping domain, 0.93 for the emotional coping domain, 0.92 for the categorical thinking domain, 0.84 for the naive optimism domain, 0.95 for the esoteric thinking domain, and 0.76 for the personal superstitious thinking domain.

Results

1. **Is there a statistically significant relationship at the significance level (α=0.05) between constructive thinking and academic engagement among university students?**

To answer this question, Pearson's correlation coefficient was extracted between constructive thinking and academic engagement, as shown in Table 1 below.

Table 1. Pearson correlation coefficient values between constructivist thinking and academic engagement

	Behavioral engagement	**Emotional engagement**	**Cognitive engagement**	**Academic engagement**
Global constructive thinking	0.18**	0.22**	0.28**	0.29**
Emotional coping	0.23**	0.21**	0.19**	0.20**
Behavioral coping	0.25**	0.27**	0.29**	0.31**
Personal superstitious	0.011	0.02	0.08	0.04
Categorical thinking	-0.25**	-0.31**	-0.34**	-0.41**
Esoteric thinking	-0.34**	-0.36**	-0.40**	-0.42**
Naive optimism	-0.28**	-0.30**	-0.22**	-0.31**

**. Correlation is significant at the 0.01 level (2-tailed).

It is noted from Table 1 that the relationship between academic engagement and constructive dimensions of thinking was a positive relationship with statistical significant, ranging from 0.18 to 0.31. Conversely, the relationship between academic engagement and the destructive dimensions

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of thinking was negative and statistically significant, ranging from -0.22 to -0.42.

This result can be attributed to the fact that constructive dimensions of thinking motivate students to focus on goals, manage academic challenges, and think critically on how to succeed. Constructive thinking is an automatic way of thinking about daily life and it helps in solving life's problems. This solution avoids pressure, tension, anxiety, or causing pain to the individual or others, thereby fostering high levels of academic engagement. Additionally, the readiness generated by behavioral coping enhances students' ability to exhibit effective behavior and maintain an optimistic outlook on life, further increasing their levels of academic engagement. Emotional coping also generates students' ability to avoid taking things personally by not being sensitive to others' rejection and not being overly concerned about failure or rejection. Thus, this helps them to achieve high levels of emotional engagement.

In contrast, categorical thinking, which is described as narrow, black-and-white thinking, does not promote academic engagement. This narrow way of thinking leads to overly simplistic judgments, as students may view academic challenges or tasks as either complete successes or complete failures without recognizing the nuances and complexity involved in learning. Such binary thinking can hinder problem solving, critical analysis and adaptive responses to setbacks, as students fail to appreciate the gray areas where growth and learning often occur. As a result, categorical thinkers may withdraw when faced with difficulties or become too rigid in their approach, thereby missing out on opportunities for deep academic engagement and flexibility in their learning process.

The overgeneralization of positive events experienced by an individual may negatively impact academic engagement. Naive optimism can lead students to form unrealistic expectations or develop a false sense of security, potentially hindering their motivation to engage in academic tasks. When students overgeneralize positive experiences, they may believe that success will come easily in future endeavors, which may lead to a lack of effort or complacency. This naive optimism can reduce the engagement of the need for continuous work and improvement, leading to detachment from academic challenges. Consequently, a negative association with academic engagement arises because the student no longer feels the same motivation to actively engage in learning processes. This is with the assumption that past success guarantees future results without effort.

2. Does the strength of the relationship between constructive thinking and academic engagement differ according to gender and specialization among university students?

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To answer the study question, Fisher's Z values were extracted to verify the differences in the correlation coefficients between constructive thinking and academic engagement according to the variables of gender and specialization. Table 2 illustrates this.

Table 2. Fisher's Z-values of the correlation coefficients between constructivist thinking and academic engagement according to the gender and specialization

Variable	Level	Academic Engagement correlation coefficients	Z-values	Constructivist Thinking correlation coefficients	Z-values
Gender	Males	0.46	0.497	0.62	0.725
	Females	0.32	0.332	0.46	0.497
Specialization	Scientific	0.34	0.354	0.52	0.576
	Humanities	0.42	0.448	0.56	0.633

It is clear from the table that the values of "z" for the correlation coefficients between constructive thinking and academic engagement according to the variables of gender and specialization were low and less than the critical value (±1.96). Therefore, there are no significant differences in the correlation coefficients attributable to gender and specialization.

Constructive thinking can be said to depend on prior knowledge, analysis and logic, arrangement and organization, and openness to experience. These variables do not stop at males without females or vice versa, and they do not stop at humanities without science or vice versa. All students, regardless of their gender or specialization, rely on the ability to analyze and infer causal relationships and logical relationships between different information, as well as the ability to think logically and derive logical conclusions. These matters are the basis for positive constructive thinking. In addition, individuals rely on prior knowledge to analyze problems and reach logical solutions for them. This knowledge either supports the constructive components of constructive thinking if it is correct or reinforces the destructive components of constructive thinking if it is incorrect or if the individual responds to a situation inappropriately.

This result can also be attributed to the fact that all university students, regardless of their academic specializations and gender, are required to achieve academic engagement and engage in various tasks and activities. Also, all specializations contain tasks, activities, and educational experiences that require individuals within the academic institution to implement and integrate effectively. For example, language specialization requires the student to engage in listening and speaking skills, go to language laboratories and interact with the tasks posed by the faculty members. The same applies to the statistics student, as he must engage in computer laboratories to learn statistical packages for various statistical software (such as SPSS, SAT, AMOS, TAT) and others.

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Students' ability to deal effectively with everyday academic challenges is a trait that transcends discipline or gender roles. It is rooted in academic achievement and is not intrinsically linked to an individual's gender or major. All students, whether in the natural sciences, humanities or any other discipline, face similar academic pressures such as exams, assignments, and the need to manage their time. Their ability to deal effectively with these challenges depends on their self-efficacy, sense of control, academic engagement, and relationships with their teachers, rather than on their gender or field of study. Consequently, self-esteem, which is closely linked to an individual's perceived ability to overcome academic obstacles, is similarly influenced across all domains.

Recommendations

Based on the findings of the current study, it is recommended to enhance academic engagement among university students by fostering positive dimensions of constructive thinking, such as global constructive thinking, emotional coping, and behavioral coping. Additionally, efforts should be made to discourage destructive dimensions of constructive thinking, including personal superstitious, categorical thinking, esoteric thinking, and naive optimism, as these were found to have a negative association with academic engagement. The study also recommends that university's faculty members should pay more attention to global constructive thinking, emotional coping, and behavioral coping. This is in addition to conducting other similar studies on constructive thinking, the big five personality factors, and academic emotions among university students.

Conclusion

The current study aimed to find out the relationship between constructive thinking and academic engagement among university students in light of some variables. Based on the findings, it is logical to conclude that the increase in constructive dimensions of constructive thinking contributes to achieving academic engagement, while the increase in destructive dimensions of constructive thinking reduces and undermines levels of academic engagement.

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Encouraging Rural Engagement Among Students: Building Career Pathways in the Agricultural Sector

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Abstract

This study explores the factors influencing the career decisions of students at the Agricultural University of Tirana (AUT), focusing on their motivations, attitudes, and willingness to engage in the agricultural sector. Albania faces significant challenges due to migration, aging farmers, and declining interest in agricultural fields, exacerbating workforce shortages in this critical sector. Using a structured questionnaire administered to 307 students from the Faculty of Economics and Agribusiness at AUT, the study identifies key motivators and barriers that affect students' career choices. The results show that employment opportunities, personal interest in the field, and financial prospects are the main factors that motivate students to choose a study program in agriculture and related fields. However, a multinomial logistic regression model identifies factors such as year of study, perception, internship, extracurricular activities, career consulting, and level of information about the field as significant determinants of students' willingness

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to pursue a career in the agricultural sector after graduation. Factors such as a positive perception of agriculture, participation in internship programs and extracurricular activities, or career consulting from the university influence students to engage and retain within the sector. This study provides valuable data to formulate and develop strategies for attracting students in the agricultural sector. It recommends improving career counseling, providing more practical experiences, and addressing stereotypes to attract and keep young people in agriculture, ensuring the sector's sustainability in the future.

Keywords: Agriculture, career decision-making, rural engagement, students, youth

Introduction

With a total population of 2 761 785 (INSTAT, 2023), of which around 23% is aged between 15 and 29 years old, Albania has one of the highest rates of migration in the world (King and Gëdeshi, 2020). After the fall of communism, many people left the country looking for a better life. Lack of job opportunities and uncertainty about the future are the main drivers of emigration (Avdulaj et al., 2021). About 33% of tertiary-educated people have migrated abroad, causing the phenomenon known as 'brain drain' (Tataj & Akbaş, 2021; King and Gëdeshi, 2023). The term 'brain drain' refers to the migration of skilled professionals from lower-income countries to higher-income countries, leading to a shortage of expertise in the former (Oladeji, 2016). As a result, the workforce has become a problem for all sectors. Lately, this phenomenon is particularly prevalent in the medical system in Southeast Europe, including Albania, where a high number of healthcare workers moved to Europe, mainly to Germany (Juric, 2021).

Apart from the mass movement of young people, other indicators such as an increase in the average age (from 33.2 years old in 2012 to 38.2 years old in 2022) and the decline of the population's natural growth rate (total births minus total deaths from 14 603 in 2012 to 690 in 2022) are transforming the population's composition of Albania (INSTAT, 2023). Agriculture remains the most vulnerable sector as the population in rural areas is shrinking faster than the total population due to migration. These movements are leading to a rapid aging of the rural population and jeopardizing the development of agriculture, given that the sector is mostly unmechanized and dependent on unpaid labor. Agriculture in Albania employs about 460,600 workers, which means that 34.9% of the total labor force is reported as employed in this sector, facing a decline from 45.39% in 2011 (ILOSTAT, 2022).

Aging farmers and the lack of willingness among youth to work in agriculture pose a threat to the availability of the agricultural workforce in the near future in the country (Meçe and Ribaj, 2021). The majority of young

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people, who move from rural areas to study in urban areas, do not return after completing their studies, and in general, they are more inclined to choose a field of study that is not related to agriculture, as they do not project their future related to the rural areas (Geza et al., 2021). Data provided by the Agricultural University of Tirana (AUT), the main agricultural university in the country, show that there has been a decrease in the number of students enrolled during the last five years. The number of newly enrolled students declined from 1 653 students in 2018 to 1 201 students in 2023. This trend is reflecting a general decline in the number of students registered in higher education overall in Albania, due to an increase in migration rates among young people.

AUT offers study programs related to agriculture, agribusiness, veterinary, food technology, forestry, aquaculture, fishery, etc. Even though these are some of the most important sectors for the Albanian economy, the decrease in interest of students, especially in agriculture-related areas, highlights the need to promote and raise awareness of the public and young generations for the importance of these fields for the future. Identifying and addressing the factors contributing to this decrease is essential to ensure the sustainability and development of the agricultural sector in the country.

While extensive research exists on the factors influencing students' career choices, there is a noticeable gap in studies specifically focused on agriculture as a career path. To our knowledge, there are no other similar studies on this topic in Albania. Our study addresses this gap by examining the factors that motivate students at AUT to pursue careers in agriculture and related fields, thereby allowing us to gain insights into the specific motivations, interests, and career aspirations of young people. The objectives of the study are to:

- Explore the factors that influence students to choose and pursue a degree in agricultural-related fields at AUT.
- Observe the willingness of students to follow a career in the agricultural sector and understand the specific fields that are most interesting for their career choices.
- Identify strategies to encourage youth to pursue and retain their agricultural professions.

Literature review

Education provides young people with the necessary knowledge and enables them to plan their future careers in the most suitable manner. The role of schools is to provide accurate guidance and encourage students to continue their education and not abandon it (Kazi & Akhlaq, 2017). Albania spent around 2.3-3.3% of its gross domestic product (GDP) on education in the last decade (Mehmetaj & Xhindi, 2022). Education in Albania is the third sector

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in terms of budget allocation, after social protection and healthcare, respectively 40%, 12%, and 9% (UNICEF, 2021). The budget for higher education accounted for 24.1% of the total funds allocated to the educational sector in 2020 (UNICEF, 2021).

Traditional notions of linear career paths have given way to a landscape characterized by volatility, uncertainty, complexity, and ambiguity (Tola & Mustafaj, 2024). Students worldwide face the same issues when it comes to career decision-making (Nguyen et al., 2023). Many of them are not satisfied with the study programs they are enrolled in. They often make wrong career decisions due to lack of information, peer pressure, misguided role modeling, or as a result of the prestige associated with certain careers, without proper career guidance and counseling (Amani, 2013). Some students make career decisions by following the path of least resistance, for example, pursuing a career favored by their parents or following the footsteps of an older sibling. Ray et al., (2020) found out that career choices of students are influenced by peers, parents, or society. Other factors such as convenience, family background, societal status, family income, and parental pressure play a significant role in shaping these choices (Kazi & Akhlaq, 2017; Afzal Humayon et al., 2018; Ray et al., 2020).

This issue of career decision-making becomes even more critical when considering the future of agriculture, a sector vital for global food security. Most of the world's food is produced by aging farmers, who are less likely to adopt necessary agricultural innovations for sustainable productivity and food security for the growing global population (Jöhr, 2012; FAO, 2014; Rigg et al., 2020). Particularly, youth in developing countries are reluctant to engage in the agricultural sector; therefore, understanding young people's perceptions of agriculture and access to knowledge and information is essential to replace the aging agricultural producers with energetic and capable youth to achieve sustainable agricultural productivity and food security (Hitka and Ližbetinová, 2023).

Access to higher agricultural education is a fundamental condition to offer potential agricultural careers to young people at all levels, from field level to research and academia to national and international agricultural policy-making and development agencies (FAO, 2014; Kőmíves et al., 2019). However, this situation is unique only to the field of agriculture when compared to other branches of natural sciences, as most high school students prefer non-agricultural career choices (Obayelu & Fadele, 2019; Girdziute et al., 2022). Agriculture is filled with negative perceptions and a lack of information and awareness. Studies show that students have a negative perception of agriculture and perceive agricultural practices as inferior, unfulfilling, and laborious (Njeru, 2017). This has led to a low level of skilled labor force in this sector, as well as a low level of adoption of agricultural

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technology and productivity. In fact, students who enroll in agricultural study programs are stigmatized as not being accepted into programs perceived as prestigious and lucrative, such as medicine, engineering, computer science, law, and business.

Shifting the mentality can be achieved by changing young people's deeply rooted perceptions and attitudes towards agriculture as a non-profit enterprise (Obayelu & Fadele, 2019). Their perception of agriculture and exposure to the sector determines their readiness to pursue agricultural studies (Baliyan & Nenty, 2015; Johnson et al., 2019). Creating agricultural policies, involving governments in agriculture, increasing the use of ICT in agriculture and teaching, functional or practical agricultural education (formal and non-formal), gamification, scholarships to improve tertiary agricultural education, and availability of startup financing opportunities are some recommendations that can be made to increase students' interest in agriculture (Omotosho et al., 2020).

Methodology

This study was conducted at the Agricultural University of Tirana. Students from the Faculty of Economics and Agribusiness were selected as the target group. A structured and self-administered questionnaire was utilized as the instrument for gathering the necessary data to achieve the objectives of the study. The questionnaire was built in Google Forms and distributed via email to more than 1,000 students during May-June 2023, with a total number of 307 respondents, which is a 31% response rate. However, this sample ensures a confidence level of 95% with a margin of error of 5%, suitable to reach statistically significant results. The questionnaire consisted of four sections with a total of 25 questions. The first section aimed to gather information about the demographic characteristics of the respondents; the second section aimed to explore the factors that influence students to choose a career in agribusiness; the third section aimed to explore participants' perceptions, attitudes, and beliefs regarding agriculture; and the last section included questions about their aspirations and concerns about the future.

Descriptive statistics and statistical analyses were performed using Excel and R software. A multinomial logistic regression model is used to identify the determinants that influence the willingness of young people to study and engage in the agricultural sector. Exploratory variables were constructed based on the literature review and include categorical variables, such as gender, year in the study program, initial preference for the study program, perception about the agricultural sector, undertaking an internship, participation in extracurricular activities, career consulting, and level of information about the agricultural sector. Multinomial logistic regression estimates separate equations for each category of willingness

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(Yes/No/Maybe), with logit transformations of the probabilities modeled as linear combinations of the independent variables and their associated coefficients (Bayaga, 2010).

Results

The analysis and the results provide evidence to support the objectives of the study.

Demographics of the respondents

The demographic data of the respondents are presented in Table 1. About 97% of the respondents are students in the age group 18-25, of which 67% are in the age group of 21-25, a typical age for bachelor and master enrollment in Albania. Females have a higher representation in our sample (78%).

Table 1. Demographics of the respondents

Variables	No	%
Age groups		
18-20	92	30
21-25	206	67
26-30	6	2
over 31	3	1
Total	307	100%
Gender		
Female	240	78
Male	64	21
Prefer not to disclose	3	1
Total	307	100%
Year in the study program		
1st year-bachelor	24	8
2nd year-bachelor	78	25
3rd year-bachelor	120	39
1st year-master	43	14
2nd year-master	42	14
Total	307	100%

Source: Own research

Preferences for choosing the study program

A potential student in Albania, according to the legal framework, has the right to apply for up to 10 study programs, ranking them based on their own preferences. Firstly, we aimed to understand if students genuinely desired and chose the major they were studying, indicating if this was their first or second preference in the list. The results revealed that 66% of the respondents are studying in a program that was their first preference (n=202), while 27% of the respondents have chosen the study program as their second preference.

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For the remaining 7%, the major was neither their first nor second choice, indicating they did not prefer it among the options they provided.

A study from the U.S. Department of Education (2017) revealed that about 30% of undergraduates in associate's and bachelor's degree programs had changed their major at least once within 3 years of initial enrollment, 35% of whom had originally declared a science, technology, engineering, or mathematics (STEM) major, likely due to the perceived difficulty of the major. To gain a deeper understanding of AUT students' attitudes towards their current majors, they were asked if they would change their enrolled program if given a second chance. The results indicate that 40% of the respondents (n=121) would change their major; however, in that case, lack of interest in the field of study emerges as the primary reason for wishing to change. The Chi-square test was used to determine if there is a relationship between initially selecting a major as the first or second choice and subsequent willingness to change that major. In this case, using the two categorical variables: preference for the major (preferred or not preferred) and intention to change the major if given a chance (yes or no), the following hypothesis was built: *There is a correlation between the initial preference for choosing the major and intentions to change this major given a second chance.*

At the significance level of 0.05, the results indicate a statistically significant correlation between the initial preference for choosing the major and intentions to change the major given a second chance ($\chi^2 = 5.840$, df = 1, p = 0.016). To determine if students who preferred their major were less likely to want to change it, or vice versa, the adjusted residuals for each cell were calculated, as shown in Table 2.

Table 2. Contingency table with the adjusted residuals

	No	Yes	No	Yes
Major not preferred	7	14	-1.604	1.989
Major preferred	179	107	0.435	-0.539

Source: Own research

As expected, students who initially preferred their major were more likely to not want to change it, as indicated by the positive residual for the 'Major preferred' category and the 'No' response. Conversely, students who did not prefer their major were more likely to want to change it, as indicated by the positive residual for the 'Major not preferred' category and the 'Yes' response.

Motivation for choosing the study program

The results show that the main factors behind choosing a study program in agriculture-related fields include employment opportunities in this sector. Personal interests in the field also play a significant role, along with

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considerations of financial prospects. An overview of the factors that motivate the students to have chosen their study program is shown in Table 3.

Table 3. Motivation for choosing the study program

Motivation	No.	%
Personal interests in the field	107	35
Family expectations	18	6
Financial prospects (salary)	31	10
Employment opportunities	146	47
Other reasons	5	2
Total	**307**	**100%**

Source: Own research

Attitudes and perceptions towards a career in agriculture

Studies show that there is a negative attitude among young people towards a career in the agricultural sector (Geza et al., 2021). To explore this further, the respondents were asked to choose if they feel like working in the agricultural sector is a profitable job, laborious work, or a poor-paying job. Approximately 47% of the respondents consider it as a profitable job, while 46% consider it as laborious work, and 7% consider it as a poor-paying job. Some of the arguments provided to support their response are: 'A profitable job but requires great effort to receive compensation'; 'There is potential for the future'; 'Hard work but profitable'; 'Agriculture involves hard work, laborious work, non-profitable work, work that young people do not show interest, due to the mentality created by those who are involved in agriculture or study agriculture, but also because there is no income'; 'The government does not provide support to farmers'; 'Undervalued work'; 'Sector that has potential for development'; 'I think it is a quite interesting sector despite not having a profitable reputation at the moment, however, there is a lot of room to bring new innovations in this field'. These attitudes reflect varying perceptions of agriculture as a career option, influenced by factors such as economic conditions, cultural beliefs, personal experiences, and the overall context of the agricultural industry in a particular region or country.

Level of guidance toward a career in the agricultural sector

Internships, extra-curricular activities, and career consulting play an important role in helping students shape and understand their career opportunities by providing practical experience, professional development opportunities, network connections, career exploration, personal growth experiences, guidance, and support along the way.

The results show that a small portion of the respondents (14%) have completed an internship or practical work in the agribusiness sector. This low figure indicates that the students need more guidance to transition from university to the workforce. Similar results are obtained for the question of

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whether they had participated in an extracurricular activity related to the agribusiness sector, where only 19% answered 'yes'. Respondents also shared their experiences in the activities they had participated in training sessions, internships in food safety, and participation in online courses related to agribusiness. Respondents were asked if they had received career support or guidance from AUR or other sources. The figures show that about 50% have received such support. Students assessed their overall level of information about the agricultural sector in Albania and job opportunities that it offers. There is a significant number of students who feel they lack information (79%), while the remaining 21% state that they have a lot of information regarding this topic.

Willingness to participate in the agricultural sector

This study aimed to understand whether students are willing to engage in the agricultural sector and agribusiness after they graduate. About 55% answered 'maybe', showing that they are undecided whether they want to pursue a career in this sector, which may stem from the lack of information about potential fields of work and career opportunities or simply a lack of interest in the field they are studying, while 31% are happy and willing to enroll in this sector after they graduate. The respondents were asked about the challenges they face in pursuing a career in agriculture after graduation. Lack of practical experience, difficulties in accessing funds, perceived low prestige of the sector, uncertainty about the future market trends, limited professional connections, and job opportunities are their major concerns, which limit their engagement in the sector.

In order to understand the determinants of the youth's willingness to be engaged in agriculture, we ran a multinomial logistic regression model. The dependent variable 'Willingness' is categorized into three-level responses: yes, no, and maybe. This method allows for the assessment of the unique effects of each independent variable on the log odds of being in each category of 'Willingness' while controlling for other variables in the model.

$$logit\ (Willingness) = \beta_0 + \beta_1(Gender) + \beta_2\ (Study\ Year) + \beta_3(Initial\ Preference) + \beta_4(Perception) + \beta_5(Internship) + \beta_6(Extracurricular\ Activities) + \beta_7(Career\ Consulting) + \beta_8\ (Level\ of\ Information) \quad (1)$$

First, a Chi-square test was performed to see if there is a relationship between each of the eight exploratory variables (gender, year in the study program, initial preference, perception about jobs in the agricultural sector, participation in internships, attending extracurricular activities, career consulting, level of information regarding careers in the agricultural sector)

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and the dependent variable (willingness). The results suggested that year of study, perception, internship, extracurricular activities, career consulting, and level of information are effective predictors of willingness, while gender and initial preferences are not. Therefore, the last two variables were removed from the model. The results are presented in Table 4. The final model is:

$$logit\ (Willingness) = \beta_0 + \beta_1(Year\ of\ study) + \beta_2(Perception) + \beta_3(Internship) + \beta_4(Extracurricular\ Activities) + \beta_5(Career\ Consulting) + \beta_6(Level\ of\ Information) \quad (2)$$

Table 4. Distribution of explanatory variables

Variable	No.	%
Year of study		
1st year-bachelor	24	8
2nd year-bachelor	72	25
3rd year-bachelor	120	39
1st year-master	43	14
2nd year-master	43	14
Total	307	100%
Perception		
Laborious job	141	46
Poor paying job	23	7
Profitable job	143	47
Total	307	100%
Internship		
No	265	86
Yes	42	14
Total	307	100%
Extracurricular activities		
No	248	81
Yes	59	19
Total	307	100%
Career consulting		
No	154	50
Yes	153	50
Total	307	100%
Level of information		
A lot of information	66	21
Little information	213	70
No information at all	28	9
Total	307	100%

Source: Own research

The variable 'Maybe' was used as the reference group for the dependent variable as it is the most frequent category, while the first category

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of independent variables was used as the reference category respectively, as shown in Table 5.

Table 5. Coefficients and Standard Errors for Multinomial Logistic Regression Model

Variable	Coefficient (yes)	Std. Error (yes)	P-value (yes)	Coefficient (no)	Std. Error (no)	P-value (no)
(Intercept)	-0.279	0.606	Na	-2.662	1.244	Na
Year_2nd_year-master	-1.243	0.607	0.013	1.049	1.219	0.106
Year_1st_year-master	-0.629	0.626	0.079	2.864	1.159	0.000
Year_2nd_year-bachelor	-1.227	0.551	0.013	1.334	1.147	0.013
Year_3rd_year-bachelor	-1.227	0.528	0.013	1.340	1.123	0.013
Perception_poor_paying_job	0.464	0.611	0.310	0.820	0.589	0.124
Perception_profitable_job	0.902	0.310	0.044	-1.243	0.479	0.079
Internship_yes	0.961	0.445	0.006	1.262	0.747	0.045
Extracurricular_activities_yes	0.690	0.369	0.095	-0.890	0.690	0.027
Career_consulting_yes	0.710	0.297	0.004	0.710	0.402	0.002
Level_of_information_little_information	-0.602	0.344	0.077	0.018	0.598	0.768
Level_of_information_no information_at_all	-0.823	0.663	0.237	0.975	0.732	0.310
[a] *Coefficients are significant at p-value<0.05*						

Source: Own research

The likelihood ratio test was used to test the validity of the model, with results of χ^2= 97.243 and a p-value of .000 (p<.05). Table 5 suggests that students in higher academic years are less likely to express willingness compared to those in earlier years. On the other side, having a perception of agriculture jobs being profitable, participation in internship programs, extracurricular activities, or receiving career consulting increases the log odds of being willing to participate in the agriculture sector.

Discussion

Agriculture is one of the oldest human activities, having helped people provide themselves with sustenance. Nowadays, it is an enormous and important sector for the global economies and provides food, resources, and employment opportunities. However, the future of agriculture is uncertain, as most people are abandoning it. Given the increasing age of farmers, depopulation of rural areas, and low interest of young people to enter the sector, there is an immediate need for action. The emergence of industries considered modern and prestigious, such as finance, medicine, and information technology, has led young people to 'ignore' the agriculture sector, jeopardizing its sustainability.

The findings of this study provide some valuable insights into the factors influencing career choices among agribusiness students and their potential impact on rural engagement. Understanding the factors that shape

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career aspirations is essential for students themselves, educators, employers, and policymakers, as they seek to support individuals in their career development journey and create environments conducive to achieving their aspirations.

The study showed that agriculture must be attractive to young people. Therefore, promoting the value of agriculture is fundamental to encouraging people to engage in rural development. To achieve this, universities, governments, and agencies must change the perceptions of young people toward the sector by increasing its reputation, expanding job availabilities, and increasing financial support. The development of curricula, the provision of internships and work experiences, as well as recommendations from faculty members and mentors, are considered important factors that influence how much information students have regarding career opportunities in the agricultural sector. Efforts should be made to raise public awareness of the importance of the agricultural sector for the existence of society and its potential for development, not only in economic terms but also for the social development of rural areas and the proper use of land as a natural resource.

Conclusion

In conclusion, to attract more young people to agriculture and to secure the future of this vital sector, it is essential that all societal and institutional actors actively contribute. Policymakers have a key role in creating a new vision for agriculture as a future and innovative profession. By including agriculture-related subjects in curricula, starting from primary schools to universities, young people can be introduced to the potential of this sector. Offering specific scholarships for agricultural studies, as well as creating professional internship programs in agribusinesses, would facilitate students' entry into this field, equipping them with practical skills and direct experience.

On the other hand, the private sector can be a catalyst for change by providing mentoring opportunities and specialized training for young people. Agro-industrial businesses can organize study visits, training focused on modern agricultural technologies, and practical projects involving the use of innovations such as drones, automation, and precision agriculture. Furthermore, creating special programs for young entrepreneurs, offering grants, low-interest loans, or support for launching start-ups in agriculture could encourage those who wish to explore this sector with new and sustainable ideas.

It is also important to change the general perception of agriculture. Practitioners, including farmers and experts in the field, can help modernize the image of this sector by sharing inspiring stories of successful farmers who have used modern technologies and sustainable practices. Through various platforms such as social media, conferences, and community engagement

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activities, the importance of agriculture to the economy and the role it plays in solving global challenges such as food security and climate change can be highlighted.

In such collaboration between policymakers, the private sector, education, and practitioners, an ecosystem can be created that makes young people feel empowered to choose agriculture as a future career. This collaboration can help revitalize rural areas, contributing not only to their economic development but also to improving the quality of life of rural communities. Ultimately, a comprehensive approach to engaging young people in agriculture will ensure that this sector remains a sustainable pillar of the global economy and food for generations to come.

Limitation of the Study

This study was solely focused on the Faculty of Economics and Agribusiness. Subsequent studies should conduct their research at other faculties of the Agricultural University of Tirana, as they offer study programs that are more closely related to the traditional disciplines of agriculture, such as horticulture, plant protection, agronomy, animal science, natural resources, fishery, etc.

Future Research

Future research should focus on longitudinal studies in order to observe changes in students' perceptions and attitudes about agriculture. This will help us understand the effectiveness of the efforts made by AUT and the Ministry of Agriculture in supporting youth in agriculture through their programs over time.

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Impact of the Distance Travelled to School on Students' Performance, Tardiness, and Absenteeism in Public Schools in Morocco

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Abstract

The challenges of providing equitable access to quality education are particularly acute in rural areas, where the distance pupils have to travel to school can have a significant impact on their academic performance. This study addresses the critical question: How does the distance students have to travel to school affect their academic outcomes? Focusing on a primary school in a rural area of Morocco, the research aims to analyze the relationship between students' travel times and their academic performance. Based on a statistical analysis of data collected from 220 students, the study uses univariate analysis, ANOVA, and Pearson correlation tests to examine the effects of commute time on tardiness, absenteeism, and academic performance. The results indicate that longer commute times are associated with higher rates of tardiness and absenteeism, as well as lower student performance. These findings highlight the urgent need to address logistical challenges in rural areas in order to improve educational outcomes. The study concludes by emphasizing the need for targeted interventions, such as improved transport infrastructure, to mitigate the negative impact of long commutes on student performance.

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Keywords: Distance, Equity, Performance, Education

Introduction

Émile Durkheim (1922) showed that schools reflect society, its value systems, and how these values are transmitted. Schools are responsible for providing moral, cultural, and scientific knowledge that helps children integrate into their social environment.

Students' academic performance is influenced by many factors including gender, age, teaching staff, students' previous schooling, the socio-economic status of the father or guardian, students' area of residence, the medium of instruction in schools, tuition trends, daily hours of study, and boarding or day-school accommodation (Ali Shoukat and al., 2013).

However, disparities in academic performance remain a significant challenge, particularly in rural areas, where students often face barriers to accessing quality education. Recognizing the importance of education in a country's development, all nations have made efforts to make education accessible to all, although the extent and success of these efforts vary from country to country (Gatchew, 2018).

In Morocco, schools are currently at the heart of the country's social project due to their crucial role in shaping future citizens, achieving sustainable human development goals, and ensuring the right to education for all. From this perspective, education occupies a central place in national priorities and concerns.

In this context, the present study aims to examine the impact of distance and travel to and from school on students' academic performance. Accordingly, the research question is How does the distance travelled by pupils to their schools affect their academic performance, given that distance is synonymous with the time spent travelling to school?

The objectives of this study are threefold:

1. To analyze the impact of the distance traveled to school on students' academic performance in public schools in rural areas in Morrocco.
2. To assess the relationship between commute time and student tardiness in rural areas, exploring how longer travel times lead to higher rates of lateness.
3. To examine the effects of commute time on absenteeism, determining whether increased travel distances contribute to higher rates of student absenteeism.

The structure of this article is as follows: The second section provides a comprehensive review of the relevant literature, followed by the third section which details the methodology and data used in the study. The fourth section

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presents and analyses the findings, and the fifth section discusses the results. The sixth section concludes the study.

Literature Review

The accessibility of schools and the distance pupils have to travel to reach them has been the focus of significant research. Schools in mountainous regions face significant accessibility challenges due to poor infrastructure, which makes it difficult for pupils to reach their schools, ultimately affecting their attendance and academic performance (Limaye, 2016). The distance that pupils travel from home to school has been the subject of numerous studies over the years and categorising travel modes into active and passive types. Active travel includes walking, cycling and skateboarding, while passive travel includes motorised transport such as cars, buses, minibusses, taxi,s and trains (Easton & Ferrari, 2015).

In most developed countries, passive transport is modern, relatively safe, and affordable, in stark contrast to developing countries where pupils often walk long distances through dangerous terrain. The impact of active and passive transport in these regions is considerably less severe compared to the challenges faced by pupils in developing countries, who often endure long walks through dangerous and difficult terrains such as mountains, rivers and forests (The New Times, 2016). Long walking distances are a common phenomenon for these students, leading to mental and physical effects as well as health risks (Zuckerman, 2021).

Studies have shown that pupils who commute long distances suffer from fatigue and low morale, which can lead to dropping out of school or poor concentration in class after spending long hours on the road (Marique et al, 2013). Early departures and late returns severely limit students' time for private study, and commuting distances profoundly affect the sleep patterns of adolescent pupils (Pradhan & Sinha, 2017). The literature consistently confirms the impact of distance to school on student performance, with various researchers documenting significant effects (Easton & Ferrari, 2015; The New Times, 2016; Vuri, 2007). Thapa (2015) and Getachew (2018) also found that distance to school has a significant impact on student achievement.

Creswell and Creswell (2017) found that distance to school has a negative impact on students' academic performance. Distance to school may influence student performance through numerous factors associated with long-distance travel to and from school (Thomas, 2016). Mhiliwa (2015) found that long walking distances to school negatively affect student performance compared to those who live closer to their schools. Students who travel long distances to school are exposed to longer travel times, reducing the time they can spend on homework or preparing for the next day of school (Andre-Bechely, 2007).

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Nelson, Misra, et al (2016) reported that pupils who live further from school find it difficult to complete out-of-school assignments assigned by their teachers. Taiwo (2019) found that walking long distances to and from school every day affects students' academic performance and contributes to absenteeism and fatigue, which leads to a lack of concentration and interest in school activities, with indirect negative consequences such as delinquency and lack of discipline.

Moyo (2013) analysed the impact of walking long distances to and from school and found that such journeys result in pupils arriving late at school and returning home late at night. In addition, longer walking distances lead to exhaustion and hunger, causing pupils to be tired while learning. This situation often results in pupils arriving at school on an empty stomach, which has a negative impact on their academic performance.

Baliyan and Khama (2020) investigated the effect of distance to school on students' mathematics performance among 168 pupils in Botswana. Their results showed that distance had a significant effect on mathematics performance, with post-hoc analysis showing that long travel distances adversely affected students' mathematics performance. Duze (2010) examined the average distance traveled to school by pupils in primary and secondary schools in three states of Nigeria and its effect on attendance. The results showed that most pupils traveled up to five kilometers, which negatively affected their attendance.

Despite extensive research, the relationship between distance to school, after-school study time, and student achievement remains unclear and under-researched (Andre-Bechely, 2007; Ledwith, 2009; Thomas, 2016; Warrington, 2005). While existing evidence suggests that the distance to school significantly impacts student performance—longer distances often lead to fatigue, reduced learning time, and lower academic achievement—there is limited research that focuses on how these factors specifically affect students in rural areas of Morocco. This study aims to fill this gap by examining the relationship between commute times, and academic outcomes in public schools in these regions.

By analyzing this context-specific data, the research seeks to provide new insights into the challenges faced by rural students and offer solutions, such as improving infrastructure and providing safer, more efficient transport options, to mitigate the negative effects of long commutes and improve educational outcomes. The figure 1 shows our model.

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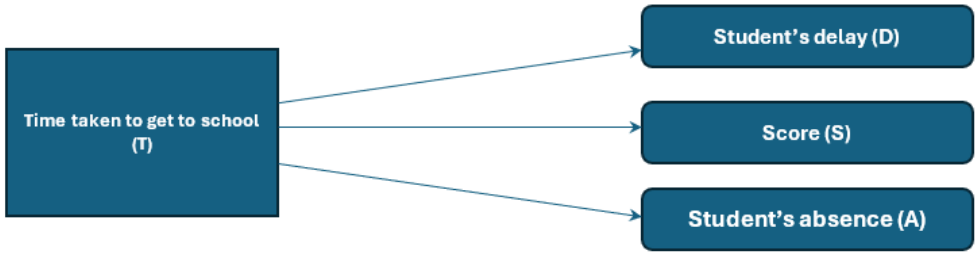
Figure 1. Representative diagram of the model



Source: Authors

Methodology and data

Methodology

In order to achieve the objectives of this study, the statistical analysis will be carried out in three stages. The first stage is a univariate analysis, which provides a descriptive overview of the variables within the study using statistics such as mean, variance, and proportion. The second step is to explore the relationships between several key variables: the time a student takes to arrive at school and the student's tardiness over a month, the time a student takes and the student's absenteeism over the same period, and the time a student takes to arrive at school and the student's academic performance during the first semester of the 2023-2024 school year. To assess these relationships, we use ANOVA and Pearson correlation tests.

Data and Results

Data

This study analyses the relationship between distance from school and academic performance. To measure academic performance, grades, tardiness, and absenteeism during the first semester of the 2023-2024 school year were used as indicators. The time taken to reach school was used as a proxy for distance from school.

In addition to these primary variables, other factors were taken into account to create a relatively homogeneous group that differs only in the time it takes to get to school. These factors include individual variables such as gender and age.

Data were collected using a questionnaire distributed to primary school pupils in a single rural school in the province of El Kelaa des Sraghna in Morocco. The pupils' teachers played a crucial role in this process, distributing hard copies of the questionnaire and explaining the questions to the pupils. Data collection took one month, starting on 1 March 2024 and ending at the end of the month.

The questionnaire was divided into three parts. The first section collected individual data such as gender, age, grade, and time spent traveling

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to school. The second section focused on school-related information, including first semester grades, instances of grade repetition, tardiness, homework completion, attentiveness in class, number of absences in the past month, and feeling tired in class

Results

Participants

The school is located in a rural area and operates as a public institution under the management of the provincial directorate of the Ministry of Education, Pre-school Education and Sports. Located 15 km from the town of El Kelaa des Sraghna, the school employs 22 teachers who teach in both Arabic and French. A total of 220 pupils took part in the survey, of whom 118 were boys (53.6%) and 102 girls (46.4%).

Descriptive statistics

Table 1. Descriptive statistics of the time taken to get to school and the score

Variables	N	Min	Max	Average	Standard deviation
Time taken to get to school (T)	220	5	60	13.75	11.75
Score (S)	220	1.86	8.94	6.1809	1.19

Source: Primary data

All pupils reported that they walked to school, which simplified the process of estimating travel time. The minimum travel time was 5 minutes, reflecting the proximity of some students' homes to the school. In contrast, the maximum time recorded was 60 minutes, indicating a significant variation in the time taken by pupils to get to school. On average, pupils took 13.57 minutes to get to school.

The data also revealed differences in the academic performance of the participants. The average score was 6.18 out of 10, with scores ranging from a low of 1.86 to a high of 8.94. The standard deviation of 1.19 points indicates that the scores vary significantly from the mean, suggesting that the academic performance of the pupils in this sample is quite heterogeneous.

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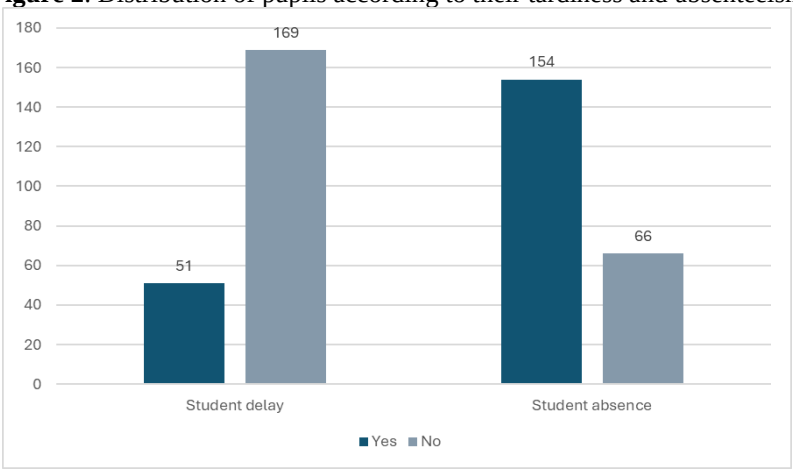
Figure 2. Distribution of pupils according to their tardiness and absenteeism



Source: Primary data

The figure 2 shows the differences between the participants regarding the variable of lateness. According to the teachers, 51 pupils are usually late at the beginning of the lesson, representing 23.18% of the total, while the remaining 169 students, representing 76.82%, arrive on time. The table also shows the distribution of participants on the basis of the absence variable. It shows that 154 students, or 70%, were absent at least once a month, while the remaining 30% were regular attendees

Table 2. Relationship between the time taken to get to school (T) and the student's delay (D)

Student delay (D)	**Average**	**N**	**Standard deviation**
Yes	19.72	51	12.339
No	12.31	169	11.170
Total	13.75	220	11.754
ANOVA test	F=14.62	Signification	0.00

Source: Primary data

The data in table 2 show that students who are frequently late, as reported by their teachers, tend to live farther away from school than their classmates who arrive on time. Specifically, students who are often late take an average of 19 minutes to get to school, while those who arrive on time take only 15 minutes. An ANOVA test was carried out to see whether the time taken to get to school had a significant effect on the probability of being late. The calculated F-value is 14.62, with a significance level of 0.00, indicating that the difference is statistically significant. This result suggests that the further a student lives from school, the higher the probability of being late.

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Table 3. Relationship between the time taken to get to school (T) and the student's absence (A)

Student absence (A)	Average	N	Standard deviation
Yes	20.45	154	10.32
No	12.31	66	12.18
Total	13.75	220	11.754
ANOVA test	F=13.62	Signification	0.00

Source: Primary data

Regarding the distribution of travel time to school (T) about absenteeism (A), it was found that students who are absent from school at least once a month report an average travel time of 20.45 minutes to get to school. On the other hand, those who do not miss any classes during the month only need an average of 12.31 minutes. This is a difference of 7 minutes between the two groups. The ANOVA test confirms that this difference is statistically significant, indicating that the farther the students live from school, the more likely they are to be absent.

Table 4. Relationship between the time taken to get to school (T) and the score (S)

Student's score (S)	Time taken to get to school (T)	
	Bilateral signification	0.44
	Pearson correlation	-0.14

Source: Primary data

To determine the nature of the correlation between X and Y, the Pearson correlation test is used, as both variables are quantitative. The results of this bilateral test show a negative correlation, which means that the two variables move in opposite directions. Specifically, as the time spent traveling to school increases, the score tends to decrease. Furthermore, the correlation is significant at the 0.05 level, indicating that this relationship is unlikely to be due to chance.

Discussions

The results of this study show significant correlations between the time students spend commuting to school and various indicators of academic performance, such as tardiness, absenteeism, and overall academic performance.

These findings are consistent with the existing literature, which highlights the impact of commuting distance on students' academic experiences. Mhiliwa (2015) found similar results in Tanzanian schools, where students commuting longer distances were more frequently tardy and absent, negatively impacting their engagement in classroom activities. Similarly, Pradhan and Sinha (2017) reported that students with long commutes often suffer from fatigue, which affects their ability to participate fully in school. The findings of the present study reinforce these conclusions,

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emphasizing that the physical and mental fatigue caused by long commutes reduces students' engagement and overall academic performance.

Furthermore, the negative correlation between commute time and academic performance suggests that students who spend more time traveling to school tend to have lower academic performance. This finding aligns with the research of Creswell and Creswell (2017)**,** who documented the detrimental effect of long distances on academic achievement. The current study extends this understanding by providing quantitative evidence of the significant impact of travel time on academic performance in rural Moroccan schools, a context that has been under-researched in previous studies. Longer travel times not only reduce time for studying and resting—both essential for academic success—but also compound the challenges already faced by rural students, such as limited access to educational resources and support at home, as noted by Nelson et al. (2016)**.**

The study's results also have broader implications for educational policy and infrastructure development in rural areas. As highlighted in previous research by Andre-Bechely (2007)**,** the physical distance between students' homes and schools in rural settings presents a substantial barrier to equal educational opportunities. This is particularly relevant in the Moroccan context, where road infrastructure in rural areas remains underdeveloped. The findings of this study emphasize the urgent need for targeted interventions to reduce travel times, whether through the provision of school transport services, the construction of schools closer to residential areas, or improvements in road and transport infrastructure. By aligning with previous studies, such as Duze (2010)**,** which demonstrated the importance of proximity in ensuring better attendance and academic performance, this study contributes new evidence supporting the prioritization of infrastructural development as a means of improving educational outcomes.

The significant relationship between commute time and academic performance underscores the importance of addressing educational inequities, particularly in rural areas where long travel distances are common. Research by Taiwo (2019) has shown that long distances to school not only affect students' attendance but also contribute to other social problems, such as reduced discipline and increased dropout rates. Policies aimed at reducing these disparities should consider commute time as a critical factor affecting students' access to quality education. Potential interventions could include expanding transportation options, offering boarding facilities, or providing additional academic support to pupils who face long commutes. These findings support the calls made by Baliyan and Khama (2020) for policymakers to focus on reducing the educational inequities that stem from long travel distances, particularly in developing countries like Morocco.

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Although this study provides valuable insights into the impact of commuting time on academic performance, it has a number of limitations. Firstly, the research was conducted in a single rural area, which may limit the generalizability of the findings to other regions with different socio-economic and geographical contexts. Additionally, the study did not take into account other factors that might influence academic performance, such as the quality of teaching, parental involvement, or the availability of learning resources at home, which have been emphasized in studies like those by Getachew (2018)**.** Future research should aim to cover a wider geographical area and include a more comprehensive set of variables to fully understand the complex relationship between commuting time and academic performance. Longitudinal studies, such as those suggested by Moyo (2013)**,** could provide deeper insights into how these relationships evolve over time and the long-term effects of commuting on students' educational outcomes. By addressing these limitations, future studies could build a more nuanced understanding of the barriers to education faced by rural students and contribute to more effective policy interventions.

Conclusion

This study highlights the significant impact of travel time on students' academic performance, showing that longer commutes are associated with increased tardiness, absenteeism, and lower academic performance. These findings highlight the urgent need for targeted interventions to reduce travel times and mitigate the negative effects of long commutes on students' education. Addressing these issues can help policymakers and educators create a more equitable educational environment, particularly in rural areas where students face unique challenges related to access and distance. This study adds to the growing body of literature on educational equity and provides a foundation for future research to investigate and address these critical issues further.

Declaration for Human Participants: The study was approved by the Multidisciplinary Research Laboratory in Economics and Management (LARPEG), Faculty of Economics and Management, Sultan Moulay Slimane University of Beni Mellal, Morocco, and the principles of the Helsinki Declaration were followed.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

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La gestion adaptative comme approche pour améliorer la performance des projets de développement rural au Cameroun

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Résumé

L'objectif principal de cet article est de satisfaire à la nécessité d'améliorer les performances des projets de développement, ce qui contribue à l'efficacité de l'aide publique. Cette question est au cœur des préoccupations du gouvernement camerounais qui fait face au défi permanent d'améliorer les conditions de vie de sa population rurale. L'approche d'étude est explicative et s'attache à identifier les causes du problème afin de faire des propositions qui tiennent compte de l'incertitude rencontrée par la plupart des projets de développement. Après la revue de la littérature, l'état de l'art et le diagnostic, l'analyse des données met en évidence la nécessité de faire face aux risques dans la gestion des projets de développement. L'accent est donc mis sur la gestion adaptative qui propose un cadre managérial dont la performance dépend de la capacité de l'équipe projet à faire face aux risques et aux incertitudes tout au long du cycle de vie du projet. Loin d'ignorer les aspects techniques et les mérites des approches standards traditionnelles telles que le Cadre Logique (CL) utilisé dans la plupart des projets de développement au Cameroun, la gestion adaptative est une approche managériale qui s'adapte aux projets complexes tels que les projets de développement rural en mettant

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l'accent sur l'apprentissage et la prise de décision structurée pour résoudre les problèmes dans des contextes d'incertitude permanente.

Mots-clés: Projet de développement rural, gestion adaptative, incertitude, risque, performance

Adaptive management as an Approach to improve the Performance of rural development projects in Cameroon

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Abstract

This article aims to address the necessity for enhancing the performance of development projects, thereby contributing to the efficacy of public development assistance. This question is at the heart of the Cameroon government's concerns, which faces the permanent challenge of improving the living conditions of its rural population. The study has an explanatory approach and concentrates on determining the root causes of the issue in order to provide recommendations that consider the unpredictability that most development projects face. Following the review of the literature, the state of the art, and the diagnosis, the analysis of the data highlights the need to face risks in the management of development projects. The emphasis is therefore placed on adaptive management, which offers a managerial framework whose performance depends on the ability of the project team to deal with risks and uncertainties throughout the project life cycle. Far from ignoring the technical aspects and the merits of the traditional standard approaches, such as the logical framework used in most development projects in Cameroon, adaptive management is a managerial approach that adapts to complex projects, such as rural development projects, with an emphasis on learning and structured decision-making to solve problems in contexts of permanent uncertainty.

Keywords: Rural development project, adaptive management, uncertainty, risk, performance

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Introduction

Afin de réaliser sa vision 2035 qui vise à faire du Cameroun un pays émergent, démocratique et uni dans sa diversité, le gouvernement a adopté en 2020 un nouveau cadre de référence pour son action de développement au cours de la prochaine décennie. Il s'agit de la Stratégie Nationale de Développement (SND30) qui s'appuie sur les leçons de la mise en œuvre du Document de Stratégie pour la Croissance et l'Emploi (DSCE) 2010-2019. Cette stratégie repose sur quatre principaux piliers, dont i) la transformation structurelle de l'économie nationale par le développement des industries et des services, la productivité et la production agricoles, les infrastructures productives, l'intégration régionale et la facilitation des échanges, la dynamisation du secteur privé, la transformation du système financier ; (ii) le développement du capital humain et du bien-être ; iii) la promotion de l'emploi et l'intégration économique ; iv) la gouvernance, la décentralisation et la gestion stratégique de l'Etat (MINEPAT, 2020). La SND30 est une consolidation des stratégies sectorielles, notamment la Stratégie de développement du secteur rural et le Plan National d'Investissement Agricole (SDSR/PNIA) 2020-2030.

Pour mettre en œuvre ses différentes stratégies de développement et répondre à ses innombrables défis, le Cameroun a toujours eu recours à l'Aide Publique au Développement. Les interventions des Partenaires Techniques et Financiers (PTF) multilatéraux et bilatéraux dans le secteur rural représentent respectivement 17,37 % et 5,35 % de leur aide (rapport DAD-Cameroun sur l'Aide au Développement 2012-2013). Selon le même rapport et durant la période de 2009 à 2018, 18 organismes de financement ont pris leur engagement en faveur du secteur rural, pour un total de 83 projets répartis dans les dix régions du pays. Nonobstant l'intervention de ces multiples PTF, la plupart des projets de développement rural n'atteignent pas leurs objectifs. L'indice de pauvreté reste proche de 40 %, représentant près de dix millions de personnes défavorisées, dont la plupart se trouvent dans les zones rurales (INS, 2024).

Selon les estimations de la Société Financière Internationale (SFI), un projet sur deux échoue. Par ailleurs, l'un des phénomènes qui caractérise la gestion des projets de développement rural aujourd'hui au Cameroun est celui de la prorogation, preuve de l'incapacité du projet à atteindre ses résultats dans les délais prescrits. Les problèmes de gestion des projets d'aide au développement dans les pays en développement sont légion (Ika, 2011). Traditionnellement, l'Approche du Cadre Logique (ACL) est la méthodologie de gestion généralement utilisée par les planificateurs et les exécutants de ces projets, qui adoptent l'hypothèse optimiste que le projet évoluera dans un environnement stable. Cependant, dans la pratique, la volatilité et l'incertitude des conditions socio-économiques, voire politiques, sont des événements

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potentiels qui apparaissent au moins une fois au cours du cycle de vie d'un projet exigeant des équipes de projet un certain niveau d'adaptation.

En réponse aux imperfections des approches traditionnelles qui révèlent souvent des limites dans des environnements économiques difficiles caractérisés par un niveau élevé d'incertitude, il serait important d'adopter une approche de gestion qui prenne en compte tous ces aléas. Dans cet article, nous proposons une approche agile de gestion des projets de développement qui tire parti et élimine les inconvénients des approches de gestion traditionnelles afin de contribuer efficacement à la réalisation des objectifs de développement contenus dans la SND30.

Méthodologique

L'approche méthodologique de cette étude repose sur la revue de la littérature et l'observation participante. La revue de la littérature a servi de base aux différents travaux pour non seulement comprendre le contexte et les enjeux du développement du secteur rural camerounais, mais aussi apporter des connaissances suffisantes sur la gestion adaptative des projets et les principaux arguments des auteurs qui l'ont expérimentée ou étudiée. Dans le souci de renforcer notre argumentaire, de contextualiser et d'assurer la pertinence de notre étude, huit articles traitant respectivement des critères de succès des projets, de la gestion agile et de l'incertitude dans les projets de développement ont été consultés. L'observation participative, quant à elle, a facilité notre immersion dans le domaine de la gestion des projets de développement au Cameroun afin d'observer les comportements, les interactions et les pratiques managériales en cours dans ce type de projet. Elle nous a également permis de prendre des notes sur les attitudes, le langage, les normes et les valeurs, de mener des entretiens informels avec les parties prenantes pour mieux comprendre leurs pensées et leurs expériences vécues.

Ce faisant, en utilisant ces deux méthodes qualitatives dans le cadre de notre étude, nous ne prétendons pas manipuler les variables, nous recherchons plutôt leur connexion. L'objectif est de contribuer à l'amélioration de la performance des projets de développement rural au Cameroun, en proposant une approche managériale qui tienne compte des incertitudes et du caractère dynamique de l'environnement dans lequel évoluent ces projets.

Résultats

L'incertitude : caractéristique implicite de la gestion de projets

Un projet est défini comme un ensemble unique d'activités ayant des objectifs plus ou moins clairement définis, réalisées dans le cadre d'un budget et d'une durée limités. Généralement, la gestion de projet nécessite une attention particulière sur deux grands domaines de responsabilité : (i) la gestion des tâches ; et (ii) la gestion des relations avec les parties prenantes.

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Les projets de développement, quant à eux, ont tendance à présenter de nombreuses incertitudes en raison du manque d'informations ou de la disposition d'informations peu fiables, de la survenance des nouvelles technologies, de la complexité du projet, de la multitude des parties prenantes, de la divergence, de la perception de satisfaction et des attentes des parties prenantes ou même des facteurs imprévisibles. Ce qui rend la tâche difficile à la plupart des coordonnateurs de projet, c'est la complexité et l'incertitude du projet.

Selon Simon (1965), la complexité peut être définie comme « un système constitué d'un grand nombre de parties qui interagissent de manière non simple… [de telle sorte que] étant donné les propriétés des parties et les lois de leurs interactions, il n'est pas trivial d'en déduire les propriétés de l'ensemble ». On distingue couramment deux principales sources de complexité dans les projets : la complexité des tâches et la complexité relationnelle. En général, la complexité des tâches est définie comme une caractéristique objective d'une tâche du point de vue structuraliste et des besoins en ressources, déterminée à partir de l'expérience subjective des exécutants de la tâche du point de vue de l'interaction. Elle fait par exemple référence au nombre de composants en interaction du projet. Pour ce qui est de la complexité relationnelle, elle est la résultante de l'existence de multiples parties prenantes ayant des intérêts contradictoires. Ces intérêts contradictoires peuvent conduire à des désaccords sur les objectifs du projet et sur les priorités entre les tâches et les caractéristiques du résultat du projet. Ce type de complexité peut être géré grâce aux tableaux de responsabilités linéaires ou à l'analyse des champs de forces.

Selon la norme ISO 31000 :2018, « l'incertitude est l'état, même partiel, de défaut d'information concernant la compréhension ou la connaissance d'un événement, de ses conséquences ou de sa vraisemblance ». Les risques du projet trouvent leur origine dans l'incertitude présente dans tout projet (PMI, 2017). D'après Chapman et Ward (2003), l'incertitude est générée non seulement par la variabilité, mais également par l'ambiguïté (ambiguïté sur les objectifs du projet, sur les priorités ou sur la base d'estimation des paramètres du projet). Les incertitudes sont donc considérées comme des déclencheurs de risques potentiels, le risque étant l'impact ou le résultat possible d'une situation incertaine. Toute incertitude produit une exposition aux risques qui, en termes de gestion de projet, peut entrainer un échec relatif soit au respect du budget, soit à l'atteinte de la date d'achèvement requise ou à l'atteinte des objectifs de performance.

Dans le but de coupler les risques aux objectifs de l'organisation, la norme ISO 31000 considère le risque comme étant l'effet de l'incertitude sur les objectifs d'une organisation. Les organisations perçoivent les risques comme l'effet de l'incertitude sur les objectifs du projet, se traduisant par une

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déficience d'information dans toute phase ou activité du processus. Ceci signifie que certaines informations pertinentes sur le résultat d'un processus ou d'une décision future ne sont pas connues ou connaissables. L'information est donc une ressource indispensable à la prise de décision, parce qu'elle réduit l'incertitude de l'organisation vis-à-vis d'une situation ou face à un problème donné. L'absence d'informations ou de connaissances disponibles est l'une des causes des incertitudes dans un projet. En effet, l'implémentation des activités d'un projet est soumise à de nombreuses incertitudes d'origine diverse : indisponibilité de certaines ressources, retard de livraison de composants ou matériels, changement du périmètre du projet, échec dans la réalisation d'une étude, nouvelles activités à réaliser non prévues, etc.

Il existe de nombreuses façons de classer les différents types d'incertitude. Meyer et al. les catégorisent en fonction de leur impact, de l'incertitude prévue, de l'incertitude imprévue et du chaos. Certains chercheurs classifient l'incertitude en fonction de leurs sources. C'est le cas par exemple de Perminova et al. (as cited Kreye & Balangalibun, 2015) qui décrivent les sources d'incertitude suivantes : l'incertitude technologique, des ressources, de la concurrence, des fournisseurs, des consommateurs et politique. Ward & Chapman (as cited Kreye & Balangalibun, 2015) se sont concentrés sur les incertitudes qui ont une grande influence sur la gestion de projet, telles que la conception, la logistique, les objectifs, les priorités et les relations entre les parties du projet, pour définir les différentes catégories d'incertitudes. Kreye & Balangalibun (2015) précisent que l'incertitude du projet fait référence à l'incertitude entourant les objectifs définis par le projet. Elle est principalement liée aux mesures de performance du projet (coût, durée ou qualité) et découle de la variabilité des estimations. Cette variabilité peut provenir d'un manque de clarification des spécifications ou des exigences en raison de l'inexpérience dans le projet, de la complexité des processus du projet, des parties impliquées, d'événements inattendus ou de biais des concepteurs et des décideurs. Une autre source d'incertitude peut résider au sein de l'organisation. L'incertitude organisationnelle est liée aux questions stratégiques, telles que l'orientation future de l'organisation, et aux questions structurelles telles que la structure organisationnelle, les fonctions des différents départements, les processus métier, des modifications de la structure organisationnelle ou l'introduction de nouvelles technologies. L'incertitude peut également provenir des partenaires du projet et de la relation entre eux, entraînant une incertitude relationnelle. L'incertitude relationnelle intègre la compréhension des parties prenantes, de leur influence et de leur intérêt pour le projet. Elle inclut la qualité et la fiabilité du travail des partenaires, leur capacité à aligner leurs objectifs aux objectifs généraux du projet. Ceci est particulièrement important lorsque la réussite du projet dépend de la qualité des services rendus par ses partenaires.

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Sur la base des réflexions de Chapman et Ward (2003), l'incertitude est inhérente à tout projet, et la plupart des activités de gestion de projet consistent à gérer l'incertitude dès les premières étapes du cycle de vie du projet, à clarifier ce qui peut être fait, à décider ce qui doit être fait et à s'assurer qu'il se fait. Il s'agit également d'une ambiguïté associée à un manque de clarté en raison du comportement des acteurs du projet, du manque de données, du manque de détails, du manque de structure pour prendre en compte les problèmes, des hypothèses de travail et de formulation utilisées pour prendre en compte les problèmes, connus et inconnus.

Selon Chapman et Ward (2003), les aspects d'incertitude peuvent être présents dans l'ensemble du cycle de vie du projet, mais ils sont particulièrement évidents dans les étapes de pré-exécution, lorsqu'ils contribuent à l'incertitude dans cinq domaines :

1. variabilité associée aux estimations ;
2. incertitude sur la base des estimations ;
3. incertitude sur la conception et la logistique ;
4. incertitude sur les objectifs et les priorités ;
5. incertitude sur les relations fondamentales entre les parties du projet.

Dans la réalité, un projet affichera généralement un mélange de ces différents types d'incertitude. L'incertitude est donc une variable intrinsèque à la vie de tout projet. Le besoin de gérer l'incertitude est inhérent à la plupart des projets nécessitant une gestion formelle de projet. Le tableau n°1 résume et décrit les différentes catégories d'incertitudes dans les projets, en proposant un style de management adapté à chaque catégorie d'incertitude.

Tableau n°1 : Les différents types d'incertitudes de projet

Catégorie d'incertitude	Description	Style de gestion	
Variation	Les niveaux de coût, de temps et/ou de performances varient de manière incertaine dans une plage.	- Planification avec tampons ; - Exécution disciplinée.	Planification
Incertitude prévue	Influence majeure sur le projet à partir de quelques facteurs individuellement identifiables. Le facteur est connu, mais on ne sait pas quelle valeur il prendra.	- Identification des risques ; - Prévention ; - Planification d'urgence.	
Incertitude imprévue	Facteur d'influence majeur (ou quelques-uns) n'est pas du tout anticipé par l'équipe de projet, ni planifié ni prévu.	Apprentissage : nouvelle résolution de problèmes, avec modifications des cibles et de l'exécution.	Apprentissage
Turbulences, chaos.	L'objectif, la stratégie et l'approche du projet sont complètement invalidés par des événements imprévus et le projet doit être redéfini.	Redéfinition complète répétée du projet	

Source : Adapté d'Arnoud et al. 2002, P.27

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Ainsi, l'un des principaux défis pour l'équipe de projet réside dans la détermination d'un degré d'incertitude acceptable afin de maximiser la création de valeur, objectif considéré comme le postulat de base dans le concept de management des risques. La gestion de l'incertitude dans les projets est donc une activité continue axée sur l'identification et la gestion de toutes les sources d'incertitude constituant des menaces ou des opportunités.

Approches traditionnelles de gestion des projets

La gestion traditionnelle des projets est une méthodologie de gestion des projets qui se déroule selon un cycle séquentiel (ou en cascade) d'étapes qui comprend généralement : le lancement, la planification, l'exécution, le suivi et contrôle, et la clôture (Szreder et al., 2019). Chacune de ces étapes est décrite dans les référentiels de gestion. La gestion traditionnelle de projet est assimilée à la gestion « push », dans laquelle les objectifs et la manière dont le projet doit être réalisé sont définis par la haute direction. Ceci conduit à un haut niveau d'effort de planification et de coordination, une faible marge de manœuvre et une faible capacité d'adaptation de l'équipe de mise en œuvre du projet.

Il existe plusieurs référentiels dans le domaine de la gestion de projet traditionnelle. C'est le cas du Project Management Body of Knowledge (PMBOK), référentiel le plus connu, dont la première publication a été effectuée en 1996 par le Project Management Institute (PMI). Le PMBOK est organisé en domaines de connaissances et fournit les lignes directrices, des outils et techniques ainsi que des caractéristiques pour la gestion de projets, de programmes et de portefeuilles. À côté du PMBOK, nous avons le Projects In a Controlled Environment (PRINCE2), référentiel de gestion traditionnelle des projets adopté par les institutions gouvernementales de Grande-Bretagne et d'autres pays, mais aussi par des organisations privées. PRINCE2 met l'accent sur la division des projets en étapes gérables et contrôlables. En plus de ces deux approches de gestion traditionnelle, nous avons HERMES, qui est la méthode suisse de gestion de projet dans les domaines de l'informatique, mais qui peut être adaptée à tous types de projets pour le développement de services/produits et l'adaptation de l'organisation de l'entreprise. Dans le domaine de la coopération pour le développement, l'approche traditionnelle de gestion la plus connue est l'approche cadre logique (ACL) utilisée comme principal dispositif de la gestion du cycle de projet (GCP) appliquée depuis 1992 par la Commission européenne. La GCP est une expression utilisée pour définir l'activité de gestion et la prise de décision pendant le cycle du projet (Commission européenne, 2004).

L'ACL est l'une des méthodologies les plus utilisées par la plupart des agences d'aide multilatérale ou bilatérale, des ONG internationales et par bon nombre d'institutions. L'ACL et les outils correspondants sont utilisés pendant

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le cycle du projet pour faciliter l'analyse, la prise de décision et garantir les résultats d'une action de développement. Elle définit la structure du projet, les indicateurs et les hypothèses relatives au projet sous la forme d'une matrice dont les lignes représentent la chaîne des résultats. La matrice cadre logique d'un projet se définit en termes de hiérarchie des objectifs (moyens, activités, résultats, objectif spécifique et objectifs de développement) avec une série d'hypothèses et un cadre pour le suivi et l'évaluation des réalisations (indicateurs et sources de vérification). Dans le cadre de la GCP, le projet est subdivisé en phases telles que la programmation, l'identification, le développement, le financement, la mise en œuvre et l'évaluation. Le projet, principal instrument de la GCP, est utilisé dans la planification des activités de coopération pour le développement. Il comprend des activités interdépendantes et coordonnées conçues pour atteindre des résultats clairement définis, allant du changement de politique à une action directe pratique (OIT, 2015). Il contribue à la résolution d'un problème de développement spécifique dans un délai et un budget donnés.

Toutes ces approches de gestion traditionnelle de projets utilisent des outils et techniques plus ou moins similaires pour mettre en œuvre les processus de gestion. Une fois les phases de formulation et de planification achevées et un plan d'affaire ou une proposition de financement soumis pour approbation, les interventions pour apporter des modifications deviennent limitées. Ce n'est qu'après la phase de contrôle que des ajustements nécessaires peuvent être apportés à mesure de l'apparition des changements. Le chef de projet est responsable de la coordination des contributions de toutes les parties prenantes du projet afin de répondre aux différents besoins et attentes. Toutefois, cela pourrait être de nature très complexe et impliquer d'intenses négociations et résolutions de conflits, dans la mesure où les différentes parties prenantes pourraient avoir des attentes différentes. En outre, pour des raisons politiques et autres, les décideurs du projet pourraient ne pas prendre en compte de manière adéquate (ou prendre en compte tardivement) les évaluations d'impact environnemental ou des changements brusques du contexte national ou international. C'est le cas, par exemple, de l'avènement de la pandémie de COVID-19 qui a provoqué une crise sanitaire et socio-économique mondiale dont les conséquences sont sans précédent.

Le PMBOK, PRINCE2 ou l'ACL sont des référentiels de gestion de projet prédictive. Ils se concentrent sur la planification du projet, l'exécution du projet conformément au plan, la vérification des écarts et la prise de mesures si nécessaire. En se référant à Cooke-Davies (2002), ces référentiels fonctionnent bien, à condition que les exigences soient très stables et que la technologie soit familière. Bien que ces standards soulignent l'importance des compétences générales, ces modèles de gestion de projet sont particulièrement mécanistes. En d'autres termes, ceci implique que la gestion de projet repose

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sur l'hypothèse que les résultats futurs peuvent être prédits avec précision sur la base des informations et des actions actuelles. Cette approche suppose également que les événements du projet sont prévisibles et que les outils et actions sont compréhensibles. La conclusion d'une phase donnée signifie qu'elle n'est plus exposée à aucune nouvelle analyse ni à aucun changement.

Dans l'approche traditionnelle, le produit ou résultat final n'est visible par le client ou le bénéficiaire que vers la fin du projet (effet tunnel), et le produit est rigide, car il est difficile pour le client de changer d'avis sur une fonctionnalité du produit durant la phase d'exécution. Les méthodologies traditionnelles de gestion de projet sont efficaces pour les projets de construction, où l'ensemble du projet peut être achevé en un seul cycle, et le succès est déterminé par l'obtention des résultats attendus dans les délais et dans le budget du projet (NEAGU, 2013). Pourtant, il est implicitement reconnu que les actions et interactions humaines (et leurs conséquences) peuvent être objectivement observées puis corrigées ou contrôlées. L'une des principales limites de cette approche réside dans le flux séquentiel d'actions basé sur des exigences que les acteurs ne sont souvent pas en mesure de déterminer au début, ce qui constitue des difficultés de planification réelle. L'un des facteurs d'échec des projets de développement est l'incapacité à cerner tous les besoins des bénéficiaires, d'autant plus que ces besoins, qui sont identifiés et analysés durant la phase de formulation, peuvent changer à une fréquence qui dépend de plusieurs paramètres, entre autres, le contexte dynamique, le cycle de vie du projet, le délai entre la phase de formulation et la phase de mise en œuvre effective du projet… En outre, la planification est continuellement influencée par les apports politiques d'une grande variété de parties prenantes et d'acteurs. En raison de la dynamique politique, des complexités du développement, des contraintes de ressources et des risques, les chefs de projet se retrouvent généralement dans un environnement hostile où la mise en œuvre intégrale des plans préétablis est pratiquement impossible.

Si pendant longtemps l'accent a été mis sur les aspects techniques de la gestion des projets de développement, de nos jours des voix s'élèvent pour attirer l'attention sur l'importance des facteurs managériaux et surtout humains à travers l'adoption des pratiques managériales qui se veulent agiles. La gestion des projets dans des conditions de complexité et d'incertitude oblige l'équipe de projet à faire preuve de créativité et d'adaptation. Cela nécessite un changement de réflexion sur la manière dont les projets de développement, y compris ceux du secteur rural, doivent être planifiés, programmés et exécutés.

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Complexité et incertitudes : principales spécificités des projets de développement rural

Un projet de développement peut prendre la forme de dons, de prêts à taux préférentiel ou d'annulation de dette et est généralement mis en œuvre conjointement par un donateur et des acteurs locaux des pays bénéficiaires à travers un cycle de vie. Les activités qui composent ce type de projet ne sont pas de simples tâches répétitives, comme peindre les pièces d'une maison ou laver un véhicule. Au contraire, elles sont complexes. En effet, le projet doit parfois couvrir plus d'une zone géographique au cours d'une même période et le changement attendu doit avoir lieu chez des bénéficiaires dont les caractéristiques socio-économiques sont différentes. C'est pour cette raison que nous rejoignons Cooke-Davies (2002) dans le sens où la réussite des projets de développement dépend de la capacité de l'équipe de projet à gérer efficacement toutes les ambiguïtés.

Le cadre logique ou cadre de résultat définit la séquence d'activités à réaliser pour aboutir au changement souhaité à l'issue de l'implémentation d'un projet de développement. Ces différentes activités sont interdépendantes, car le résultat d'une activité est une donnée d'entrée d'une autre, nécessaire à la réalisation d'un ou plusieurs résultats mesurés par des indicateurs objectivement vérifiables. Cette interdépendance ajoute un niveau de complexité et de communication qu'il faut être capable de gérer pour assurer l'avancement du projet, l'utilisation efficace et efficiente des ressources financières, la satisfaction des différentes parties prenantes et la durabilité avant sa date d'achèvement. La mise en œuvre de toute activité ou lot d'activités par l'équipe de projet est soumise à l'obtention préalable d'un avis de non objection obtenu auprès du bailleur de fonds.

Les projets de développement sont des organisations à faible maturité (Khan & Zahid, 2013) car leur organisation, relativement nouvelle dans la gestion formelle, ne met généralement pas en œuvre les processus de gestion des risques de projet en raison de certaines contraintes ou difficultés. C'est la raison pour laquelle l'externalisation, encore appelée « faire faire », est utilisée pour réaliser les composantes dans la plupart des interventions de développement, car le projet ne dispose généralement pas de ressources humaines suffisantes pour mettre en œuvre toutes les activités dans les délais impartis. Il s'agit de confier la mise en œuvre d'un certain nombre d'activités du projet à des prestataires privés ou publics. Cette approche d'intervention vise non seulement à garantir l'ancrage institutionnel des prestataires, mais aussi la durabilité de l'appui en renforçant les capacités des acteurs locaux dans la fourniture de services dans le domaine du développement socio-économique à la base. Cependant, son application est source d'incertitude en raison de la qualité des prestations fournies, parfois conséquence de l'indisponibilité de l'expertise locale.

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Selon la norme ISO 31000V2018, « l'incertitude est l'état, même partiel, de manque d'information concernant la compréhension ou la connaissance d'un événement, de ses conséquences ou de sa vraisemblance ». Elle est générée non seulement par la variabilité, mais aussi par l'ambiguïté (Chapman et Ward, 2003), et les risques de projet naissent de l'incertitude présente dans tout projet (PMI, 2017). Pour Wysocki (2014), ces deux termes sont indissociables. En effet, plus le niveau de complexité d'un projet est élevé, plus il s'accompagne d'un niveau d'incertitude. En raison des nombreux aléas et incertitudes qui l'affectent, on constate que la réalisation des activités d'un projet de développement devient de nos jours de plus en plus complexe et incertaine au vu de l'apparition d'événements défavorables imprévus qui influencent l'atteinte des résultats. Il revient donc à l'équipe projet d'ajuster ses approches de gestion de projet pour gérer l'incertitude afin que cette dernière puisse non seulement s'adapter au changement, mais aussi l'accepter et ainsi devenir plus efficace.

Gestion adaptative des projets

Les projets de développement rural s'inscrivent généralement dans des environnements complexes et dynamiques qui impliquent de nombreux éléments imprévisibles avec diverses parties prenantes et sont caractérisés par un degré élevé d'incertitude. La plupart de ces projets n'atteignent pas les objectifs escomptés, en grande partie parce que les approches traditionnelles ou conventionnelles de gestion de projet ne permettent pas de s'adapter convenablement à un environnement en perpétuelle dynamique. Dans un tel environnement, une approche adaptative de planification et de pilotage des projets complexes est nécessaire pour permettre à l'équipe de projet de faire preuve de créativité dans l'exécution de toutes leurs activités.

Le terme « gestion adaptative » ne date pas d'aujourd'hui. Historiquement, il tire ses origines de la gestion adaptative des ressources naturelles qui remonte aux travaux de Beverton et Holt (1957) dans la gestion des pêcheries (Williams, 2011). Le concept devient courant lorsque C. S. Holling, considéré comme le « père » de la gestion adaptative, publie son ouvrage « Adaptive Environmental Assessment and Management » en 1978 (Holling, 1978). Durant cette période, la gestion adaptative correspond à une méthode permettant de sonder la dynamique et la résilience des systèmes tout en poursuivant la gestion par des expériences de gestion développées pour améliorer l'apprentissage et réduire l'incertitude (Allen et al., 2011). À la suite de Holling, dont les travaux avaient pour objectif de combler le fossé entre la science et la pratique, Carl Walters (1986) a traité les activités de gestion comme des expériences conçues pour réduire l'incertitude. Dans le domaine de la coopération au développement, c'est à partir de 1983, face aux nombreux problèmes liés à l'incertitude du travail de développement, que Dennis

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Rondinelli a préconisé l'utilisation d'approches plus itératives et adaptatives qui privilégient un apprentissage progressif (Michael, 2020). Dès lors, le concept de gestion adaptative s'est appliqué dans plusieurs domaines d'activités, dans différents contextes sociopolitiques et par plusieurs acteurs.

Également connue sous le nom de gestion de projet « agile », la gestion de projet adaptative est un processus structuré et itératif de prise de décision solide face à l'incertitude (Michael, 2020). C'est un ensemble de modèles de cycle de gestion de vie de projet qui peut être utilisé pour gérer des projets complexes dont les objectifs sont clairement spécifiés mais dont les solutions ne sont pas connues au début du projet (Wysocki, 2014). Pour Walters (as cited Allen et al., 2011), la gestion adaptative est une approche de gestion des ressources qui met l'accent sur l'apprentissage par la gestion, basée sur la philosophie selon laquelle les connaissances sont incomplètes et qu'une grande partie de ce que nous pensons savoir est en réalité erronée, mais malgré l'incertitude, les gestionnaires et les décideurs politiques doivent agir. Il s'agit d'une approche de mise en œuvre du cycle de programme qui vise à mieux atteindre les résultats et les impacts souhaités grâce à l'utilisation systématique, itérative et planifiée des connaissances et des apprentissages émergents tout au long de la mise en œuvre des stratégies, des programmes et des projets.

En se référant à ces différentes définitions, la gestion adaptative est une approche qui s'accommode aux projets complexes afin de permettre aux équipes de projets de prendre des décisions pour anticiper l'avènement des risques et faire des ajustements nécessaires à l'atteinte des résultats. D'après Michael (2020), la gestion adaptative repose sur les cinq principes suivants :

- L'acceptation de l'incertitude sur ce qui fonctionne ou non afin de relever les défis ;
- Se focaliser davantage sur le pourquoi ? et moins sur le comment ? l'important étant d'atteindre les buts avec les ressources disponibles ;
- Prise de décision itérative pour pouvoir s'adapter rapidement et apporter des ajustements sur la base des leçons apprises ;
- Apprentissage continu et rapide par tâtonnement et/ou testant des différentes approches ;
- Une attention particulière sur le relationnel en mettant l'humain au cœur des processus car, plus une situation est complexe, plus les compétences, la motivation et le savoir-être des personnes sont importants.

Ces différents principes résument les éléments d'un processus itératif d'amélioration continue axé sur une prise de décision structurée et l'apprentissage (cf. figure 1).

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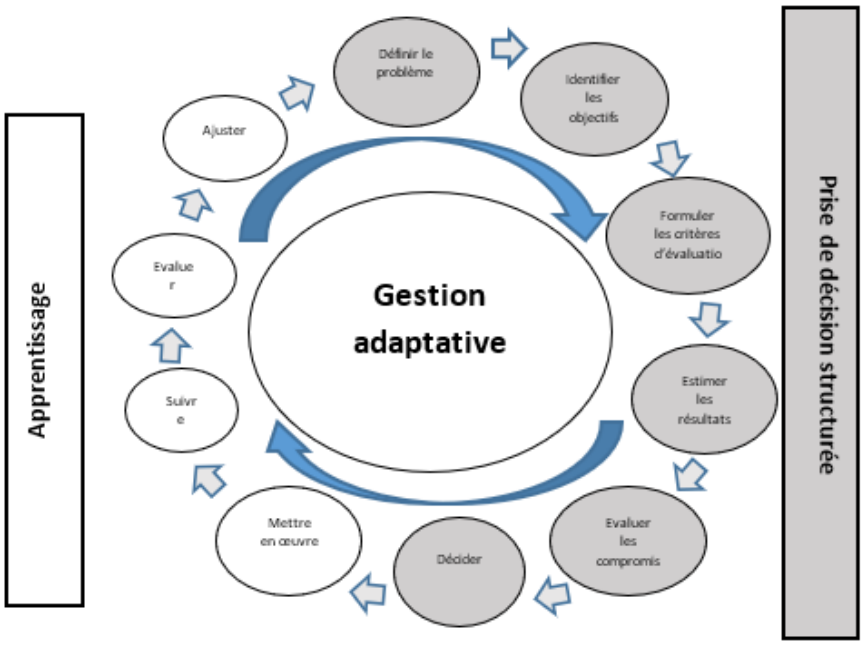
Figure 1 : processus de gestion adaptative des projets



Source : adapté d'Allen et al. 2011, P.1340

Comme l'illustre la figure 1, le processus de gestion adaptative est composé de deux phases principales (prise de décision structurée et apprentissage) qui permettent aux praticiens d'apprendre en faisant. La prise de décision structurée est une approche de résolution de problèmes empruntée aux domaines sociologiques, utilisée pour identifier et évaluer des options alternatives de gestion des ressources en impliquant les parties prenantes, les experts et les décideurs dans le processus de décision et en abordant la complexité et l'incertitude inhérentes pour gérer les ressources de manière proactive et transparente. Le cadre de prise de décision structurée fournit un modèle idéal pour faciliter le processus de prise de décision inhérent à la gestion adaptative. L'objectif clé de la gestion adaptative est l'identification et la réduction de l'incertitude partout où cela est possible. Cette réduction est rendue possible grâce à des expériences de gestion qui améliorent l'apprentissage. Ainsi, la gestion adaptative se caractérise par une méthodologie flexible qui implique des tests, un suivi, une rétroaction et des ajustements si nécessaire. C'est ce qui caractérise l'approche adaptative de l'approche traditionnelle qui est plus linéaire et mécanique.

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Différences entre l'approche adaptative et l'approche traditionnelle

Leau et al. (2012), Nerur et al. (2005) ainsi que Nerur & Balijepally (2007) ont identifié des caractéristiques adaptées à chaque approche permettant d'établir une distinction claire.

Tableau n°2 : Différences entre l'approche traditionnelle et l'approche adaptative

Critères /aspects	Approche adaptative	Approche traditionnelle
Analyse des exigences	Approche itérative	Profil d'exigences détaillé
Modification des coûts	Faible	Elevé
Développement de la Direction	Peut être modifié à tout moment	Fixe
Test	Après chaque itération	Quand la phase de développement est achevée
Interaction avec le client ou bénéficiaire	Forte	Faible
Mise à l'échelle du projet	Projet de taille faible à moyenne	Projets étendus
Cible	Adaptation, flexibilité, réactivité	Optimisation
Environnement	Turbulent, difficile à prévoir	Stable, prévisible
Rationalité	Substantiel	Technique/Fonctionnel
Structure organisationnelle	Biologique (flexible, coopératif et participatif)	Mécanique (bureaucratique avec une formalisation élevée)
Gestion	Leadership et collaboration	Commander et contrôler
Focus	Centré sur l'humain	Centré sur le processus
Rôle du client	Critique	Important
Gestion des connaissances	Tactique	Explicite
Type d'apprentissage	Double boucle, générative	Boucle unique, adaptative
Cycles de projet	Guidé par les fonctions du produit	Guidé par des tâches et des activités
Modèles de développement	Modèle de prestation évolutif	Modèle de cycle de vie (cascade, spirale, etc.)
Répartition des rôles	Equipes auto-organisées	Individuelle, Spécialisation privilégiée
Résolution du problème	Apprendre en expérimentant et en recadrant constamment le problème et la solution	Sélection des moyens les plus appropriés pour réaliser et mener à bien une activité donnée et largement planifiée et formalisée.

Source : nos soins issus de la revue littérature

Comme nous l'avons mentionné dans les paragraphes précédents, l'approche adaptative est adaptée aux projets complexes et est propre à chaque projet. Cependant, la mise en place de cette approche de gestion qui s'adapte continuellement à l'évolution de la situation et de son environnement nécessite la création préalable d'un environnement agile. L'environnement agile repose

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sur une ressource humaine de qualité ayant un esprit d'équipe au sein d'une culture organisationnelle adaptée.

Ressources humaines. Compte tenu du fait que l'attitude face aux incertitudes et aux changements diffère d'un individu à l'autre, le chef de projet, dans le processus de constitution de son équipe, doit être capable de répondre efficacement aux principales préoccupations suivantes : Quelles sont les compétences fondamentales pour soutenir une intervention agile ? Comment développer des compétences globales favorables à l'agilité telles que la confiance, le relationnel et la pensée critique ? Michael (2020) a identifié les principales compétences et attitudes personnelles susceptibles de faciliter la construction d'un management agile, notamment : la capacité d'anticiper pour réfléchir à des scénarios de développement potentiels ; la curiosité ; de solides capacités de communication et d'écoute ; la pensée critique indispensable dans le processus de prise de décision basée sur des faits ; Être capable de s'adapter face à l'incertitude et au changement.

L'esprit d'équipe est le deuxième pilier qui soutient un environnement agile. Dans la mesure où l'avènement des incertitudes et des changements ont un impact global sur les organisations, et sur les ressources humaines en particulier, le renforcement des liens humains entre les membres d'une équipe de projet est un facteur de résilience déterminant pour la continuité de la mise en œuvre des activités d'un projet. La conscience collective et la culture du risque face aux enjeux et défis doivent être construites pour pouvoir répondre aux enjeux et s'adapter à la complexité.

La culture organisationnelle qui guide les actions et les comportements des membres d'une équipe agile doit être construite autour de valeurs telles que : la résilience, la flexibilité, la confiance en soi, l'innovation, la transparence, la responsabilité sociétale, la performance, l'éthique et la sécurité. Elle permet une cohésion dans l'équipe projet en favorisant l'amélioration des performances de l'entreprise et l'adaptation face aux incertitudes et aux changements. Pour le faire, le coordonnateur de projet doit créer un environnement qui facilite les communications interpersonnelles, la transparence, les encouragements par des récompenses significatives, le développement personnel et la flexibilité.

- Dans le cadre des projets de développement, la mise œuvre de la gestion adaptative des projets ne dépend pas uniquement des équipes de projet. Elle est fortement influencée par les sources de financement dont chacune dispose des modalités ou procédures de fonctionnement ou de financement qui ont un impact non négligeable dans la gestion opérationnelle des projets de développement. Hormis les bénéficiaires, il existe généralement deux principales sources de financement d'un projet de développement rural : le gouvernement et le bailleur de fonds. Au Cameroun, les fonds de contrepartie qui représentent la part que

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supporte l'État dans le cadre de la mise en œuvre d'un projet à financement conjoint, en application d'une convention de prêt ou de don, font parfois face aux retards de mobilisation, avec pour conséquence de faibles taux de décaissements. Michael (2020) énumère des propositions que les bailleurs de fonds peuvent initier pour veiller à l'agilité des systèmes de financement, de planification ainsi que la gestion des performances. Il s'agit notamment :

- Accepter l'incertitude au démarrage d'une intervention quant aux résultats qui pourraient être obtenus en permettant, par exemple, l'affinage des objectifs et des indicateurs pendant une période de lancement ;
- Adapter les instruments de financement à la complexité d'une situation et/ou des objectifs stratégiques ;
- Intégrer dans les contrats des « fonds de crise », c'est-à-dire des dispositions d'ajustement en cas de crise qui permettent de modifier l'allocation budgétaire ou de fournir des fonds supplémentaires sans modifier l'accord de subvention ;
- Permettre une plus grande prise de décision par le personnel du bailleur de fonds le plus proche de la mise en œuvre de l'intervention ;
- inclure dans les critères de sélection des propositions une vérification sur les capacités d'une organisation à s'ajuster à différents moments de l'intervention ;
- Simplifier et rationaliser les processus de validation des demandes de modification des budgets, des activités et des cadres de résultats (par exemple, ajout d'une période de démarrage après laquelle des résultats plus affinés peuvent être spécifiés) ;
- Financer de manière adaptée les mécanismes de suivi et d'apprentissage dans les budgets;
- Adapter les cadres de suivi des résultats pour mieux reconnaître la réussite des interventions complexes, en recherchant selon les cas la contribution aux changements, plutôt que les résultats qui ne peuvent être attribués qu'à une seule intervention.

Discussion

Ces dernières années, les discussions se sont multipliées sur la manière dont l'aide au développement devrait contribuer efficacement à un changement transformateur. Cette transformation vise à répondre aux grands défis du développement par un changement durable des systèmes de gestion. Il ne s'agit pas de renoncer absolument aux normes d'approche traditionnelles ou de multiplier les nouveaux outils et techniques qui pourraient alourdir la gestion des projets de développement. Il s'agit plutôt de mettre en place un système qui facilite la création et la mise en œuvre d'un environnement

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adaptatif qui contribue à l'atteinte des résultats de développement tout en améliorant la capacité à faire face aux changements ou aux incertitudes qui surviennent.

Au terme de cette étude, nous pouvons conclure que l'application de la gestion adaptative dans le secteur rural au Cameroun nécessite certains changements dans le cycle de gestion du projet, notamment :

- **La culture de la pensée agile.** Pour réussir à mettre en œuvre l'approche adaptative, les équipes impliquées dans le cycle de vie d'un projet de développement doivent adopter un état d'esprit agile. Qu'il s'agisse du personnel du comité de pilotage, du partenaire technique et financier en amont ou de l'équipe de mise en œuvre en aval, l'état d'esprit agile, qui est un processus de réflexion impliquant la compréhension, la collaboration, l'apprentissage et la flexibilité pour obtenir des résultats réussis, doit être partagé. Ce n'est qu'en combinant cet état d'esprit agile avec des processus et des outils que ces équipes peuvent s'adapter aux changements et produire des résultats pertinents. L'état d'esprit agile est donc l'approche parfaite pour faire face à des environnements turbulents et difficiles, car il enseigne à adopter le changement plutôt qu'à l'éviter ;
- **Favoriser l'innovation au sein d'une équipe de projet.** Au lieu de se référer systématiquement aux manuels et autres procédures d'exécution pour la mise en œuvre des activités du projet, l'approche adaptative favorise la mise en place d'arrangements organisationnels qui favorisent l'innovation en permettant aux membres d'une équipe de fournir des retours d'information collaboratifs et constructifs, de produire de nouvelles idées menant à des expérimentations susceptibles de transformer la culture de l'équipe dans son ensemble. Cela est rendu possible lorsque suffisamment de temps et d'espace sont accordés pour expérimenter la créativité et la possibilité de penser librement ;
- **Mise en œuvre de l'amélioration continue.** L'amélioration continue est l'essence même d'un processus d'apprentissage durable. Puisque chaque activité mise en œuvre dans un projet semble être quelque chose de nouveau, et donc une opportunité d'apprentissage, les équipes doivent s'efforcer de trouver des moyens d'optimiser, de résoudre des problèmes, de réfléchir et d'améliorer continuellement les processus pour prétendre obtenir une certaine maîtrise au fil du temps ;
- **Satisfaction continue des bénéficiaires.** L'objectif d'un projet de développement est de satisfaire les besoins de la population ciblée en lui offrant de la valeur le plus rapidement possible. Étant donné que l'analyse des besoins est réalisée dans la phase d'identification du projet et que parfois beaucoup de temps s'écoule entre la phase de

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formulation et la phase de mise en œuvre du projet, il est important de procéder à une mise à jour fréquente des besoins afin de rassurer que les solutions apportées par le projet restent pertinentes. Cela passe souvent par la systématisation des mécanismes de feedback, de plaintes et de réponses dans l'organisation des projets de développement. Cela permet à une équipe agile d'anticiper un certain nombre de problèmes liés aux bénéficiaires et d'apporter des solutions fréquentes adaptées à leurs besoins. Un système de communication constante avec les bénéficiaires permet ainsi de définir leurs besoins réels afin de concevoir une offre pertinente.

- **Renforcement continu des capacités.** Etant des projets complexes qui évoluent dans des environnements difficiles, dynamiques et soumis à des risques de toute sorte, les projets de développement rural doivent se doter de ressources humaines dont les capacités doivent être continuellement renforcées pour répondre aux différents défis et enjeux. Outre les domaines techniques, le renforcement des capacités des membres d'une équipe agile doit porter sur des thématiques liées à la gestion des risques et du changement, à la gestion de la communication, à la technologie et au leadership. Cela s'inscrit dans le principe d'amélioration continue, indispensable pour assurer l'amélioration des performances d'une équipe projet.

Conclusions

Cet article invite la communauté mondiale de l'aide au développement à explorer le rôle que l'agilité peut jouer dans la conduite de changements transformationnels. Pour relever efficacement les grands défis tels que le changement climatique, la pauvreté, les inégalités, la violence et les conflits. Face à un environnement socio-économique en constante évolution, la plupart des chercheurs et praticiens en gestion de projets admettent qu'à l'exception des projets les plus simples ou des projets fréquemment répétés, il est difficile, voire impossible, de spécifier des exigences complètes au début d'un cycle de projet de développement et d'exécuter les activités exactement selon les plans établis.

Compte tenu de toutes ces limites et malgré l'existence de normes d'approche traditionnelles qui ont jusqu'à présent fait leurs preuves, le besoin d'agilité est essentiel pour améliorer substantiellement la performance des projets de développement. Sans être une panacée, la gestion adaptative de projets est une approche de gestion que nous proposons dans le cadre de cette étude pour améliorer les résultats des interventions de développement dans le secteur rural. Sans négliger les aspects techniques, cette approche met l'accent sur l'attitude et la capacité des ressources humaines à faire face aux incertitudes et aux changements tout au long du cycle de vie d'un projet. La

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prise de décision structurée et l'apprentissage soutiennent l'efficacité du processus de gestion adaptative dont l'existence dépend de l'harmonie des trois piliers de l'environnement agile.

L'indisponibilité d'informations sur la pratique formelle de l'approche adaptative dans la mise en œuvre des projets de développement au Cameroun constitue la principale limite de notre article. L'existence de telles informations permettrait de mieux comprendre l'approche, de faire ressortir les leçons apprises nécessaires à une meilleure capitalisation des expériences pour une diffusion factuelle.

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The Organizational Contribution of the PMO: An Assessment Using Structural Equation Modeling

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Abstract

This research is part of a thesis project that includes two main phases, and it aims to develop and examine a conceptual model to understand and verify the contribution of the PMO to the performance of Moroccan organizations as well as to their level of project management maturity in terms of organization and practices. Thus, the main objectives of this research are: (1) to examine the PMO's contribution to organizational performance and project management maturity, but also (2) to contribute to consolidating the theoretical basis of the project management school. To this end, a quantitative approach was adopted, with a questionnaire administered online over three consecutive months. Firstly, the president of the Moroccan chapter of PMI was contacted to solicit his collaboration. Secondly, direct interaction was carried out with people working in project management in organizations with a Project Management Office (PMO), who were able to respond to the questionnaire via the "LinkedIn" professional network. Two hundred and five (205) responses were received, of which seventy-six (76) were discarded because respondents stated that no PMO existed within their organization, or that it had existed for less than three years. Finally, one hundred and twenty-nine (129) responses were considered usable and represented our final database from which we proceeded to a series of analyses and tests. Data analysis was carried out in two stages. First, a descriptive and exploratory analysis of the data collected was carried out using SPSS. Then, a

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confirmatory analysis using structural equation modeling was carried out with SmartPLS to examine the validity of the model's concepts and test hypotheses. The results of this study provide a solid basis for linking PMO functions to organizational contributions. The study concluded that PMO functions contribute to organizational performance and project management maturity. It also highlights the mediating effect of project management maturity. However, the possible moderating effect of PMO type on structural relationships could not be verified.

Keywords: Project Management Office, Organizational performance, Project management maturity, Structural equation modeling

Introduction

There are several reasons that can lead organizations to implement a PMO. Reasons that consider the organizational context and market expectations (Alghadeer & Mohamed, 2016).

The PMO implementation is far from being standardized by a single approach (Andersen et al., 2007). Instead, it is guided by several factors that must be considered (Zouheir el al., 2020; Desouza & Evaristo, 2006; Andersen et al., 2007; Hobbs & Aubry, 2007), in addition to a multitude of barriers and challenges that must be addressed (Desta et al., 2006; Singh et al., 2009; Hubbard & Bolles, 2012; Oliveira et al., 2017).

Today, the true value of the PMO is perceived through its contribution to performance and the degree to which objectives are achieved (Pellegrinelli & Garagna, 2009). Thus, the creation of a PMO contributes primarily to the improvement of project management maturity (Hobbs & Aubry, 2007; Andersen et al., 2007; Al Ahmad, 2015), but also plays a key role in the success of projects within organizations (Kiani et al., 2015; Shalal et al., 2016; Aubry & Brunet, 2016; Lavoie-Tremblay et al., 2017; Szalay et al., 2017). Furthermore, the establishment of such an entity within the organization participates in the improvement of organizational performance and the development of project management by providing a range of management tools as well as strengthening communication within the organization (Zouheir et al., 2019; Rachid, 2019; Lavoie-Tremblay et al., 2012; Spalek, 2012).

According to Aubry et al (2010), the PMO is subject to events from its external and internal environment, just like the organization, which prevents it from following a clear life cycle. For this reason, the establishment of a sustainable PMO should be based on the reality of the organization’s environment and the recognition of the need to adapt to the changing users’ expectations and not necessarily the performance of the project (Kutsch et al., 2015).

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Indeed, the major obstacle to the PMO implementation remains the diversification of existing models in addition to the lack of a consensus on its added value within the organization (Ferreira et al., 2016). This ties in with the findings of Hobbs et al. (2008) who argue that when setting up the PMO, organizations should perceive the real value that this one will bring, by identifying in advance its mission and functions in line with organizational expectations, and not trying to imitate existing models that can lead to a total failure. In fact, the real value perceived through the PMO implementation lies primarily in the synergy between its functions and roles (Van der Linde & Steyn, 2016).

At this stage, the PMO as an organizational structure continues to attract the interest of researchers and practitioners around the world, increasingly focusing on areas that have not yet been explored or reinforcing and substantiating early findings.

In Morocco, despite the numerous projects, programs and portfolios launched every day, the role of the PMO is not very visible within organizations. Today, only some large organizations have embarked on the adventure of setting up a PMO. This implementation does not follow the same path and certainly does not have the same goals, since the framework in which it was carried out remains influenced by many factors.

This lack of visibility prompted our interest in conducting an initial research project closely related to this issue, and more specifically about the PMO's contribution to organizational performance and project management maturity.

Indeed, this research is part of a thesis project comprising two main phases; the first, which focuses on the problem of setting up the PMO, and the second, which is the subject of this research work, and which aims to develop and examine a conceptual model in order to understand and verify the contribution of the PMO to the performance of Moroccan organizations, as well as to their level of project management maturity in terms of organization and practices.

Accordingly, the main objectives of this research phase are as follows:

1) To examine the contribution of PMO to organizational performance and project management maturity, but also
2) To contribute to the solidification of the theoretical basis of the project management school.

Literature review

In recent years, the PMO concept has been increasingly associated with the success of projects, programs, and portfolios (Aubry & Brunet, 2016; Lavoie-Tremblay et al., 2017; Szalay et al., 2017) and is a key lever for performance improvement (Aubry et al., 2010).

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Today, the PMO is constantly under pressure (Aubry & Richer, 2011), due to numerous organizational expectations (Desouza & Evaristo, 2006; Hobbs et al., 2008; Alghadeer & Mohamed, 2016). It acts as a guarantor of improvement and expansion of best practices in project management (Hubbard & Bolles, 2012), but also as a catalyst for excellent project management (Hill, 2004), making the success of projects closely linked to an organization's ability to succeed in achieving these goals (Martin & Martin, 2012).

Effect on organizational performance

According to Aubry and Hobbs (2011), the PMO's contribution to organizational performance is the result of multiple values that exist within the organization. To measure this contribution, the two researchers drew attention to the fact that it is necessary to consider the possible changes that the PMO undergoes to get closer to reality. Based on an analysis of four case studies, Aubry et al. (2011) provided an initial examination of PMO's contribution to organizational performance using the competing values framework. They concluded that a paradox existed since the results obtained showed that there were oppositions between the two groups of respondents regarding the value of the PMO's contribution to organizational performance. The same approach was applied one year later where the PMO seemed to be an interesting transition towards supporting changes and contributing to organizational performance (Lavoie-Tremblay et al., 2012). This can be explained probably by the changes found in the context of the PMO that make the assessment of its contribution to organizational performance also change over time (Cunha & Moura, 2014).

Using the transition process model, Aubry (2015) attempted to explore the relationship that may exist between the factors promoting PMO change and performance improvement. The model adopted in this research was able to explain between 33% and 47% of the observed performance improvement within organizations. Aubry (2015) also provided strong arguments, justifying the need to consider and implement a change management plan to ensure better project performance and, consequently, better organizational performance.

For their part, Kutsch et al. (2015) used the BSC approach to assess the PMO's contribution to improving organizational performance. They used four main perspectives in their assessment approach: (1) The project value perspective, (2) The "user" perspective, (3) The internal process perspective, and (4) The learning and innovation perspective. The BSC approach has allowed researchers to have a contextual view of the PMO through the application of the strategic map, which provides a synthetic view of the different implications and contributions of the PMO within the organization.

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Indeed, Kutsch et al. (2015) concluded that the PMO through its services actively participates in the generation of value within any organization, especially regarding the actors benefiting from its services. These findings were also validated by Van der Linde and Steyn (2016) by assessing the effect of the PMO functions in the creation of value, both within projects and within the organization. To do so, both researchers assumed the existence of a set of effects created by the PMO and adding value to the organization, a value that can be positive or negative and that influences the organization's performance. The two researchers made a comparison before and after the implementation of the PMO and found that there was a clear improvement in project management that impact the overall performance of the organization.

On the other hand, perfect management of the PMO should be guaranteed to reach an improvement in organizational performance (Spalek, 2013), especially in terms of knowledge management and communication (Müller et al., 2013). Also, the operationalization of the PMO and its direct involvement in problem-solving can lead to improved management of initiatives and thus to improved organizational performance (Spalek, 2013; Sandhu et al., 2019).

However, we can clearly observe that the examination of the relationship between PMO and organizational performance has received little attention and is still generating more research due to the lack of a consensus on whether PMO contributes to the improvement of organizational performance or not. Indeed, the attempts to provide evidence supporting this relationship have yielded little empirical validation (Unger et al., 2012).

Effect on Project Management Maturity

One of the reasons behind implementing or changing the PMO remains the improvement of project management maturity (Hubbard & Bolles, 2012). The relationship between project management maturity and PMO can be characterized as circular and self-reinforcing (Hobbs & Aubry, 2007). Indeed, several studies have concluded that PMO contributes to the improvement of the level of project management maturity within organizations (Hobbs & Aubry, 2007; Andersen et al., 2007; Al Ahmad, 2015), but also that the success of its implementation remains under the influence of the organizational maturity level (Martins & Martins, 2012; Salamah & Alnaji, 2014).

According to Khaksefidi and Miri (2015), any attempt to implement the PMO within an organization without taking into consideration the organizational project management maturity level will fail. The positioning of the PMO within the organization is largely dependent on the level of project management maturity and its success will be enhanced if the latter is high (Salamah & Alnaji, 2014). By using correlation and regression statistical models, Khalema et al. (2015) confirmed the existence of a positive

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relationship between PMO maturity and organizational project management maturity. Indeed, PMO maturity and project management maturity are highly interdependent (Khaksefidi & Miri, 2015).

Through the results of their research program, Hobbs and Aubry (2007) concluded that the level of project management maturity can improve with the presence of an effective PMO. Indeed, over the course of its life, the PMO is likely to progress and become more mature, and thus participate in improving organizational project management maturity (Andersen et al., 2007). Hobbs and Aubry (2008) demonstrated a significant relationship between PMO maturity and its age. They concluded that, over time, the PMO contributes to the improvement of project management maturity within the organization through the implementation of numerous processes and tools.

Similarly, Blažević et al. (2014) confirmed the remarkable involvement of the PMO in improving the level of project management maturity. Most of the interviewees in their study emphasized the role of the PMO in this process through different initiatives. This ranges from standardizing data collection and processing to decision support (do Valle & Soares, 2014).

Aubry (2015) for her part, and by studying the evolutionary process of the PMO, showed that this one is also capable of improving the level of project management maturity within organizations. She even pointed out the need to rely on effective change management to achieve the desired objectives. Van der Linde and Steyn (2016), based on an analysis of maturity assessments conducted before and after the implementation of the PMO, found an impressive improvement in project management maturity within the organizations they studied. They found no other explanation except that the PMO was responsible for this improvement, primarily through the acquisition of knowledge from lessons learned in previous projects and by providing a range of project support and facilitation services.

Finally, although the current trend defends the idea that with an empowered PMO, organizations move on to the next stages of maturity (Al Ahmad, 2015), some research has highlighted contradictory results. Indeed, according to (Martins & Martins, 2012), there is no dependency between the existence of the PMO through its functions and competencies and the degree of project management maturity within organizations.

Methodology

Data Collection

The data collection for this research phase was characterized by the administration online of our questionnaire for 3 consecutive months, to analyze and understand the implications of PMO implementation regarding performance and maturity. Indeed, two main ways were adopted. Firstly, we

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contacted the president of the PMI Moroccan chapter to request their collaboration. Secondly, we interacted directly with people who could answer our questionnaire through the professional network "LinkedIn".

Sample

Our questionnaire was sent to people evolving in project management within organizations that have a Project Management Office (PMO). We received two hundred and five (205) responses, of which fifty-five (55) were discarded because the respondents declared the non-existence of a PMO within their organizations. Of the remaining one hundred and fifty (150) responses, we decided to retain the responses stating that the PMO has existed for at least three years. Finally, one hundred and twenty-nine (129) responses were considered usable and represent our final database from which we proceeded to a set of analyzes and tests to measure the PMO's organizational contribution in terms of project management performance and maturity.

Data analysis

We conducted a two-step data analysis. First, we conducted a descriptive and exploratory analysis of the data collected on SPSS (Version 25.0). Then, we proceeded with a confirmatory analysis using structural equation modeling, an analysis technique that uses both regression and factor analysis (Roussel et al., 2002), with the help of SmartPLS (Version 3.2.9) to examine the validity of the constructs of our model (Figure 1) and to test our hypotheses:

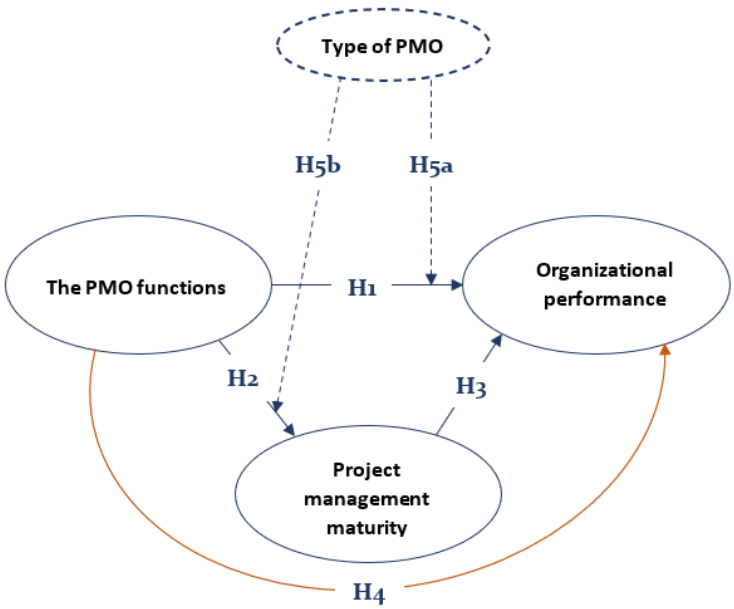

Figure 1: Conceptual model

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H1: The PMO through its functions contributes to organizational performance
H2: The PMO through its functions contributes to project management maturity
H3: Project management maturity contributes to organizational performance
H4: Project management maturity has a mediating role between the functions performed by the PMO and the organizational performance
H5a: The type of PMO has a moderating role on the relationship between the functions performed by the PMO and the organizational performance
H5b: The type of PMO has a moderating role on the relationship between the functions performed by the PMO and the project management maturity

Results and discussion

Exploratory analysis

At the end of this exploratory analysis, we can conclude that the results obtained are promising (Table 1). The KMO value clearly exceeds the threshold of 0.5 and Bartlett's sphericity test yielded sufficiently high values at a significance level of p< 0.000, which fulfills the criteria of sample adequacy for factor analysis. On the other hand, Cronbach's α is well above 0.8 for all indicators. The unidimensionality is confirmed for all the dimensions of each construct.

Table 1: Reliability and dimensionality analysis

Dimensions	KMO	Bartlett's sphericity	Eigenvalue	Percentage of variance explained	Communality	Factor weight	Cronbach's Alpha
PRO	0.817	0,000	2.796	69.907	0.582 > 0.756	0.763 > 0.869	0.855
NOR	0.727	0,000	2.474	82.468	0.759 > 0.864	0.871 > 0.930	0.893
SPP	0.740	0,000	2.546	84.856	0.826 > 0.888	0.909 > 0.943	0.909
GMP	0.781	0,000	2.681	67.032	0.503 > 0.760	0.709 > 0.872	0.834
GS	0.762	0,000	2.617	87.247	0.854 > 0.883	0.924 > 0.940	0.925
GC	0.744	0,000	2.496	83.198	0.801 > 0.859	0.895 > 0.927	0.898
PF	0.839	0,000	3.099	77.466	0.741 > 0.822	0.861 > 0.906	0.903
PNF	0.870	0,000	4.554	65.059	0.551 > 0.759	0.742 > 0.871	0.909
PGP	0.914	0,000	6.052	60.516	0.520 > 0.743	0.721 > 0.862	0.927
OGP	0.911	0,000	5.889	73.613	0.609 > 0.820	0.781 > 0.905	0.948
Recommended value	> 0.5	Close to 0	≥ 1	≥ 0.6	≥ 0.5	≥ 0.5	≥ 0.7
Reference	Jolibert & Jourdan (2006)	Evrard et al., 2009	Hair et al. (2006)	Hair et al. (2006)	Jolibert & Jourdan (2006)	Evrard et al. (2009)	Thiétart (2007)

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Confirmatory analysis

To examine our research hypotheses and to validate the results obtained at this stage, we conducted a confirmatory analysis, using structural equation modeling performed on the SmartPLS.

Evaluation of the measurement model

The evaluation of the measurement model provided a ruling on the reliability and validity of the constructs (Table 2). The recovered loadings exceed the threshold of 0.7, with a Cronbach's α above 0.8 for all dimensions and a composite reliability that ranges between 0.889 and 0.967. On the other hand, the convergent validity is confirmed since the AVE displays values above 0.6. Discriminant validity is also verified through the two indices HTMT and Fornell-Larcker.

Table 2: Reliability and validity analysis of constructs

Dimensions	Loading	Cronbach's Alpha	Composite reliability	AVE	Fornell-Larcker criterion	HTMT
PRO	0.769 > 0.866	0.855	0.903	0.699	Verified	Verified
NOR	0.872 > 0.928	0.893	0.934	0.825		
SPP	0.907 > 0.937	0.911	0.944	0.848		
GMP	0.751 > 0.867	0.834	0.889	0.668		
GS	0.920 > 0.942	0.927	0.954	0.872		
GC	0.892 > 0.928	0.899	0.937	0.832		
PF & PNF	0.720 > 0.844	0.942	0.950	0.633		
PGP OGP	0.721 > 0.856	0.964	0.967	0.621		
Recommended value	> 0.7	> 0.7	> 0.7	> 0.5	AVE > Square of correlations between latent variables	< 0.9
Reference	Hair et al. (2011)	Hair et al. (2011)	Hair et al. (2011)	Hair et al. (2011)	Fornell & Larcker (1981)	Gold et al. (2001)

Evaluation of the structural model

Overall, the model has a high level of quality and a very good predictive capacity. Indeed, the evaluation indices of the structural model are of a satisfactory level (Table 3), with coefficients of determination "R^2" that exceed 0.6 and a GoF of about 0.643.

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Table 3: Overall analysis of the structural model

	R^2	Q^2		GoF
		Comm.	Red.	
OP	0.685	0.528	0.398	0.643
PMM	0.632	0.539	0.358	
Criterion	< 0.19 « not acceptable » between 0.19 and 0.33 « low » between 0.33 et 0.67 « moderate » > 0.67 « high »	> 0	> 0	< 0.1 « nothing » between 0.1 et 0.25 « small » between 0.25 et 0.36 « medium » > 0.36 « large »
Reference	Chin (1998)	Tenenhaus et al. (2005)		Wetzels et al. (2009)

Regarding the significance of the structural relationships, hypotheses H1, H2 and H3 were confirmed at a level of 1% (Table 4), which ruling the contribution of the PMO to organizational performance and project management maturity, but also the non-negligible impact of the latter on performance.

Table 4: Significance of structural relationship

	Regression coefficient	t-value	p-value	Decision
PMO functions -> OP	0.335	4.133	0.000	Confirmed**
PMO functions -> PMM	0.795	15.616	0.000	Confirmed**
PMM -> OP	0.536	6.707	0.000	Confirmed**

* p< .05 ; ** p< .01

Indeed, we have reached the same conclusions as Kutsch et al. (2015) and Van der Linde and Steyn (2016), who stipulate that the PMO, through its functions and services actively participate in the generation and creation of value within the organization. This contribution to organizational performance can be seen in different components and at distinct levels. The implementation of the PMO seems to be an interesting step towards contributing to organizational performance.

These results also contradict the findings of Martins and Martins (2012), and therefore confirm those set out by Blažević et al. (2014), Valle and Soares (2014), Al Ahmad (2015) as well as Van der Linde and Steyn (2016) and which argue for the remarkable participation of the PMO in the improvement of the project management maturity level. A contribution that is conditioned according to Hobbs and Aubry (2007) by the effective implementation of the PMO, as well as its maturity level (Andersen et al., 2007).

The analysis of the mediator effect (H4) that the construct "Project Management Maturity" presents in the model was confirmed as the value zero does not exist between the two calculated levels LL and HL (Table 5). This analysis was based on Preacher and Hayes (2008) approach.

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Indeed, the result of the data analysis demonstrated a significant relationship between the two constructs, such that the presence of a high level of maturity generally translates into positive impacts on performance (Lockamy & McCormack, 2004). And considering that the PMO is supposed to promote project management practices (Hubbard & Bolles, 2012), this can only lead to efficiency gains and better performance as was suggested by Lavoie-Tremblay et al. (2017).

Table 5: Analysis of the mediator effect

					Confidence interval	
IV -> Mediator	Mediator -> DV	Indirect effect	SD	t-value	95% LL	95% HL
0.795	0.536	0.426	0.073	5.837	0.283	0.569

Based on the analysis technique proposed by (Lacroux, 2009), the moderating effect of the PMO type could not be confirmed (rejection of H5a and H5b). According to the results obtained, the type of PMO does not play a moderating role in the relationship between "Project Management Office (PMO) Functions" and the two constructs "Organizational Performance" and "Project Management Maturity" (Table 6 and 7).

Table 6: Moderator effect analysis (OP)

	Regression coefficient	t-value	R^2	Decision
(1) Y = a + b1 X + b2 Z	b1 = 0.350	4.227	0.689	Rejection of the moderator effect hypothesis
	b2 = -0.065	1.310		
(2) Y = a + b1 X + b2 Z + b3 XZ	b1 = 0.370	3.945		
	b2 = -0.069	1.263	0.693	
	b3 = 0.058	0.523		

t must be > 2.58 for a significance level α = 1% and > 1.96 for an α = 5%

Table 7: Moderator effect analysis (PMM)

	Regression coefficient	t-value	R^2	Decision
(1) Y = a + b1 X + b2 Z	b1 = 0.777	14.163	0.658	Rejection of the moderator effect hypothesis
	b2 = -0.163	2.857		
(2) Y = a + b1 X + b2 Z + b3 XZ	b1 = 0.781	15.004		
	b2 = -0.165	2.990	0.684	
	b3 = 0.161	1.519		

t must be > 2.58 for a significance level α = 1% and > 1.96 for an α = 5%

This result is surprising, since the support type PMO generally refers to the improvement of project performance and the development of increased project management skills, while the control type PMO is mainly concerned with practices and governance modes compliance (Aubry et al., 2010). This implies that the implementation of one or the other should have an impact on the performance and project management maturity within the organization.

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Therefore, this result suggests that perhaps the lack of a moderating effect of the PMO type in the context of the relationships studied is due to confusion about the functions supposed to be performed by each type, if not because of the host organizations' lack of mastery of the notion of typology.

Conclusion

Using a quantitative approach, this research enabled us to assess the PMO's organizational contribution. This contribution was examined from two perspectives: (1) organizational performance and (2) project management maturity.

The examination of the significance of the relationships between the constructs of the conceptual model confirmed the basic hypotheses. Indeed, according to the results, the PMO through its functions and roles contributes to both organizational performance and project management maturity.

On the other hand, the hypothesis stipulating the existence of a significant relationship between project management maturity and organizational performance was also confirmed. Consequently, the mediating effect that maturity plays in the relationship between the PMO through its functions and organizational performance is in turn verified. In other words, improved maturity leads primarily to improved performance.

However, the hypotheses concerning the moderating effect associated with the type of PMO (support PMO and control PMO) were rejected. The type of PMO had no influence on the relationship between PMO functions and organizational performance, or between PMO functions and project management maturity.

The conclusions drawn from this research represent a new building block in the current debate on the PMO's organizational contribution and its role in value creation, as well as another avenue for guiding the implementation of the PMO in line with organizational expectations.

Indeed, the results of this research phase may represent an opportunity for organizations that have implemented a PMO or are considering implementing one, to reflect further on the expectations behind this implementation and the resulting implications, to ensure alignment with the vision and strategic/operational objectives.

However, it should be noted that this study has some limitations. First, given the difficulty in identifying our target sample, we used convenience sampling, which to some extent constrains the representativeness and generalizability of the results.

In consequence, we believe that it would also be interesting to examine this issue in greater depth through the implementation of longitudinal studies of cases characterized by similarities or evolving in similar or almost similar

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contexts. This would provide more visibility on this contribution and its implications.

Declaration for Human Participants: This study has been approved by Ecole Nationale de Commerce et de Gestion – ENCG Settat**,** University Hassan 1st and the principles of the Helsinki Declaration were followed.

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Mesure du Conservatisme de la Banque Centrale : Une évaluation empirique appliquée au cas de la Banque des Etats de l'Afrique Centrale (BEAC)

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Résumé

Dans cet article, nous proposons une mesure simple et fiable du degré de conservatisme de la Banque des États de l'Afrique centrale (BEAC). Cet indicateur est fondé sur la courbe de Taylor et s'inspire des travaux de Levieuge et Lucotte (2014). Contrairement à d'autres indicateurs de conservatisme développés dans la littérature, qui dépendent fortement du modèle économique et de la règle monétaire adoptés, la mesure que nous proposons ici est purement empirique et facilement calculable. Elle requiert seulement la connaissance des variances empiriques de quelques variables et peut aisément s'étendre à un large échantillon de pays. Les résultats empiriques montrent que, sur la période 1980-2015, la BEAC a accordé la priorité au soutien à l'activité économique plutôt qu'à l'objectif de couverture extérieure de la monnaie dans la CEMAC.

Mots-clés: Banque Centrale, BEAC, Conservatisme, Politique monétaire

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Measuring Central Bank Conservatism : An empirical assessment applied to the case of the Bank of Central African States (BEAC)

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Abstract

In this article, we propose a simple and reliable measure of the degree of conservatism of the Bank of Central African States (BEAC). This indicator is based on the Taylor curve and draws on the work of Levieuge and Lucotte (2014). Unlike other conservatism indicators developed in the literature, which are highly dependent on the economic model and monetary rule adopted, the measure we propose here is purely empirical and easily calculable. It requires only knowledge of the empirical variances of a few variables, and can easily be extended to a large sample of countries. The empirical results show that, over the period 1980-2015, the BEAC prioritized support for economic activity over the objective of currency hedging in the CEMAC.

Keywords: BEAC, Central Bank, Conservatism, Central Bank, Monetary policy

Introduction

Après les années 80, les préférences des banquiers centraux[1] et la conception de la Banque Centrale sont progressivement apparues comme deux caractéristiques cruciales de la gouvernance des Banques Centrales, susceptibles de façonner la politique monétaire (Masciandaro, 2020). A cet égard, la gouvernance des Banques Centrales quant à elle est devenue de plus en plus importante lorsque les analyses économiques ont commencé à

[1] Avant les années 1980, la macroéconomie ne prêtait pas explicitement attention aux préférences des banquiers centraux ou au cadre institutionnel de la banque centrale lors de l'élaboration d'arguments positifs et normatifs.

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souligner son rôle dans la détermination des performances macroéconomiques (pendant la révolution néo-classique). La recrudescence des nombreuses crises ces dernières années vont révéler qu'à trop se concentrer sur l'objectif d'inflation, les Banques Centrales en général auraient non seulement négligé la stabilité de l'activité économique, mais aussi la stabilité financière (Frappa et Mésonnier (2010), Lin (2010), Levieuge et Lucotte (2014)). A cet effet, les économistes et les praticiens sont justement divisés au sujet de la hiérarchisation des objectifs des Banques Centrales ; mettant ainsi en évidence le conflit d'intérêts potentiel pouvant résulter de la réalisation des deux objectifs avec un seul instrument politique (Goodhart et Schoenmaker, 1995). Pour les uns, les Banques Centrales se seraient excessivement concentrées sur l'objectif de stabilité des prix au détriment de la stabilisation de l'activité économique (l'objectif explicite d'inflation n'implique pas qu'il faille se désintéresser de la croissance (King (1997), Svensson (1999), (2010)). Pour les autres, dans un contexte de grande modération, profitable à tous les régimes de politique monétaire, sans distinction, quand bien même le banquier central opterait pour une stratégie de ciblage dite « stricte », qui revient à faire de la stabilisation de l'inflation le seul objectif de la politique monétaire, il serait sous-optimal de négliger l'activité économique (Svensson (1997) ; Penot et Pollin (1999) ; Rudebusch et Svensson (1999)).

Le rôle des préférences des banquiers centraux et de la conception de la Banque Centrale sont apparus par l'application d'une approche de la théorie des jeux après la découverte des problèmes généraux d'incohérence temporelle qui caractérisent la politique économique (Kydland et Prescott (1977), Calvo, (1978)). La littérature économique à travers la problématique de l'incohérence temporelle va tenter d'exploiter la courbe de Phillips afin de réduire le chômage par l'inflation. En supposant que l'autorité monétaire poursuit la maximisation du bien-être social composé d'inflation et de chômage, on croit alors pouvoir résoudre le biais inflationniste en modifiant l'objectif social qui oriente le comportement de l'autorité monétaire. Rogoff (1985) propose, en développant et modélisant le raisonnement, **la notion de conservatisme**[2] comme solution au biais inflationniste.

Par **conservatisme**[3], on entend une aversion majeure à l'inflation, un poids plus élevé donné au niveau de l'inflation par rapport au taux de chômage

[2] Le conservatisme sacrifie partiellement la flexibilité au profit de la crédibilité. C'est la non solution de l'arbitrage crédibilité-flexibilité. La perte de flexibilité se traduit par une plus grande attention vers la lutte contre l'inflation en laissant partiellement de côté la production ou l'emploi, d'où une réponse non optimale aux chocs économiques détériorant la production et l'emploi.

[3] Le conservatisme cherche à résoudre le problème du biais inflationniste en sauvegardant la flexibilité. Il passe par la redéfinition de l'objectif de l'autorité monétaire. Le conservatisme, tout en réduisant le biais inflationniste, constitue seulement une solution de troisième degré

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(Nosetti, 2003). Il reflète l'importance accordée à la recherche de la stabilité des prix par rapport aux autres objectifs énoncés dans les statuts de la Banque Centrale (Levieuge et al., 2016). En générale, est **conservatrice l'autorité qui possède une préférence temporelle plus longue, donc qui considère les effets sur le long terme de sa propre politique.** Traditionnellement une Banque Centrale définit dans ses statuts un ou plusieurs objectifs propres à sa politique monétaire. Mais dans la pratique, il est difficile pour elle d'atteindre simultanément ces objectifs dans le cas où il y'en a plusieurs. Cela étant, il se posera alors un problème d'arbitrage et de hiérarchisation des objectifs de politique monétaire de la part des autorités monétaires. Leurs actions et décisions tout au long d'une année auront tendance à privilégier un objectif au détriment d'un/des autres. Le banquier central traditionnel encore appelé « conservateur » aura pour fonction objective la stabilité des prix quel que soit le contexte dans la sphère économique.

Bien que déjà défini dans ses statuts comme nous avons souligné plus haut, ce papier pourra nous éclairer sur quel objectif la politique monétaire a été privilégié dans un exercice par le gouvernement d'une Banque Centrale et déduire ses implications sur l'activité économique. Nous nous focalisons sur le cas de la Banque des Etats de l'Afrique Centrale (BEAC), conformément à l'article 1er de ses Statuts, **l'objectif final de la politique monétaire de la BEAC est de garantir la stabilité monétaire. Sans préjudice de cet objectif, la BEAC apporte son soutien aux politiques économiques générales élaborées par les Etats membres**. Pour la BEAC, dont la monnaie est rattachée à l'Euro par une parité fixe, l'objectif de stabilité monétaire signifie un taux d'inflation faible et un taux de couverture de la monnaie suffisant (le seuil minimal est de 20 %[4]). **On peut donc identifier trois (03) objectifs à atteindre pour la BEAC**. Notons que les pays appartenant à cette Banque Centrale évoluent en régime de change fixe, et de ce fait l'objectif de stabilité des prix est de fait maitrisé par nature de l'ancrage à l'Euro et n'est plus un réel enjeu pour cette Banque Centrale. **Il serait donc plus intéressant d'examiner l'arbitrage entre la stabilité externe de la monnaie et le soutien à l'économie au sein de la BEAC** ; d'où la question de savoir : **Quelle est la préférence relative de la BEAC en termes d'objectifs ?** Ainsi, l'objectif de cet article sera de **mesurer empiriquement le degré de**

(*third-best*). La solution de premier degré (*first-best*) consiste à déraciner la distorsion présente sur le marché du travail (distorsions fiscales, présence de syndicats,…).

[4] La convention monétaire et les règlementations en matière de change prévoient dans la CEMAC : le rapatriement et la rétrocession de l'ensemble des actifs en devises étrangères détenus par toutes les entités résidentes de la CEMAC, y compris les États membres, à la BEAC ; la mise en commun de l'ensemble des réserves internationales de la CEMAC à la BEAC ; l'obligation pour la BEAC de maintenir au moins 50 % de ses réserves internationales sur le compte d'opérations et de s'assurer que ses réserves internationales représentent au moins 20 % de ses exigibilités à vue.

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conservatisme de la BEAC et d'en déduire sa préférence en termes d'objectifs.

Cet article qui complète la littérature qui est très limitée sur cette thématique est une étude pionnière en Afrique Subsaharienne (ASS) qui construit un indice de conservatisme pour la Banque Centrale de Etats de l'Afrique Centrale. A notre connaissance, seul Levieuge et al. (2016) l'on fait pour 73 pays dont deux d'Afrique Subsaharienne (ASS). A l'aide de la mesure développée par Levieuge et Lucotte (2014), nos résultats montrent que dans la hiérarchisation des préférences des objectifs de politique monétaire, la BEAC aurait accordé plus de priorité au soutien de l'activité économique qu'à la couverture extérieure de la monnaie. L'objectif de stabilité des prix étant naturellement atteint en régime de change fixe.

Le reste de l'article est organisé comme suit. : La section (I) est consacrée à la présentation des fondements aussi bien théoriques et qu'empiriques. La section (II) présente la méthodologie. La section (III) présente et discute des résultats, puis nous achevons l'article par conclusion.

Revue de la Litterature

Quelques études théoriques (A) et empiriques (B) mettent en exergue les considérations relatives à l'analyse du conservatisme des Banques Centrales et l'efficacité de la politique monétaire.

Origines et considérations théoriques du conservatisme : l'incohérence temporelle

L'idée centrale dans la théorie est qu'une Banque Centrale coupée du pouvoir politique serait la garante de la stabilité des prix et ce, sans influencer d'autres variables macroéconomiques comme la croissance ou le chômage. Cette théorie est née autour de la problématique de « **l'incohérence temporelle** » entre les objectifs fixés par le gouvernement et les objectifs réellement atteints par ce dernier en matière monétaire (Kydland et Prescott, 1977). Cette incohérence pose la question de l'optimalisation du bien-être social en usant de manière discrétionnaire des instruments de politique économique. Kydland et Prescott[5] résument cette incohérence en une

[5]La théorie économique de Kydland et Prescott (1977) n'est pas exempte de critiques. Le modèle proposé par ces deux économistes se basait essentiellement sur un modèle d'économie nationale fermée. La place des phénomènes économiques internationaux et autres chocs externes était réduite à sa portion congrue, alors que le système économique international connaissait alors de fortes turbulences (fin du système monétaire de Bretton Woods et chocs pétroliers ; Steiner, (2003)).Comme autre paradoxe, alors que les premiers modèles intégraient d'autres déterminants de l'inflation au plan conceptuel du moins, les travaux les plus actuels semblent désormais limiter la source première de l'inflation à la politique monétaire. Ce point est d'autant plus paradoxal que les travaux de Barro et Gordon qui ont ouvert la voie à l'application du modèle de Kydland et Prescott à la politique monétaire se

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maxime « **la règle contre la discrétion** », et en un axiome, la règle peut permettre au gouvernement d'optimaliser le bien-être social, jamais l'utilisation discrétionnaire.

En s'appuyant sur une courbe d'offre de Phillips augmentée des anticipations rationnelles à la Lucas, Barro et Gordon (1983) déduisent que l'utilisation discrétionnaire de la politique monétaire, ou le non-respect de la règle comme par exemple une cible d'inflation, serait indubitablement contrecarrée par les agents économiques et produirait l'effet contraire escompté à savoir, dans le cas de la politique monétaire, par une augmentation de l'inflation. En effet, dans un premier temps, le gouvernement fixe un objectif d'inflation pour l'année à venir. Ce signal émis, les acteurs privés engagent la négociation collective en vue d'ajuster les salaires. La négociation collective aboutie, le gouvernement a tout intérêt, en régime discrétionnaire, d'user de l'arme monétaire et ce, malgré la règle fixée auparavant.

Le calcul du gouvernement est simple : il s'agit pour lui d'initier une politique monétaire expansive favorisant la demande globale, donc l'emploi, et ce sans hausse de l'inflation, les salaires étant déjà fixés. Cependant, les acteurs privés ayant anticipé rationnellement une telle « **tricherie** », les résultats des négociations collectives incorporeraient déjà une hausse du revenu annuel nominal ; hausse tenant compte d'un dépassement de la cible d'inflation du gouvernement en raison d'une probable politique monétaire expansive de ce dernier. Conséquences : Le niveau d'emploi varie peu mais, surtout l'inflation augmente significativement. En d'autres termes, il y a là une incohérence temporelle entre les objectifs originellement fixés par le gouvernement et les résultats atteints par ce dernier.

De ce fait, la négociation collective aboutie, le gouvernement a tout intérêt, en régime discrétionnaire, d'user de l'arme monétaire et ce, malgré la règle fixée auparavant. Dès lors, la question est de savoir pourquoi ce gouvernement adopte un comportement discrétionnaire ? A cet effet, Alesina (1989) puis Alesina et Roubini (1994), complète les travaux de Barro et Gordon (1983) par l'apport de Nordhaus (1975) sur le cycle politico-économique. Selon ces travaux, l'opportunisme des gouvernants les conduit, peu avant une élection, à user de manière discrétionnaire de l'arme monétaire afin d'augmenter leurs chances de réélection, sans tenir toutefois compte des effets néfastes d'une telle politique sur la stabilité des prix.

Solution au problème de l'incohérence temporelle

La solution au problème posé par le comportement discrétionnaire des autorités politiques, proposé dans la littérature consiste à « **lier** » les mains du

basaient à l'époque sur une courbe de Phillips. Cela signifiait que l'impact de l'emploi, et par extension le résultat de la négociation collective influait également sur le niveau des prix.

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gouvernement en matière de politique monétaire. Plusieurs mesures ont été proposées pour atteindre cet objectif. Kydland et Prescott (1977) ont prôné l'établissement d'une règle de conduite monétaire. Barro et Gordon (1983) rétorquent qu'une règle seule, une cible de croissance de la masse monétaire par exemple ne suffit pas. Il faut y adjoindre l'idée de « **réputation** ». Pour eux, plus un gouvernement respecte la règle monétaire précédemment fixée, plus sa réputation augmente auprès des acteurs privés, plus sa crédibilité en matière de politique monétaire se renforce. Ainsi, une « bonne » réputation en politique monétaire, entendue comme une moindre déviation par rapport à la règle, conduit les partenaires sociaux à faire confiance aux cibles annoncées et donc, à modérer les hausses salariales issues de la négociation collective. Les performances économiques du gouvernement s'en trouvent ainsi améliorées.

Pour Rogoff[6] (1985), la réputation et la crédibilité finissent tôt ou tard par céder le pas face aux velléités des gouvernants à appliquer une politique discrétionnaire. Sa solution réside dans la nomination d'un gouverneur « **conservateur** » à la tête de la Banque Centrale, ce qui signifie que l'autorité monétaire suit une fonction objective qui donne plus d'importance à la lutte contre l'inflation qu'au soutien à la croissance ou à la lutte contre le chômage. L'autorité monétaire est conservatrice, si elle s'écarte des préférences sociales en donnant un poids plus important à la stabilité des prix. Dans ce contexte, le banquier central conservateur assurerait le maintien de la règle monétaire tout en renforçant la réputation et la crédibilité de son institution et par extension, celles du gouvernement.

Walsh (1995) critique cette dernière idée sur un point de logique. Il avance qu'un gouvernement peut certes déléguer le respect de la règle monétaire à un banquier central conservateur mais, sans moyens pratiques pour y parvenir cette délégation de compétence reste vaine. Le premier moyen pratique d'y parvenir consiste à donner au banquier central le choix de la cible d'inflation. Sans une telle mesure, un gouvernement serait toujours tenté de fixer cet objectif à un niveau plus haut que l'équilibre d'inflation socialement optimal et ce, malgré la présence d'un banquier central conservateur. Mais se pose encore le problème du respect par le gouverneur de ses engagements. S'inspirant de la théorie du principal-agent (le gouvernement et la société sont le principal et le banquier est l'agent), Walsh (1995) montre qu'« **un contrat** » peut-être passe entre les deux agents, avec un objectif en termes d'inflation.

[6] Le processus du jeu de Rogoff (1985) se fait comme suit : (1) un conservateur qui détermine la politique monétaire est nommé, (2) les agents privés anticipent le taux d'inflation et fixe le salaire nominal, connaissant l'objectif du gouvernement, (3) le choc se réalise, (4) en raison des fluctuations, le banquier central fait subir à la politique monétaire des modifications, (5) de l'observation *ex-post* de la situation sur le marché du travail, le banquier central est maintenu ou il perd son poste au profit d'un gouverneur moins conservateur.

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En cas de non-respect du contrat, le principal peut punir l'agent (le meilleur moyen, selon Walsh, est d'indexer le salaire du banquier central en fonction des résultats obtenus en matière d'inflation pour l'inciter à respecter ses engagements et ainsi atteindre l'équilibre socialement optimal et le risque de limogeage).

Mais l'inefficacité dans le temps de toutes ces mesures, ont conduit à envisager la solution de la coupure institutionnelle de la Banque Centrale du pouvoir politique. Cette solution est soutenue par les travaux empiriques démontrant le lien entre indépendance de la banque centrale et contrôle de l'inflation.

Lohmann (1992) introduit le principe d'*override* (ou *escape clause*) c'est-à-dire la possibilité que le gouvernement puisse intervenir auprès de la banque centrale, quand celle-ci exagère en termes de rigidité. Autrement dit, on accepte le principe du conservatisme, mais on cherche à limiter les effets négatifs de la perte de flexibilité, en donnant la possibilité au gouvernement d'intervenir dans les cas extrêmes.

Eijffinger et Hoeberichts (1998) montrent que le conservatisme et l'indépendance sont des substituts stratégiques et qu'il existe un compromis entre eux, dans le sens où une société peut choisir de nommer un gouverneur plus conservateur pour compenser un manque d'indépendance de la Banque Centrale.

Quelques enseignements empiriques sur le conservatisme

De plus en plus, les chercheurs ont reconnu que l'indépendance et le conservatisme des Banques Centrales sont des concepts différents (Eijffinger et Hoeberichts (1998), Hefeker et Zimmer (2011), Darabi et Samimi (2016)). L'indépendance est comme une caractéristique institutionnelle du régime monétaire, tandis que le conservatisme est une attitude personnelle du banquier central et une caractéristique clé du responsable de la politique monétaire. De nombreuses études ont montré qu'il est optimal d'engager un banquier central plus conservateur que le citoyen moyen (Rogoff (1985), Herrendorf et Lockwood (1997), Hallet et Proske (2018)).

Clarida et al. (1999) ont montré que la nomination d'un banquier central conservateur est souhaitable dans un nouveau modèle keynésien[7], dans lequel

[7] Dans la vision keynésienne, la Banque Centrale est un organe technique qui conserve un pouvoir discrétionnaire dans la mise en œuvre de la politique au jour le jour ; et la nécessité d'une coopération entre la Banque Centrale et le trésor public est soulignée (Bibow (2002), Rivot (2013)). Cependant, dans cette perspective, le besoin de coopération est défini dans un ensemble de règles qui régissent la relation hiérarchique entre le responsable de la politique monétaire (c'est-à-dire le gouvernement) et une bureaucratie d'experts (c'est-à-dire la Banque Centrale). En d'autres termes, la conception de la Banque Centrale ne sera probablement rien de plus qu'une application des règles générales qui régissent les interactions entre le mandant politique et ses agents administratifs bureaucratiques.

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la présence de chocs persistants liés aux coûts crée un biais de stabilisation dans la politique monétaire discrétionnaire ; c'est-à-dire un arbitrage à court terme inférieur entre la stabilisation de l'inflation et de la production par rapport à la politique de Ramsey[8] non cohérente dans le temps. Adam et Billi (2008, 2014) et Niemann (2011) ont examiné les avantages de la politique monétaire discrétionnaire de conservatisme dans des versions des nouveaux modèles keynésiens complétées et par une politique budgétaire endogène. Cependant, toutes ces études ont fait abstraction de la contrainte de la Banque Centrale à taux directeur zéro.

Tachibana (2004) à partir du poids relatif des fluctuations de la production et de l'inflation dans la fonction de perte de la Banque Centrale, déduit l'objectif qui déplaît à l'autorité monétaire. Il propose une méthode pour estimer ce poids, qui est différente de celle de Cecchetti et Ehrmann (2002)[9]. Il examine les politiques monétaires au Japon, au Royaume-Uni et aux États-Unis après le premier choc pétrolier. Il s'avère que le Royaume-Uni a la plus grande aversion pour la variabilité de la production parmi les trois pays de l'échantillon complet et que les trois pays de l'échantillon n'apprécient pas la variabilité de l'inflation depuis 1980 environ.

Krause et Méndez (2005) vont générer des données sur les préférences relatives des décideurs de politique pour la stabilité de l'inflation et la stabilité de la production. Ils réexamineront le comportement des décideurs politiques et des partis politiques pour 24 pays en utilisant une nouvelle approche. Les auteurs font l'hypothèse que ce comportement est essentiel à la fois dans les modèles de cycles partisans et dans l'analyse des cycles politiques opportunistes. Leurs résultats suggèrent que les partis de droite affichent une préférence relative plus élevée pour la stabilisation de l'inflation que les partis de gauche. Ils obtiennent également des résultats mitigés sur le comportement opportuniste des partis en place. Enfin, lorsqu'ils analysent le comportement des idéologies de gauche et de droite séparément, ils trouvent un soutien écrasant dans la ressemblance des partis au cours de l'année électorale et de fortes preuves du comportement opportuniste des partis de droite.

Assenmacher (2006) va estimer les fonctions de réaction de la politique monétaire pour les États-Unis, le Royaume-Uni et l'Allemagne en utilisant un modèle à changement de régime Markov qui permet des changements dans les coefficients de la fonction de réaction de la Banque Centrale, ainsi que des changements indépendants dans la variance résiduelle. Les estimations indiquent que la politique des Banques Centrales peut être caractérisée comme relevant d'un régime de faible et de forte inflation. Pour

[8] Aux Etats-Unis d'Amérique.

[9] Voir : Cecchetti S. et Ehrmann M. (2002). Does inflation targeting increase output volatility ? an international comparison of policymakers' preferences and outcomes. Working Paper 7426 http://www.nber.org/papers/w7426.

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retrouver les préférences des Banques Centrales, l'auteur estime les paramètres de préférence conjointement avec un petit modèle de l'économie. Les résultats montrent que la Bundesbank a accordé un poids relativement plus important à l'inflation que la Fed. De plus, pour la Bundesbank et la Fed, les différences entre les deux régimes semblent provenir principalement d'une préférence changeante pour le lissage des taux d'intérêt.

Adam et Billi (2008) vont étudier empiriquement un jeu de conservatisme entre la politique monétaire et la politique fiscale sans engagement et non coopératif, dans une économie dynamique, stochastique à prix rigides avec des distorsions monopolistiques. Dans ce contexte, la politique monétaire détermine les taux d'intérêt nominaux et la politique fiscale fournit des biens publics générant une utilité au secteur privée. Les auteurs constatent que l'absence d'engagement budgétaire donne lieu à des dépenses publiques excessives. Le taux d'inflation optimal internalisant cette distorsion est positif, mais le manque d'engagement monétaire génère trop d'inflation. Pour eux, une autorité monétaire conservatrice reste donc souhaitable. Ils concluent que, lorsque la politique budgétaire est déterminée avant la politique monétaire à chaque période, l'autorité monétaire doit se concentrer exclusivement sur la stabilisation de l'inflation. Le conservatisme monétaire élimine alors les biais d'état stationnaire associés au manque d'engagement monétaire et fiscal et conduit à une politique de stabilisation proche de l'optimum.

Pasca, Aragón et Marcelo (2012) dans une étude vont identifier les préférences de l'autorité monétaire dans le régime péruvien de ciblage de l'inflation à travers la dérivation de règles monétaires optimales. Pour ce faire, les auteurs ont utilisé une stratégie de calibration basée sur le choix des valeurs des paramètres de préférences, qui minimisent la déviation carrée entre le taux d'intérêt réel et le taux d'intérêt optimal de simulation. Les résultats ont montré que l'autorité monétaire a appliqué un système de ciblage flexible de l'inflation, donnant la priorité à la stabilisation de l'inflation, mais sans négliger le gradualisme des taux d'intérêt.

Levieuge et Lucotte (2012, 2014) proposent une mesure empirique, simple et indépendante du conservatisme des Banques Centrales basée sur la courbe de Taylor (1979). Cette courbe traduit l'arbitrage entre variabilité de l'inflation $(\sigma_\pi^2)\sigma_\pi^2)$ et variabilité de l'output $(\sigma_y^2)\sigma_y^2)$ auquel les autorités monétaires sont confrontées. Pour ces auteurs, ce nouvel indicateur peut facilement être étendu dans le temps et dans l'espace, quel que soit le régime monétaire sous-jacent des pays considérés. Ils démontrent qu'il évolue en fonction des expériences monétaires de 32 pays membres de l'Organisation pour la Coopération et le Développement Economique (OCDE) depuis 1980 ; et qu'il est largement équivalent à la mesure basée sur un modèle fourni par

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Krause et Méndez (2005). Les auteurs finissent par mettre en avant l'intérêt d'un tel indicateur pour des analyses empiriques ultérieures portant sur les préférences des Banques Centrales.

En utilisant le modèle de Rogoff (1985), Hallett et Prosk (2017) déterminent à quel point l'aversion à l'inflation d'un banquier central devrait être important, étant donné le niveau de volatilité et l'écart de production projeté dans l'économie. Les auteurs confirment un fort degré de conservatisme, presque le double de ce que la société aurait choisi. Mais, pour une série de pays en développement et de l'OCDE, les économies qui connaissent systématiquement des niveaux plus élevés de volatilité de la production auraient intérêt à engager un banquier central plus averse à l'inflation que la société, mais moins que dans les économies développées stables. Ainsi, si un banquier central conservateur reste souhaitable, et le *trade-off* se fait avec la volatilité de la production plutôt qu'avec l'écart de production lui-même.

Nakata et Schmidt (2018) étudient la politique monétaire optimale lorsque la limite inférieure au taux zéro est occasionnellement contraignante et que les anticipations de futurs créent un arbitrage pour les Banques Centrales discrétionnaires entre la stabilisation de l'inflation et de la production. Comme conséquence, les auteurs constatent que l'inflation tombe systématiquement en dessous de la cible même lorsque le taux directeur est supérieur à zéro et que la nomination d'un banquier central conservateur à la Rogoff (1985) réduit les coûts de bien-être de la politique discrétionnaire induite par la limite inférieure à ce taux zéro.

Masciandaro (2020) en utilisant une approche d'économie politique met en lumière la façon dont deux (02) facteurs - les préférences des banquiers centraux et la conception de la Banque Centrale - ont progressivement assumé un rôle crucial dans l'évolution de l'économie de la politique monétaire au cours des quatre dernières décennies. Ces deux facteurs mettent conjointement en évidence l'importance de la gouvernance de la Banque Centrale pour influencer les décisions de politique monétaire par le biais de leurs interactions avec les règles de politique monétaire, compte tenu de certaines hypothèses sur le fonctionnement des systèmes macroéconomiques. En outre l'auteur montre que la compréhension de la pertinence de la gouvernance des Banques Centrales a été récemment enrichie par l'application de la perspective de l'économie comportementale.

Approche Methodologique

Parallèlement, comme dans le cas de l'indépendance des Banques Centrales, les chercheurs ont développé des indices du conservatisme des banquiers centraux (Fry (1998), Ozlale (2003), Berger et Woitek (2005),

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Dennis (2006), Levieuge et Lucotte (2014), Berlemann et Hielscher (2013, 2016)).

Dans cette étude, la méthodologie s'appuie sur la formulation de Levieuge et Lucotte (2014) pour mesurer le degré de conservatisme de la BEAC. Ces auteurs ont développé un indicateur fondé sur l'arbitrage d'objectifs théorisé par Taylor (1979) ; qui permet d'identifier les préférences relatives des autorités monétaires en termes de stabilisation de l'inflation d'une part, et de l'output d'autre part. L'importance relative accordée à l'objectif de stabilisation de l'inflation (par rapport à tout autre objectif) peut être représentée et déduite de la courbe de Taylor (1979), qui représente le compromis entre volatilité des prix et de la production. Cette courbe traduit l'arbitrage entre variabilité de l'inflation ($\sigma_\pi^2 \sigma_\pi^2$) et variabilité de l'output ($\sigma_y^2 \sigma_y^2$). Par extension, une préférence élevée pour l'objectif de stabilité des prix coïncide avec le degré de conservatisme des Banques Centrales au sens de Rogoff (1985).

Les tentatives de mesure du conservatisme sont très rares dans la littérature, elles sont souvent invariantes dans le temps et dans l'espace, et dépendantes du modèle. Ces mises en garde sont contournées par le récent indicateur conservatisme proposé par Levieuge et Lucotte (2014). Leur indicateur présente au moins deux (02) avantages principaux. Il varie dans le temps et est indépendant du modèle. Il n'impose aucune hypothèse concernant la règle de politique monétaire ou la stratégie suivie par une Banque Centrale. Ainsi, il peut évaluer les préférences relatives d'une Banque Centrale quel que soit le régime monétaire en place. Ces caractéristiques sont particulièrement importantes pour notre étude, car nous considérons que les stratégies de politique monétaire ont considérablement changé dans le monde au cours des dernières décennies. Cet indicateur présente ainsi l'avantage d'être simple à calculer (seules les variances empiriques de l'inflation et de l'activité sont requises) et indépendant de tout modèle.

Théoriquement, tout point sur la courbe de Taylor (1979) est le résultat, en termes de variances de l'output et de l'inflation, d'une politique monétaire optimale, étant donné le modèle structurel de l'économie et le poids relatif **λ** assigné à la stabilisation de l'inflation dans une fonction objectif assimilable à (**1**). La courbe de Taylor peut ainsi être vue comme une frontière d'efficience qui relie tous les couples **(**$\sigma_y^2; \sigma_\pi^2) \sigma_y^2; \sigma_\pi^2)$ générés par une politique monétaire optimale conditionnellement à **λ**. Partant de ce fondement théorique, Levieuge et Lucotte (2014) suggèrent que la position d'un pays sur cette courbe, à un moment donné, révèle les préférences relatives de la Banque Centrale correspondante. Une Banque Centrale peut être considérée comme

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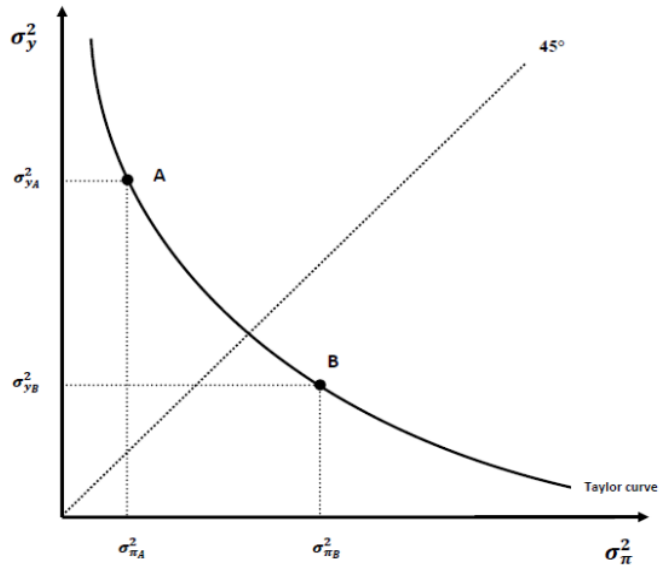
plus averse à l'inflation lorsque le couple ($\sigma_y^2; \sigma_\pi^2$)$\sigma_y^2; \sigma_\pi^2$) observé se situe au-dessus de la bissectrice. Le point ***A*** traduit le cas où les autorités monétaires ont une nette préférence relative pour la stabilisation de l'inflation. Au contraire, le point ***B*** renvoie à une situation où la priorité est donnée à la stabilisation de l'output (voir le **graphique 1** ci-dessous).

Graphique 1 : Courbe de Taylor et degré de conservatisme.



Source : Levieuge et Lucotte (2014).

La méthode d'identification proposée consiste ainsi à **calculer la valeur de l'angle de la** droite partant de l'origine et reliant le couple ($\sigma_y^2; \sigma_\pi^2$) ($\sigma_y^2; \sigma_\pi^2$) observé pour un pays, à une date donnée ou pour une période donnée. Soit, conformément à la définition trigonométrique usuelle :

angle (α) = atan ($\sigma_y^2; \sigma_\pi^2$)$\sigma_y^2; \sigma_\pi^2$**) x 180 /pi (1)**

Il suffit finalement d'opérer un changement d'échelle, en divisant par **90**, pour obtenir un indicateur de **λ**, compris entre **0** et **1**, nommé ***CONS***, et qui peut être interprété comme le degré de conservatisme des autorités monétaires[10], soit :

[10] En toute rigueur, il faudrait parler de degré d'aversion des autorités monétaires à l'inflation. Toutefois, Levieuge et Lucotte (2014) montrent qu'il est acceptable de considérer que le degré d'aversion des autorités monétaires à l'inflation est supérieur à celui de la société.

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$$CONS = \frac{1}{90}\left[atan\left(\frac{\sigma_y^2}{\sigma_\pi^2} \right) \times 180 / pi \right] \quad \textbf{(2)}$$

Notons que cet indicateur ***CONS*** est compris entre **0** et **1**. Plus la Banque Centrale se rapproche d'un score de **1** plus elle est considérée comme conservatrice.

Partant de là, dans le cas de la CEMAC[11], l'objectif de stabilité des prix est maitrisé par nature du fait l'ancrage à l'Euro et n'est plus un réel enjeu pour la BEAC qui évolue en régime de change fixe. **Il serait donc intéressant d'examiner l'arbitrage entre la stabilité externe de la monnaie et le soutien à l'économie au sein de la BEAC**. Ainsi, nous remplaçons dans la formulation de Levieuge et Lucotte (2014) l'objectif inflation (variabilité de l'inflation) par l'objectif de stabilité externe de la monnaie (variabilité du taux de couverture extérieur de la monnaie).

Nature et source des données

Les données recueillies sont de sources secondaires. Il s'agit des variables macroéconomiques suivantes : le taux d'inflation (indice de prix à la consommation) dans le pays **i** au cours de l'année **t** (**$INFL_{i,t}$**) et le taux de croissance réelle du Produit Intérieur Brut par habitant dans le pays **i** au cours de l'année **t** (**$PIB_{i,t}$**). Ces données proviennent des bases statistiques de la Banque des Etats de l'Afrique Centrale de 2018. L'indice de conservatisme est donc calculé par nos propres soins suivant la méthodologie de Levieuge et Lucotte (2014). L'échantillon porte sur les (06) pays de le CEMAC (le Cameroun, le Congo, le Gabon, le Guinée Equatoriale, le République Centrafricaine et le Tchad) qui se retrouvent au sein de la BEAC et la périodicité est annuelle. Elle part de 1980 à 2015.

Presentation et Interpretation des Resultats

Par application, le degré de conservatisme relatif à la couverture extérieur de la monnaie dans la zone CEMAC est assez faible soit en **0.06241367 point** sur la période 1985-2015. Le **graphique 2** qui est la représentation graphique de la formulation de Levieuge et Lucotte (2014) montre que **la plupart des actions et décisions de politique monétaire au sein de la BEAC entre 1980 et 2015 ont largement eu une préférence pour l'objectif de soutien de la croissance économique par rapport à l'objectif**

[11] Communauté Economique et Monétaire des Etats de l'Afrique Centrale.

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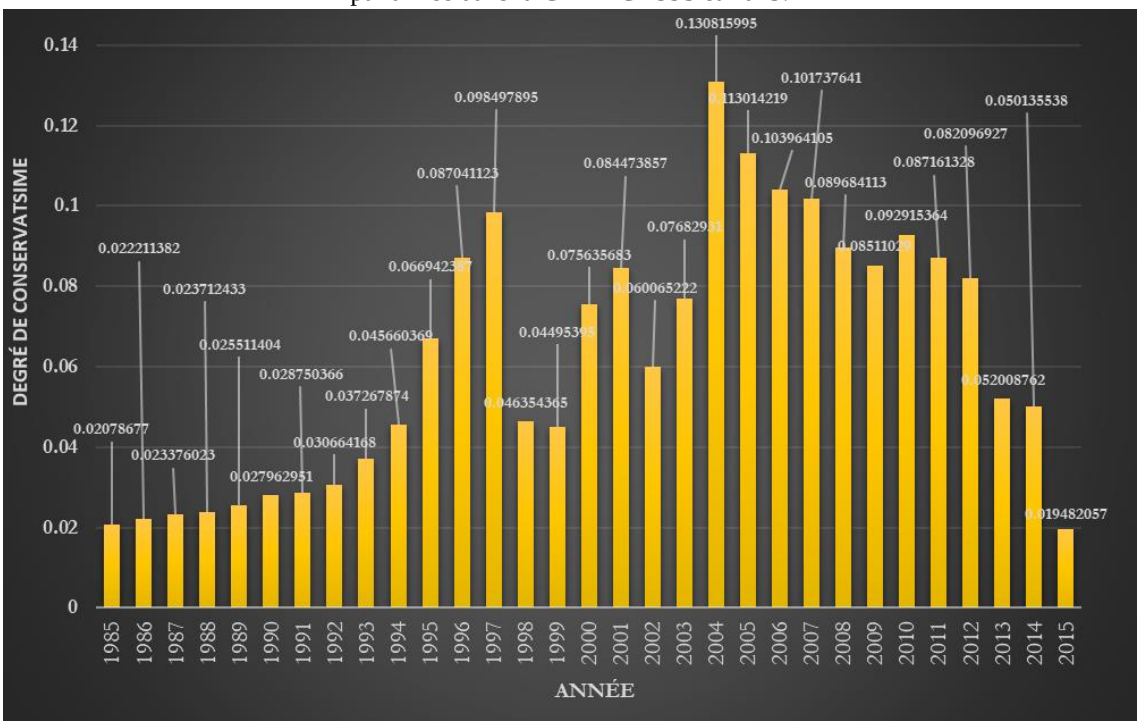
de couverture extérieur de la monnaie. Il en est de même pour Banque Centrale du Nigéria évoluant en change flexible (**0.415877 point**) (voir **graphique 3**) et dont les objectifs de politique monétaire sont la stabilité des prix, la stabilité macroéconomique et la croissance économique. Les objectifs de cette Banque Centrale se rapprochent à celle de BEAC, nous constatons qu'elle a également accordé beaucoup plus de privilège l'objectif de croissance économique malgré le fait qu'elle évolue en change flexible.

Par contre, **le graphique 4** qui présente l'arbitrage entre l'objectif de stabilité des prix et l'objectif de soutien à l'économie par année dans la CEMAC montre qu'après la dévaluation du Franc CFA de 1994, la stabilité des prix a été prioritaire au soutien à l'économie. Cela justifie bien les réformes de politique monétaire qui sont survenues à cette époque au sein de la BEAC, dont le but était de réduire l'inflation induite par la dévaluation de la monnaie de la Zone Franc.

Graphique 2 : Arbitrage la couverture extérieure de la monnaie et le soutien à l'économie par année dans la CEMAC 1995 et 2015.



Source : Construction des auteurs

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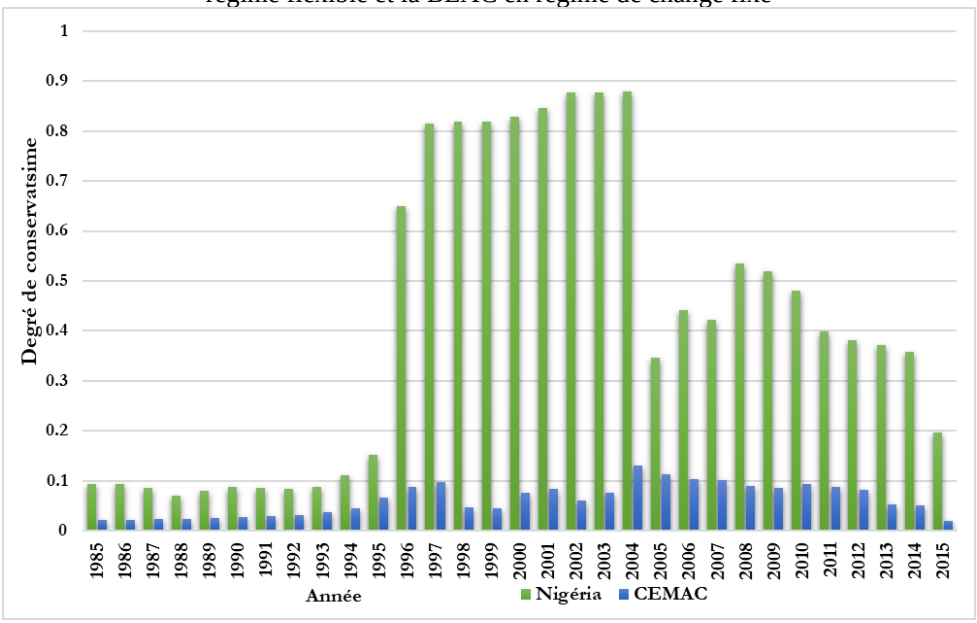
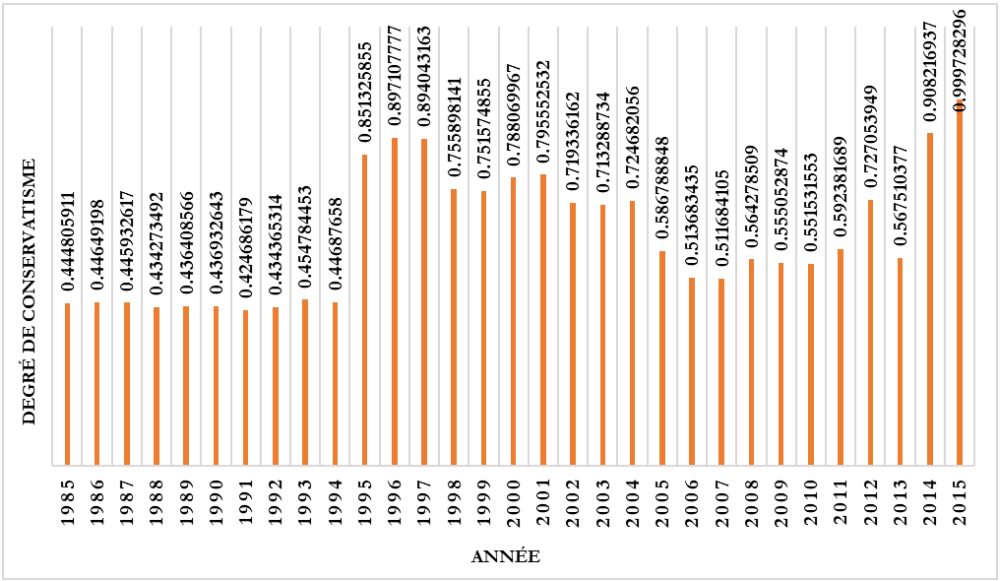
Graphique 3 : Comparaison de conservatisme entre la Banque Centrale du Nigéria en régime flexible et la BEAC en régime de change fixe



Source : Construction des auteurs

Graphique 4 : Arbitrage entre la stabilité des prix et le soutien à l'économie par année dans la CEMAC entre 1995 et 2015



Source : Construction des auteurs

Conclusion

La littérature décrit le banquier central moderne comme un joueur aux préférences conservatrices dont les incitations dépendent d'un cadre qui

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garantit son statut d'agent de politique monétaire indépendant. En outre, il est également reconnu que les banquiers centraux sont des individus qui sont soumis aux mêmes sources de biais comportementaux que tous les individus. En présence d'un biais comportemental, le résultat de la prise en compte de différents ensembles d'informations ou de différentes règles de gouvernance peut être sensiblement différent du résultat de l'analyse standard.

En Afrique Subsaharienne, la mise en œuvre des politiques monétaires est plus compliquée qu'avant en raison de la vulnérabilité des pays à l'évolution défavorable des termes de l'échange, de l'approfondissement financier en cours et de l'évolution des régimes de change. De plus, elle se heurte à un certain nombre d'obstacles institutionnels et de problèmes de capacités, notamment l'absence de données adéquates pour mesurer correctement l'inflation étant donné la dichotomie villes/campagnes dans le panier de consommation, l'état de l'économie, une compréhension imparfaite des canaux de transmission, une responsabilisation insuffisante concernant les objectifs de politique économique et la transparence des processus décisionnels, et une attention insuffisante aux stratégies de communication.
L'objectif de cet article était de mesurer empiriquement le degré de conservatisme de la BEAC et d'en déduire sa préférence en termes d'objectifs. Les résultats démontrent que la plupart des actions et décisions de politique monétaire au sein de la BEAC entre 1980 et 2015 ont largement eu une préférence pour l'objectif de soutien de la croissance économique par rapport à l'objectif de couverture extérieur de la monnaie.

Sur le plan normatif, cela soulève la question de la détermination d'instruments adéquats (en termes de nombre et d'assignation) pour atteindre ces objectifs parfois contradictoires. Pour être pleinement efficace, cela nécessiterait également des réformes formelles énonçant de tels objectifs supplémentaires en droit. Les banques centrales et particulièrement la BEAC serait alors officiellement responsable de ces objectifs.

En d'autres termes, les banquiers centraux peuvent justifier leurs actions en invoquant des raisons informationnelles ou des motifs de gouvernance. Toutefois, comme il s'agit à la fois de bureaucrates (c'est-à-dire d'acteurs soucieux de leur carrière) et d'humains, d'autres éléments peuvent entrer en jeu. Cette perspective mérite l'attention étant donné que l'analyse de la conception des Banques Centrales doit tenir compte de la pertinence potentielle des biais comportementaux. Les recherches futures devront s'attacher davantage à mettre en évidence la relation entre les biais comportementaux et les différentes configurations des organes de politique monétaire.

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Contribution de l'Intelligence Artificielle à la Performance des Projets de Recherche Scientifique

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Résumé

L'avancement des connaissances et les progrès dans divers domaines dépendent de la recherche scientifique. L'évolution rapide de l'intelligence artificielle (IA) offre de nouvelles perspectives pour améliorer l'efficacité et les résultats de ces efforts scientifiques. L'IA, notamment l'apprentissage automatique et la manipulation du langage naturel, a le pouvoir de transformer le processus de recherche scientifique. Elle permet d'analyser efficacement de vastes ensembles de données, révélant des modèles complexes qui sont difficiles à détecter manuellement. L'IA stimule également les avancées scientifiques en formulant des hypothèses de recherche. De plus, elle libère les chercheurs en automatisant les tâches répétitives, ce qui leur permet de se concentrer sur les aspects créatifs de leur travail. Cependant, l'intégration de l'IA dans la recherche scientifique soulève des questions et des obstacles importants. La crédibilité des résultats obtenus grâce à l'IA peut être remise en question, et comprendre les choix effectués par les systèmes d'IA peut être

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complexe pour les chercheurs. Il est donc essentiel de comprendre l'effet de l'IA sur la performance des projets de recherche scientifique, afin de maximiser les avantages tout en atténuant les risques. Notre étude vise à étudier l'effet de l'IA sur la recherche scientifique en utilisant une approche qualitative. Nous avons mené des entretiens approfondis avec des doctorants chercheurs dans le domaine des sciences de gestion. L'analyse des données a été réalisée à l'aide d'une méthode d'analyse de contenu incluant des fréquences de mots, des matrices à condensés pour l'analyse thématique et un croisement matriciel des nœuds avec les sources. En suivant une méthodologie rigoureuse et systématique, nous cherchons à obtenir un aperçu complet des perspectives des chercheurs et à générer des connaissances sur le rôle de l'intégration de l'IA dans la recherche scientifique. Les résultats de notre étude montrent que l'intégration de l'IA dans la recherche scientifique améliore l'efficacité et favorise la découverte de nouvelles significations. Plus précisément, elle présente plusieurs avantages notables : une efficacité accrue grâce à l'automatisation des tâches répétitives ; une découverte de nouvelles significations, optimisée par l'analyse de structures de données avancées ; et une amélioration des performances, se manifestant par un impact positif sur la génération d'hypothèses et la conception d'expériences. Ces résultats corroborent les avantages soulignés dans la littérature existante, tout en mettant en lumière des enjeux éthiques et réglementaires importants.

Mots-clés: Intelligence artificielle, Recherche scientifique, Performance, Apprentissage automatique

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The Contribution of Artificial Intelligence to the Performance of Scientific Research Projects

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Abstract

The advancement of knowledge and progress in various fields depend on scientific research. The rapid evolution of artificial intelligence (AI) offers new opportunities to improve the efficiency and results of these scientific efforts. AI, including machine learning and natural language manipulation, has the power to transform the scientific research process. It allows for the efficient analysis of large data sets, revealing complex patterns that are difficult to detect manually. AI also drives scientific advances by formulating research hypotheses. In addition, it frees up researchers by automating repetitive tasks, allowing them to focus on the creative aspects of their work. However, the integration of AI into scientific research raises significant questions and obstacles. The credibility of the results obtained through AI can be questioned, and understanding the choices made by AI systems can be complex for researchers. It is therefore essential to understand the effect of AI on the performance of scientific research projects, in order to maximize benefits while mitigating risks. Our study aims to investigate the effect of AI on scientific research using a qualitative approach. We will conduct in-depth interviews with doctoral students who are researchers in the field of management sciences. Data analysis was performed using a content analysis method, including word frequencies, condensed matrices for thematic analysis, and matrix cross-referencing of nodes with sources. By following a rigorous and systematic methodology, we seek to gain a comprehensive overview of researchers' perspectives and generate knowledge about the role of integrating AI into scientific research. The results of our study show that the integration of AI into scientific research improves efficiency and promotes the discovery of new meanings. Specifically, it has several notable advantages:

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increased efficiency through automation of repetitive tasks; the discovery of new meanings, powered by the analysis of advanced data structures; and improved performance, manifested in a positive impact on hypothesis generation and experiment design. These results corroborate the benefits highlighted in the existing literature while highlighting important ethical and regulatory issues.

Keywords: Artificial Intelligence; Scientific Research; Performance; Machine Learning.

Introduction

L'intelligence artificielle (IA) est devenue un puissant catalyseur dans divers domaines, notamment la recherche scientifique (Boushaba & Chakor.A, 2023). Son impact sur les efforts de recherche est profond et promet de révolutionner le paysage. En exploitant les capacités de l'IA, les projets scientifiques peuvent ouvrir de nouvelles perspectives, améliorer la productivité et accélérer le parcours de découverte. L'utilisation de l'intelligence artificielle (IA) dans la recherche scientifique offre la possibilité d'approfondir des domaines vastes et complexes (Abramo, & Ciriaco A, 2023). Cela facilite la gestion de grandes quantités de données, ainsi que l'identification de modèles et d'interconnexions complexes qui autrement posent un défi à discerner (Jmoula & Belouali, 2022).

Les algorithmes d'apprentissage automatique et les réseaux de neurones sont capables d'examiner rapidement de vastes ensembles de données, d'en extraire des informations pertinentes et, par conséquent, de favoriser la création de nouvelles informations (LeCun, Y. & al, 2015). L'intégration de l'intelligence artificielle (IA) dans la recherche scientifique a le potentiel d'améliorer l'efficacité des processus de collecte, d'expérimentation et d'analyse de données (Connor.N & Momoko.U;, 2023). Grâce à l'utilisation de robots et de capteurs autonomes, les données peuvent être collectées de manière indépendante, réduisant ainsi le temps et les efforts nécessaires à la collecte d'informations (Moustafa Zouinar, 2024). De plus, la mise en œuvre de techniques d'analyse automatisées contribue à accélérer le traitement des données et à identifier les modèles et tendances cachés (Tyagi, A. K., 2021).

L'IA peut également contribuer à l'optimisation de la planification et la gestion des projets de recherche scientifique (Boushaba & Chakor.A, 2023). Les systèmes d'IA peuvent aider à identifier les lacunes dans les connaissances existantes, suggérer des pistes de recherche prometteuses et orienter la conception expérimentale (Connor.N & Momoko.U;, 2023). De plus, en utilisant des modèles prédictifs, l'IA peut prédire les résultats probables, aider à prendre des décisions éclairées et minimiser les risques.

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D'un autre côté, intégrer l'intelligence artificielle dans la recherche scientifique pose une série de difficultés et de dilemmes éthiques (Jobin, Vayena, & Ienca, 2019). Il est impératif de garantir la transparence, la responsabilité et la reproductibilité des résultats obtenus grâce à l'IA. En outre, il ne faut pas que l'IA remplace complètement les chercheurs, elle doit plutôt servir d'aide et d'outil pour améliorer les compétences et l'efficacité. Dans ce contexte, il est nécessaire d'étudier l'impact de l'intelligence artificielle sur la performance des projets de recherche scientifique. Nous allons donc répondre à la question suivante : **Comment l'intégration de l'intelligence artificielle impact-t-elle la performance des projets de recherche scientifique ?**

Afin de répondre à cette problématique de recherche, nous avons adopté une méthodologie axée sur l'approche qualitative, en utilisant une revue de littérature approfondie et des entretiens semi-directifs. Notre revue minutieuse des écrits scientifiques nous a permis de discerner les principales perspectives et obstacles liés à l'intégration de l'intelligence artificielle dans la recherche scientifique.

Parallèlement, nous avons mené des entretiens semi-directifs avec des doctorants chercheurs en utilisant un guide d'entretien pour comprendre comment l'IA impact la performance des projets de recherche scientifique. Ces entretiens visaient spécifiquement à examiner les variables indépendantes identifiées dans notre cadre conceptuel. Grâce à cette approche, nous avons obtenu un aperçu qualitatif des expériences, des obstacles et des avantages potentiels rencontrés par les doctorants lors de l'utilisation de l'intelligence artificielle pour améliorer leurs projets de recherche scientifique.

Revue de littérature sur le concept de l'intelligence artificielle

Définition de l'intelligence artificielle (IA)

Le domaine de l'intelligence artificielle (IA) englobe un large éventail de disciplines informatiques dans le but de créer des machines capables d'effectuer des tâches traditionnellement réservées à l'intelligence humaine. Au fil du temps, le concept de l'IA s'est développé parallèlement aux progrès de la technologie, de la science et de la théorie. Les chercheurs abordent l'étude de l'IA sous différents angles, en se concentrant sur des domaines tels que le raisonnement, l'apprentissage, la perception, la compréhension du langage, la résolution de problèmes et l'interaction intelligente avec l'environnement. Les définitions de l'IA sont façonnées par des approches à la fois théoriques et techniques, notamment le raisonnement symbolique, l'apprentissage automatique, les réseaux neuronaux et l'apprentissage profond, chacune offrant des perspectives distinctes sur la manière dont les machines acquièrent et utilisent des connaissances pour imiter l'intelligence humaine et atteindre divers objectifs. La définition de (McCarthy, Minsky, Rochester, & Shannon, 1955) , l'une des premières et des plus influentes dans le domaine de

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l'intelligence artificielle, propose d'étudier les aspects de la recherche qui permettent de rendre les machines intelligentes. Ils souhaitent donner une signification précise à l'expression « penser comme un être humain » et concevoir des expériences qui permettent de tester ces propositions. En adoptant cette approche, leur objectif est de comprendre les principes fondamentaux de l'intelligence et de les reproduire dans des machines. Cette définition a jeté les bases de la recherche en IA et a influencé le développement ultérieur du domaine.

Les différentes perspectives des autres auteurs sur l'intelligence artificielle (IA) peuvent être liées aux concepts mentionnés précédemment, tels que le raisonnement symbolique. Les définitions proposées par ces auteurs témoignent de l'évolution et de la diversité de l'IA en tant que domaine d'étude. (Rich.E & Knight, 1991), soulignent l'objectif fondamental de l'IA : « imiter l'intelligence humaine ».

L'idée de développer des machines intelligentes, y compris des programmes informatiques, est en accord avec la notion d'utiliser le raisonnement symbolique pour manipuler des symboles et des règles logiques (Russell & Norvig, 1995).

La référence à des systèmes capables de simuler l'intelligence humaine dans des domaines tels que la reconnaissance vocale, la vision par ordinateur et la prise de décision (Thrun, S, Norvig, P, & al, . 2016), correspond à l'application concrète de l'IA dans des domaines spécifiques, en utilisant des méthodes telles que l'apprentissage automatique et les réseaux neuronaux. Les définitions qui décrivent l'IA comme la création de systèmes capables de percevoir, raisonner, apprendre, planifier et prendre des décisions (Nilsson, N. J., 2014), ainsi que la capacité des machines à apprendre de l'expérience, à s'adapter et à améliorer leurs performances au fil du temps (Mitchell, T. M, 1997), sont liées aux approches d'apprentissage automatique et d'apprentissage profond, qui permettent aux machines d'acquérir des connaissances et de s'améliorer par elles-mêmes. Enfin, l'évocation de la compréhension du langage naturel, la résolution de problèmes complexes et l'adaptation à des situations nouvelles ou inattendues (Russell & Norvig, 2010), renforce l'idée que l'IA vise à doter les machines de capacités cognitives similaires à celles des êtres humains.

De nos jours, l'intelligence artificielle englobe une variété d'approches et de définitions, mais elles partagent toutes un objectif commun : développer des machines capables d'imiter l'intelligence humaine et d'exécuter des tâches qui nécessitent généralement une telle intelligence.

Historique de l'intelligence artificielle

Au cours des six dernières décennies, l'intelligence artificielle a connu diverses étapes et approches. Initialement, dans les années 1950 et 1960, selon

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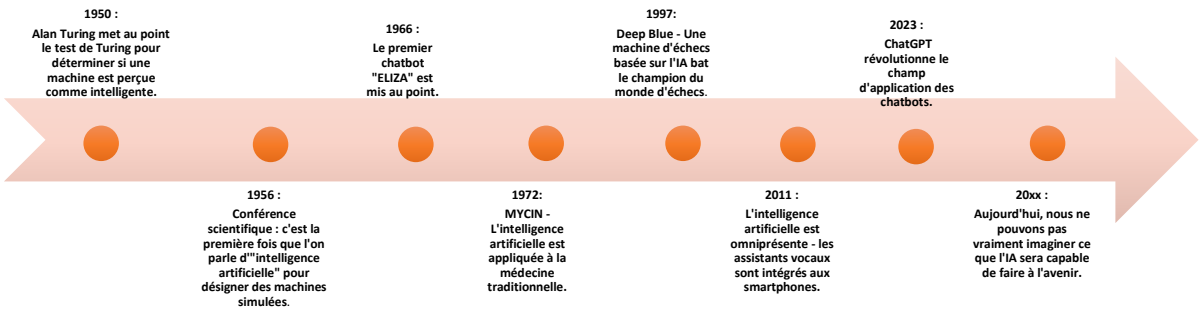
(Mantouzi.S & Said.Y, 2023) , l'accent principal tournait autour des techniques symboliques et logiques, avec des recherches approfondies consacrées à la résolution de problèmes, au raisonnement et à la représentation des connaissances. Au fil du temps, dans les années 1980 et 1990, parmi les avancées majeures dans le domaine de l'IA on peut souligner un intérêt croissant pour des domaines spécifiques tels que la reconnaissance vocale, la traduction automatique et les systèmes de vision par ordinateur (Boushaba & Chakor.A, 2023).

Durant la transition vers le 21e siècle, l'intelligence artificielle a subi une transformation substantielle en raison de l'essor de l'apprentissage automatique, notamment grâce à l'utilisation de réseaux de neurones artificiels et d'algorithmes d'apprentissage profond. Ces progrès ont entraîné des progrès notables dans des domaines tels que la vision par ordinateur, la reconnaissance vocale, la traduction automatique et les systèmes de recommandation. Au cours des dernières décennies, l'intelligence artificielle a également profité de l'expansion des technologies de l'information et de la disponibilité de données massives, permettant à l'apprentissage automatique et à l'informatique de progresser plus rapidement.

Dans notre monde moderne, l'intelligence artificielle est devenue omniprésente faisant partie intégrante de notre vie quotidienne. Nous pouvons constater son impact sur de multiples aspects de nos vies, que ce soit à travers les assistants virtuels sur smartphones, les voitures autonomes révolutionnaires qui parcourent nos rues, ou encore les chatbots et les systèmes de recommandation en ligne. Le domaine est en constante évolution, avec l'émergence de recherches et de nouvelles applications dans des domaines aussi divers que la robotique, l'IA éthique, l'IA interprétative et l'IA générale. Le développement de l'intelligence artificielle ne montre aucun signe de ralentissement, ce qui souligne son importance et sa pertinence dans la société contemporaine.

Figure 1: Histoire de l'intelligence artificielle



(Source : auteurs)

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Domaines de l'intelligence artificielle

L'intelligence artificielle comprend plusieurs domaines clés qui contribuent à son développement : l'apprentissage automatique, également connu sous le nom de machine learning, est l'un de ces domaines (Samuel, A., 1959). Il se concentre sur la création d'algorithmes et de modèles permettant aux machines d'acquérir des connaissances à partir de données. Le traitement du langage naturel (Natural Language Processing - NLP) est un autre domaine majeur de l'IA qui facilite l'interaction entre les humains et les ordinateurs en utilisant le langage naturel (Jones, K. S, 1972) . Il implique l'analyse, la compréhension et la génération de données linguistiques de manière significative pour les ordinateurs. Les réseaux de neurones artificiels sont des structures mathématiques utilisées pour simuler les réseaux neuronaux biologiques. Leur utilisation est primordiale dans divers domaines tels que la reconnaissance d'images, la traduction linguistique, la prédiction de séries chronologiques et la recommandation de produits (McCulloch, & Pitts, 1943). Les systèmes experts sont des applications informatiques développées pour reproduire les compétences de raisonnement et d'expertise d'un professionnel humain dans un domaine spécifique (McCorduck, P. & Feigenbaum, E, 1983) . Enfin, la logique et le raisonnement fournissent les fondements pour la représentation des connaissances et le raisonnement logique dans les systèmes d'intelligence artificielle (McCarthy J. , 1958). Par la combinaison de la logique et du raisonnement, les systèmes d'IA sont capables de manipuler des connaissances, de résoudre des problèmes complexes, de prendre des décisions et de fournir des réponses justifiées. En intégrant ces domaines, l'IA offre la capacité aux machines d'apprendre à partir de données, d'interagir avec le langage humain, de simuler des réseaux neuronaux et de reproduire l'expertise humaine dans des domaines spécifiques.

Définition de la recherche

La recherche est un processus méticuleux et systématique conçu pour approfondir notre compréhension, répondre à des questions spécifiques, résoudre des problèmes et découvrir de nouvelles idées. Cela nécessite une approche rigoureuse de la collecte, de l'évaluation et de l'interprétation des données pertinentes afin de former une vision holistique d'un sujet spécifique. Elle couvre des domaines tels que les sciences naturelles, les sciences sociales, les sciences humaines, la médecine et la technologie. Les chercheurs utilisent diverses méthodes, notamment l'observation, l'expérimentation, les enquêtes et l'analyse statistique, pour garantir la fiabilité et l'exactitude de leurs résultats. Son but ultime est d'apporter une contribution significative à l'avancement des connaissances et d'apporter des solutions efficaces dans un domaine précis.

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La recherche reste donc une démarche rigoureuse visant à étudier de manière systématique un problème ou une question spécifique. Elle implique une interprétation précise des données collectées pour générer des connaissances fiables (Dionne, .B, 1994). En d'autres termes, la recherche peut être décrite comme un effort visant à découvrir quelque chose ou comme une démarche intellectuelle pour accéder à la connaissance (Le grain, M, 1994).

La recherche scientifique

Le progrès des nations est propulsé par la recherche scientifique, qui contribue au progrès grâce à la fourniture de connaissances, de solutions innovantes et de progrès technologiques. Ce rôle essentiel s'étend à favoriser la prospérité économique, à l'amélioration du bien-être des communautés et à la résolution des défis mondiaux. En tant que source de sagesse, la recherche scientifique reste un canal de diffusion de connaissances approfondies et de découvertes révolutionnaires. De plus, elle favorise des solutions imaginatives qui ouvrent la voie à des progrès notables dans divers domaines social, économique et environnemental. La poursuite des connaissances scientifiques implique une approche méticuleuse et méthodique en vue d'élargir notre corpus de connaissances, à résoudre des problèmes complexes et à répondre à des questions scientifiques. Cet effort repose sur l'utilisation de méthodologies et de pratiques distinctes, notamment une observation minutieuse, une expérimentation contrôlée, une analyse méticuleuse des données et la formulation de théories globales.

Définition de la recherche scientifique

Divers auteurs soulignent l'existence d'une diversité de définitions de la recherche scientifique, qui dépendent du domaine de recherche spécifique et des méthodes utilisées par les chercheurs pour exploiter les connaissances. La recherche scientifique peut être décrite comme une enquête qui repose sur une approche "systématique" (Ngongo & Paul, 1999). Cela implique une méthode rigoureuse et organisée, basée sur des procédures et des étapes clairement définies, visant à examiner de manière critique les hypothèses formulées sur les relations présumées entre les phénomènes de la nature. Ces auteurs mettent en évidence le caractère systématique et contrôlé de la recherche scientifique, ainsi que son orientation vers l'exploration des relations entre les phénomènes naturels. Ils soulignent également l'importance de l'approche empirique, qui implique la collecte et l'analyse de données pour étayer ou réfuter les hypothèses formulées.

Le processus systématique de recherche scientifique, tel que décrit par d'autres auteurs, vise à découvrir, élucider et anticiper les phénomènes naturels et sociaux grâce à l'application de méthodes rigoureuses et de normes empiriques de vérification (Bunge, M., 2006). C'est une approche méthodique

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et systématique qui cherche à répondre à des questions, à tester des hypothèses et à générer des connaissances fiables et valides en utilisant des méthodes empiriques et des procédures rigoureuses (Salkind, N. J, 2017). Ce processus est un effort méthodique et objectif conçu pour générer de nouvelles connaissances fiables en utilisant des méthodes rigoureuses de collecte, d'analyse et d'interprétation des données (William, M.K & al, 2018). De plus, ce processus englobe la collecte et l'examen de données pertinentes afin de produire des informations précieuses et applicables qui contribuent à notre compréhension et à l'amélioration du monde environnant (Sekaran, U & Bougie, R., 2016).

La recherche scientifique se caractérise donc par une approche dynamique et systématique de la connaissance, permettant d'explorer des phénomènes, de résoudre des problèmes et d'acquérir des connaissances. Le processus de recherche implique une acquisition systématique de connaissances par le biais d'investigations, de résolutions de problèmes et d'examens de phénomènes.

Elle se distingue par sa rigueur et sa systématicité, dans le but d'obtenir des réponses précises et de relever des questions et des défis. La présentation des faits vise à améliorer la compréhension et à élargir les connaissances.

La performance : une définition contextuelle de concept

La performance est un concept fréquemment employé, bien qu'il soit difficile de lui attribuer une définition concise en raison de sa complexité multidimensionnelle. Traditionnellement, la performance est appréhendée à travers les notions d'efficacité et d'efficience. (Bourguignon.A, 1998), décrit la performance comme l'habileté à accomplir efficacement les tâches essentielles, en maximisant l'utilisation des ressources disponibles pour obtenir les meilleurs résultats possibles. (Bachet.D, 1998) , souligne que la performance est une "caractéristique émergente" qui va au-delà de la simple agrégation des performances individuelles. Elle repose sur une interaction positive entre les aspects économiques et sociaux, ainsi qu'une préoccupation pour la réussite à long terme.

(Lorino.P, 1997), définit la performance dans une entreprise comme étant tous les éléments qui jouent un rôle significatif dans la réalisation des objectifs stratégiques. (Pesqueux.Y, 2004), souligne que la performance englobe à la fois la réalisation d'un processus ou d'une tâche, les résultats qui en découlent et le succès qui peut y être associé. Il précise également que la performance n'est pas intrinsèquement bonne ou mauvaise, mais évaluée en fonction des objectifs fixés.

Enfin, (Wilfrid.A, 2007), restreint la signification de la performance à celle du développement, soulignant son lien étroit avec l'idée de progression et d'évolution constantes. Ainsi, nous tenons à signaler que la performance

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peut être définie comme l'aptitude à accomplir efficacement les tâches essentielles en utilisant au mieux les ressources disponibles, tout en tenant compte des aspects économiques et sociaux, de la réalisation des objectifs stratégiques, des résultats obtenus et du succès associé. Elle est évaluée en fonction des objectifs fixés et est étroitement liée à l'idée de progression et de développement constant.

L'impact de l'IA sur la performance de la recherche scientifique

L'intelligence artificielle (IA) offre un potentiel considérable pour améliorer la recherche scientifique dans de nombreux domaines. Selon (Inria, 2016), les avancées de l'IA, telles que l'apprentissage automatique, les connaissances et le web sémantique, les neurosciences et les sciences cognitives, ainsi que l'analyse du langage, ont le potentiel d'améliorer la performance de la recherche scientifique. L'automatisation des tâches répétitives, l'analyse avancée des données, la découverte de nouvelles connaissances à partir de vastes ensembles de données et l'aide à la prise de décision sont quelques-unes des applications potentielles de l'IA dans ce domaine. Selon (Salvagno & al, 2023), l'intégration de l'intelligence artificielle est prometteuse pour améliorer la précision et la qualité des publications scientifiques. En intégrant l'IA à la rédaction scientifique, il devient possible de générer de nouvelles idées basées sur la littérature scientifique préexistante, de simuler diverses approches pédagogiques et d'améliorer la recherche assistée par l'IA. De plus, l'IA facilite la communication scientifique entre les chercheurs et le grand public, élevant ainsi les normes de recherche, de communication et de qualité des articles.

D'après (Ghosh.A & Aishik, 2023), l'intelligence artificielle peut contribuer à la génération d'hypothèses, à la conception et au suivi d'expériences, à la collecte de données, aux simulations, au raisonnement rapide et à bien d'autres domaines de la recherche scientifique. Elle permet également de découvrir de nouvelles significations dans la littérature scientifique, de réutiliser des outils développés pour l'IA et de quantifier et diffuser l'incertitude. L'impact de l'IA sur la science s'étend également à d'autres domaines, tels que la communication scientifique, la science citoyenne et la recherche sur l'IA elle-même. Dans leur étude sur l'influence potentielle de l'intelligence artificielle (IA) dans la recherche scientifique, notamment dans les sciences de gestion, (Véry.Ph & Ludovic.C, 2019) mettent en avant le caractère révolutionnaire de l'IA et son potentiel de transformation du travail des chercheurs et du processus de recherche dans divers domaines. Ils soulignent également que l'IA peut accélérer le processus de recherche en automatisant la création de modèles analytiques et en identifiant des modèles complexes dans de vastes ensembles de données, ce qui peut conduire à de nouvelles découvertes. Cependant, les auteurs reconnaissent également les

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défis et les enjeux liés à l'utilisation de l'IA dans la recherche scientifique. Ils signalent que l'introduction de l'IA suscite des débats sur des concepts fondamentaux tels que la rationalité, l'empirisme, la rigueur et la pertinence. Ils mettent en garde contre la nécessité d'une réflexion critique sur l'impact de l'IA dans la recherche scientifique.

Dans cette étude, les auteurs mettent en évidence l'importance de prendre en compte à la fois les avantages et les difficultés liés à l'application de l'IA. Alors que l'IA continue de se développer et de s'intégrer dans le domaine de la recherche scientifique, des considérations telles que le développement des carrières de recherche et les débats scientifiques seront des aspects clés à prendre en compte.

L'analyse complète de diverses études établit indéniablement la puissance de l'intelligence artificielle (IA) en tant qu'instrument remarquable qui impact grandement la performance de la recherche scientifique. En intégrant l'IA dans la rédaction scientifique, on peut améliorer la précision, le calibre et l'efficacité des publications, tout en accélérant le processus de la recherche scientifique. De plus, l'IA présente la capacité de générer des concepts révolutionnaires, de construire des validations mathématiques et de collecter et analyser des données avec compétence. Par conséquent, cette avancée technologique offre de vastes possibilités pour transformer de manière significative les résultats et les performances de la recherche scientifique. Cependant, il est impératif de reconnaître que l'IA présente également un ensemble de défis et nous incite à nous engager dans une analyse critique continue.

Méthodes

Méthodologie et Objectifs de l'Étude

La méthodologie adoptée pour cette recherche est une approche qualitative, qui permet d'explorer en profondeur les perceptions et les expériences des participants. L'objectif de cette étude est d'explorer l'impact de l'intelligence artificielle sur la performance des projets de recherche scientifique, de comprendre comment l'IA peut améliorer l'efficacité, les résultats et la créativité dans ce domaine, et de fournir des informations précieuses aux chercheurs et aux institutions de recherche. Cela vise à maximiser les avantages de cette technologie et à favoriser des avancées significatives dans le domaine scientifique. La collecte des données est basée sur des entretiens semi-directifs, (Wacheux.F, 1996) a identifié les entretiens comme un outil important pour recueillir des données primaires sur un projet de recherche. Le but d'un entretien est de permettre au chercheur de recueillir les opinions, les pensées et les interactions des répondants concernant les objets de recherche. Ces informations peuvent ensuite être analysées par le chercheur pour approfondir sa compréhension du sujet (Hiétart.R, 2014) . Les

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entretiens sont une méthode de collecte de données qui présente plusieurs avantages (Olibert.A, & Jourdan.P.J, 2011).

Notre guide d'entretien vise à examiner l'impact de l'IA sur la performance des projets de recherche scientifique. Il est structuré pour recueillir des informations de base sur les participants, explorer leurs parcours de recherche, évaluer leur familiarité avec l'intelligence artificielle, et examiner l'utilisation d'outils basés sur l'IA. De plus, il s'intéresse à l'impact potentiel de l'IA sur l'efficacité et la productivité dans le domaine de la recherche scientifique, ainsi qu'aux changements observés par rapport aux approches traditionnelles. Ce guide est conçu de manière à vérifier les relations énumérées dans le modèle conceptuel et à susciter des réflexions approfondies sur les concepts étudiés.

Lors de la planification de notre recherche qualitative, il est important de justifier la taille de l'échantillon pour obtenir les informations nécessaires à notre analyse ultérieure. En recherche qualitative, la pertinence de la stratégie d'échantillonnage dépend de l'adéquation de l'échantillon aux données souhaitées (Onwuegbuzie.A.J., & & Leech.N., 2005), afin d'éviter la saturation théorique (Corbin.J & Strauss.A., 2008) et la redondance des informations (Guba.EG & Lincoln.YS, 1994). La saturation est un critère d'excellence dans la recherche (Morse.JM, 1995). La taille de l'échantillon en recherche qualitative est souvent déterminée de manière arbitraire, sans règles strictes définies (Patton.MQ, 2002).

Dans notre étude, nous avons sélectionné un échantillon de 25 doctorants chercheurs dans les sciences de gestion, ayant entre 1 et 4 ans d'expérience dans la recherche utilisant l'intelligence artificielle dans leurs projets de recherche doctorale. Cependant, en raison de la saturation des données, nous avons finalement retenu 15 participants, le processus d'entretien a été principalement en face à face, ce qui a permis interaction directe et fluide avec les participants, tout en veillant à respecter strictement l'anonymat pour assurer la confidentialité des informations partagées.

Les données collectées ont ensuite été analysées à l'aide du logiciel NVIVO, un outil d'analyse qualitative qui facilite aux chercheurs de coder, d'organiser et d'analyser des informations provenant de diverses sources, telles que des entretiens, des enquêtes et des documents. Cet outil facilite l'identification de thèmes et de modèles, ce qui nous a permis d'identifier des tendances significatives et d'approfondir notre compréhension des perceptions et des expériences des participants.

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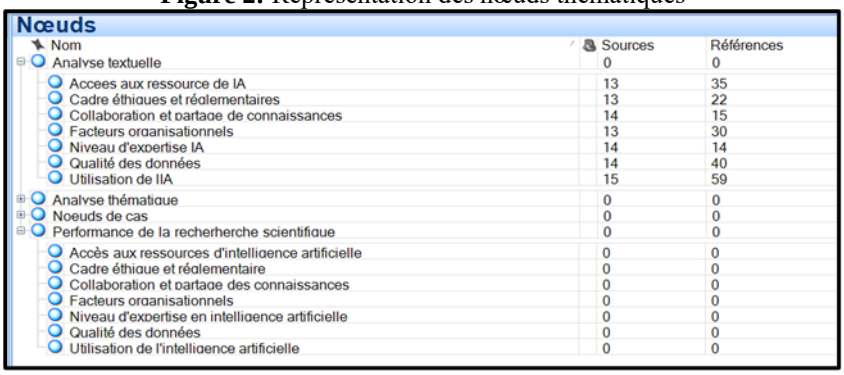
Résultats

Analyse des résultats : Exploration de l'impact de l'IA sur la performance des projets de recherche scientifique à travers les interactions des interviewés

Pour analyser les données collectées, nous avons choisi la méthode d'analyse de contenu en raison de sa flexibilité pour l'analyse des données textuelles (Cavanagh, S., 1997).

Figure 2: Représentation des nœuds thématiques



Nœuds

Nom	Sources	Références
Analyse textuelle	0	0
Accees aux ressource de IA	13	35
Cadre éthiques et réglementaires	13	22
Collaboration et partage de connaissances	14	15
Facteurs organisationnels	13	30
Niveau d'expertise IA	14	14
Qualité des données	14	40
Utilisation de IIA	15	59
Analyse thématique	0	0
Noeuds de cas	0	0
Performance de la recherherche scientifique	0	0
Accès aux ressources d'intelligence artificielle	0	0
Cadre éthique et réglementaire	0	0
Collaboration et partage des connaissances	0	0
Facteurs organisationnels	0	0
Niveau d'expertise en intelligence artificielle	0	0
Qualité des données	0	0
Utilisation de l'intelligence artificielle	0	0

(Source : sortie du logiciel Nvivo 10)

Figure 3:Importance des mots par densité -Analyse des fréquences

(Source : sortie du logiciel Nvivo 10)

La lecture de ce graphique nous indique la fréquence des mots exprimés par les personnes interrogées de notre étude qualitative (figure 3). A titre d'exemple, nous sommes en face de : Recherche et projet scientifique, Intelligence artificielle, Performance, Ethique etc.

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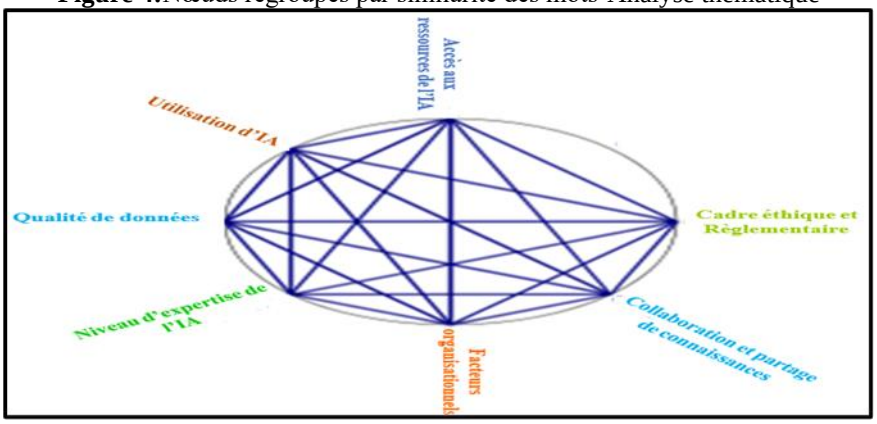
Figure 4:Nœuds regroupés par similarité des mots-Analyse thématique



(Source : sortie du logiciel Nvivo 10)

L'utilisation de l'IA, le niveau d'expertise en IA, l'accès aux ressources d'IA, la collaboration et le partage des connaissances, les facteurs organisationnels, la qualité des données et le cadre éthique et réglementaire sont tous des facteurs qui peuvent potentiellement impacter la performance des projets de recherche scientifique (figure 4). Une compréhension approfondie de ces variables peut aider à identifier les éléments clés pour améliorer la performance globale des projets de recherche scientifique.

Figure 5: Matrices à condensés-Analyse thématique

	A : Avantages DE l'utilisation IA dans le projet de recherche	B : Collaboration avec d'autres chercheurs ou équipes dans le domaine IA	C : considérations éthiques et réglementaires dans le projet de recherche	D : Évaluation de la qualité des données utilisées pour l'intelligence artificielle dans le projet de recherche	E : impact de IA sur ... la performance des projets de recherche scientifique	F : Niveau d'expertise IA	G : Ressources utilisées pour soutenir l'utilisation IA dans le projet de recherche	H : Utilisation de IIA dans le projet de recherche (phases et domaines)
Interv01	l'usage de l'intelligence artificielle m'a permis d'être plus efficace dans la construction de mes travaux et m'a aussi permis de faire à chaque fois le tour des sujets et dans certains cas me permet de découvrir d'autres aspects sur les concepts étudiés. Formuler des recommandations plus	Pas pour le moment	Je respecte l'éthique, et cela n'as pas vraiment d'impact considérable sur la performance de mon projet.	Actualité Représentativité La fiabilité des sources de données La validité des mesures utilisées La cohérence des données collectées sur une période donnée.	L'intelligence artificielle a une influence significative et transformative sur la performance des projets de recherche scientifique Globalement, elle améliore l'efficacité en automatisant des tâches complexes, en accélérant l'analyse de données volumineuses et en identifiant des modèles non évidents.	Intermédiaire	Bases de données Logiciels spécialisés d'apprentissage automatique Services d'API d'intelligence artificielle	La collecte de données, et pour simplifier mes recherches au niveau de la construction de travaux Revue de littérature Extraire des modèles et des tendances à partir des données La phase de raisonnement
Interv02	Efficacité des travaux de recherches Découverte de nouvelles significations Améliorer la recherche Analyse avancée des données Faciliter la communication scientifique Raisonnement rapide La précision Accélérer le processus de recherche Génération des modèles	Oui J'ai collaboré avec d'autres chercheurs et équipes	Je respecte l'éthique Il est essentiel de prendre en compte les considérations éthiques et réglementaires lors de l'utilisation de l'intelligence artificielle (IA) dans un projet de recherche	Actualité Représentativité La cohérence des données collectées sur une période donnée.	L'intelligence artificielle a une influence significative et transformative sur la performance des projets de recherche scientifique elle améliore l'efficacité en automatisant des tâches complexes	niveau avancé	Logiciels spécialisés d'apprentissage automatique Services d'API d'intelligence artificielle	Génération d'hypothèse Détermination des variables Conception de modèle conceptuelle Simulation Revue de littérature La phase de raisonnement

(Source : sortie du logiciel Nvivo 10)

L'analyse de la matrice suggère que l'intégration de l'intelligence artificielle (IA) dans le cadre d'un projet de recherche scientifique présente des avantages significatifs sur le plan de l'efficacité (figure 5), de la découverte de

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nouvelles significations et de l'amélioration des performances. Cependant, il est crucial de prendre en considération les aspects éthiques et réglementaires, ainsi que d'évaluer rigoureusement la qualité des données utilisées. L'IA peut être adaptée à différents niveaux d'expertise et requiert des ressources technologiques appropriées pour soutenir son application dans les différentes phases et domaines de la recherche scientifique.

Figure 6: Croisement matriciel des nœuds avec les Source-Analyse des relations

	A : Accès aux ressourceS de IA	B : Cadre éthiques et réglementaires	C : Collaboration et partage de connaissances	D : Facteurs organisationnels	E : Niveau d'expertise IA	F : Qualité des données	G : Utilisation de lIA
Interv01	3	3	0	3	1	4	3
Interv02	2	1	1	3	1	3	4
Interv03	3	2	1	3	1	2	5
Interv04	4	1	1	1	1	4	5
Interv05	0	0	1	0	1	0	2
Interv06	2	3	1	3	1	4	4
Interv07	3	1	1	1	1	3	6
Interv08	3	1	1	3	1	3	6
Interv09	3	1	1	2	1	2	2
Interv10	2	0	1	1	1	1	1
Interv11	2	1	2	3	1	1	4
Interv12	3	2	1	3	1	3	4
Interv13	3	3	1	3	1	4	5
Interv14	0	1	1	0	1	2	4
Interv15	2	2	1	1	0	4	4

(Source : sortie du logiciel Nvivo 10)

L'analyse de la matrice de croisement matriciel révèle des aspects cruciaux concernant l'utilisation de l'intelligence artificielle (IA) dans les projets de recherche scientifique. Les scores variés en matière d'accès aux ressources (0 à 4), de cadre éthique (0 à 4), de collaboration (0 à 2), de facteurs organisationnels (0 à 3), de niveau d'expertise (0 à 1), de qualité des données (0 à 6), et d'utilisation de l'IA (1 à 6) soulignent les défis et les opportunités présents. L'accès aux ressources et la qualité des données sont des déterminants majeurs du succès, tandis que le manque d'expertise et les obstacles à la collaboration nécessitent une attention particulière. Par exemple, le score de 0 pour l'accès aux ressources chez interviewé 5 indique une limitation sévère, tandis que le score de 6 pour la qualité des données chez interviewé 7 montre un potentiel élevé.

L'analyse de cette matrice souligne l'impact positif d'IA sur la performance des projets de recherche scientifique. Ces résultats fournissent des informations précieuses pour comprendre cet impact et peuvent être utilisés pour orienter et améliorer les futurs projets de recherche (figure 6).

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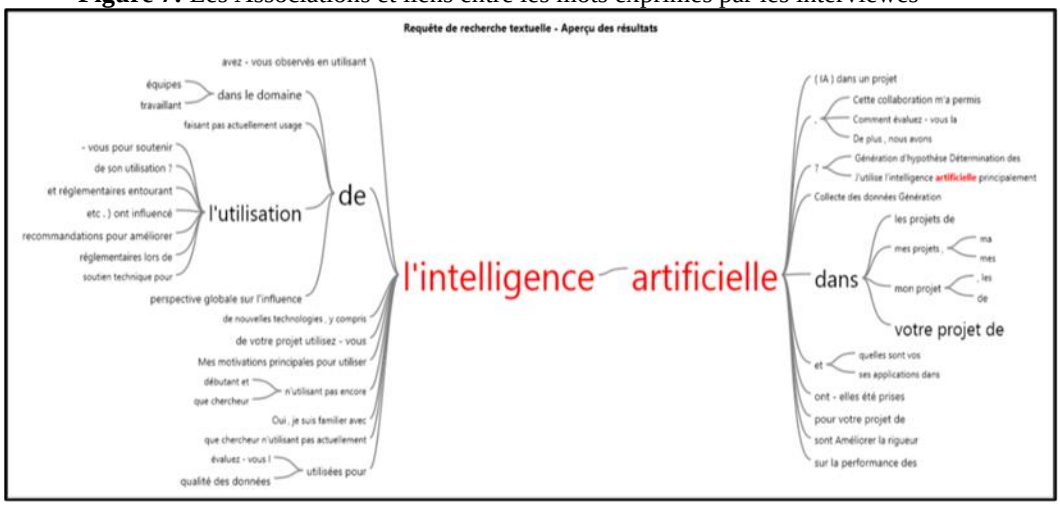
Figure 7: Les Associations et liens entre les mots exprimés par les interviewés



(Source : sortie du logiciel Nvivo 10)

La lecture de cet arbre montre les liens entre les mots exprimés par les interviewés, mettant en évidence les avantages potentiels de l'IA dans la recherche scientifique. Parmi ces avantages, on retrouve l'analyse rapide de grandes quantités de données, la découverte de nouvelles connaissances, le raisonnement rapide, l'accélération des processus de recherche et l'automatisation de tâches répétitives. Ces avantages soulignent l'impact significatif de l'IA pour transformer la façon dont la recherche scientifique est menée et pour faciliter les avancées scientifiques.

Discussion

Synthèse de l'analyse des résultats de la recherche qualitative

Depuis ses débuts dans les années 1950, l'utilisation de l'intelligence artificielle (IA) dans la recherche scientifique a connu une évolution significative. Les chercheurs ont progressivement exploré les multiples possibilités offertes par l'IA pour simuler des processus cognitifs et résoudre des problèmes complexes. Aujourd'hui, l'IA est largement adoptée dans divers domaines de la recherche scientifique. Cependant, il est essentiel d'adopter une approche proactive en matière d'éthique lors de l'utilisation de cette technologie. Cependant, il est impératif d'adopter une approche proactive en matière d'éthique, en prenant en compte les aspects réglementaires et en effectuant une évaluation rigoureuse de la qualité des données utilisées. La transparence des algorithmes est essentielle pour assurer que les chercheurs puissent comprendre et interpréter les décisions prises par l'intelligence artificielle. En revanche, les biais présents dans les données peuvent engendrer des résultats inéquitables, compromettant ainsi l'équité des conclusions. Il est également crucial de définir clairement la responsabilité en cas d'erreurs

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commises par l'IA, afin de déterminer les acteurs qui devront assumer les conséquences de ces erreurs. Par ailleurs, la protection des données personnelles des participants à la recherche est fondamentale pour garantir la confidentialité et obtenir un consentement éclairé.

Les entretiens menés avec les doctorants chercheurs dans le domaine des sciences de gestion à l'Université Ibn Zoh, utilisant l'IA dans leurs projets de recherche, ont permis de mettre en œuvre une stratégie de recherche qualitative exploratoire. Les résultats de cette phase ont été analysés en utilisant la méthode d'analyse de contenu, et plusieurs éléments clés ont émergé. Il a été constaté que l'intégration de l'IA dans les projets de recherche scientifique présente des avantages significatifs en termes d'efficacité, de découverte de nouvelles significations et d'amélioration des performances.

En faisant le lien entre la revue de littérature et l'analyse des données qualitatives, il est clair que la littérature existante soutient également l'impact significatif de l'IA sur la performance des projets de recherche scientifique. Les études antérieures ont souligné les avantages potentiels de l'automatisation des tâches répétitives, de l'analyse avancée des données et la découverte de nouvelles connaissances grâce à l'IA.

Notamment, (Inria, 2016) a montré que l'IA peut améliorer la performance de la recherche scientifique. En outre, (Ludovic & al, 2019) ont affirmé qu'elle accélère la recherche en créant des modèles analytiques et en identifiant des motifs complexes. (Salvagno & al, 2023) , ont noté que l'IA facilite la génération d'idées et améliore la communication scientifique, tandis que (Ghosh.A & Aishik, 2023) ont souligné son rôle dans la génération d'hypothèses et la conception d'expériences. De plus, les résultats de l'analyse des entretiens confirment ces avantages et mettent en évidence des facteurs supplémentaires tels que le niveau d'expertise en IA, l'accès aux ressources d'IA, la collaboration et le partage des connaissances, les facteurs organisationnels, la qualité des données et le cadre éthique et réglementaire. Enfin, à la fois la revue de littérature et l'analyse des données qualitatives confirment l'impact significatif de l'IA sur la performance des projets de recherche scientifique. L'IA offre des avantages en termes d'efficacité, de découverte de nouvelles significations et d'amélioration des performances. Néanmoins, la prise en compte des aspects éthiques et réglementaires est essentielle, ainsi que l'évaluation rigoureuse de la qualité des données utilisées. En continuant à explorer et à développer l'utilisation de l'IA dans la recherche scientifique, il est essentiel de trouver un équilibre entre les avantages potentiels de l'IA et les considérations éthiques et réglementaires pour maximiser son impact positif.

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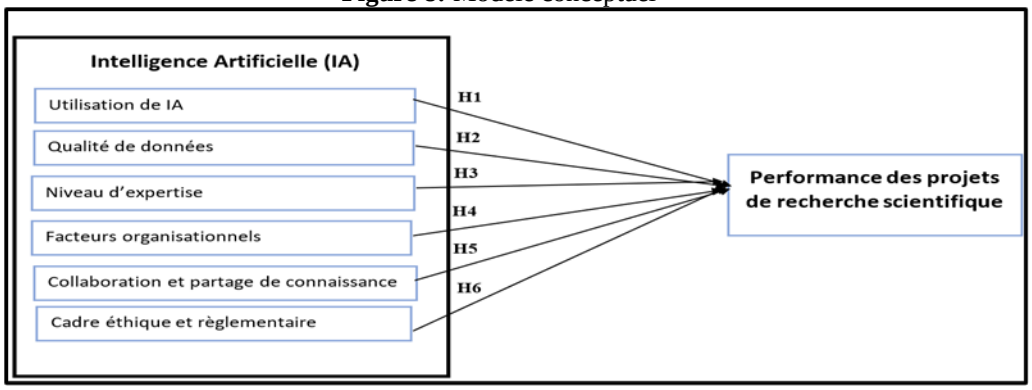
Conclusion

L'intelligence artificielle présente de nombreuses opportunités dans le domaine de la recherche scientifique. Cependant, son adoption est confrontée à des obstacles tels que la formation, le coût et les questions éthiques. Cette étude a pour objectif d'explorer l'impact de l'intelligence artificielle sur la performance des projets de recherche scientifique en analysant à la fois les avantages et les défis liés à cette technologie qui s'intègre désormais dans notre vie quotidienne. Une revue exhaustive de la littérature sur le concept d'intelligence artificielle est présentée, couvrant son évolution historique, ses domaines d'application et les recherches antérieures portant sur son impact sur la performance des projets de recherche scientifique et les questions connexes. Par la suite, nous contextualisons ce concept dans le cadre d'un projet de recherche scientifique. En complément de notre revue de la littérature et de l'analyse des avantages et défis de l'IA dans la recherche scientifique, nous avons développé un modèle conceptuel qui illustre les différentes variables contribuant à la performance des projets de recherche scientifique en utilisant la technologie IA. Ce modèle offre une représentation visuelle du parcours menant à la performance, en mettant l'accent sur les facteurs clés qui influencent les résultats obtenus.

Figure 8: Modèle conceptuel



(Source : auteurs)

L'intelligence artificielle ouvre des horizons prometteurs et présente des perspectives considérables pour les doctorants chercheurs. Cette technologie présente un potentiel considérable pour générer des avancées significatives, non seulement en termes de découverte de nouvelles connaissances et d'exploitation avancée des données, mais également en améliorant et en accélérant le processus de recherche scientifique.

Pour relever les défis identifiés, il est recommandé que les organismes de financement de la recherche mettent en place des programmes de formation spécifiques pour les doctorants chercheurs sur l'utilisation éthique et efficace de l'IA. De plus, il serait bénéfique d'établir des lignes directrices claires

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concernant l'utilisation de l'IA dans la recherche, afin de garantir la transparence et la fiabilité des résultats.

Une approche prudente consiste à prendre en compte attentivement les implications éthiques associées à l'IA, afin d'assurer une utilisation responsable et respectueuse des principes éthiques dans la recherche scientifique. Il est également crucial que les institutions académiques collaborent avec les experts en IA pour développer des outils d'évaluation de la qualité des données, garantissant ainsi des résultats fiables et applicables. Toutefois, Il est crucial de considérer les défis et les limites de l'IA afin de garantir une utilisation adéquate et fiable de cette technologie dans la recherche scientifique. Il est nécessaire de tenir compte de la transparence des résultats et de la fiabilité des modèles.

Dans cette perspective, il est essentiel d'accorder une grande importance à la formation des doctorants chercheurs, en les dotant des compétences nécessaires pour s'engager de manière adéquate et productive dans un domaine en constante évolution. Les universités devraient également établir des partenariats avec l'industrie pour faciliter l'accès aux ressources en IA et encourager l'innovation.

Pour enrichir efficacement la recherche scientifique, il est important d'intégrer harmonieusement les compétences humaines avec la technologie de l'IA. Bien que l'IA présente un potentiel significatif, il est primordial de reconnaître que la recherche demeure une activité fondamentalement humaine. Quelle que soit l'avancée de la technologie de l'IA, il incombe toujours aux êtres humains d'identifier les problèmes, les risques et de proposer des améliorations. Par conséquent, l'intelligence artificielle ne peut pas totalement se substituer à l'expertise et à la créativité humaine dans le processus de recherche scientifique. Néanmoins, cette étude présente certaines limites. Un biais de sélection peut être présent, car elle se concentre exclusivement sur les doctorants chercheurs en sciences de gestion, limitant ainsi l'applicabilité des résultats à l'ensemble de la communauté scientifique et à d'autres disciplines.

Pour approfondir la recherche future, il est pertinent d'élargir la portée de l'étude en comparant l'impact de l'intelligence artificielle dans diverses disciplines scientifiques. De plus, une étude confirmatoire pourrait compléter cette étude qualitative pour tester les hypothèses retenues, renforçant ainsi la robustesse des conclusions. En intégrant ces perspectives, nous pouvons mieux comprendre l'impact de l'IA sur la recherche et ses implications pratiques pour la communauté scientifique.

Conflit d'intérêts : Les auteurs n'ont signalé aucun conflit d'intérêts.

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Disponibilité des données : Toutes les données sont incluses dans le contenu de l'article.

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