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DESCRIPTION

Strategy and Development Review is an international, double-blind peerreviewed, Bi-annual, free of charge and open-access journal published by the Faculty of Economics, Business and Management Sciences- Abdelhamid Ibn Badis University – Mostaganem, Algeria. The journal focuses on the following topics: Economics; Management; Finance and Accounting. It provides an academic platform for professionals and researchers to contribute innovative work in the field.

The journal carries original and full-length articles that reflect the latest research and developments in practical aspects of Economics, society and human behaviors. The journal is published in paper and e-copy. The latter is open-access and free to download. All international submissions are very welcome and articles can be sent at any time for consideration. Our two issues are published in January and July respectively and comprise but not restricted to the following areas:

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PREFACE AND ACKNOWLEDGMENTS

"Economics of Sustainable Development & Innovation Technology in Engineering"

Dr. Mohsen BRAHMI*, Dr. Luigi ALDIERI**& Dr. Wissal BEN ARFI ***

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This special issue is a result of the collaboration between the *Journal: Strategy & Development Review (SDR)* and the *High Institute ISETK Hellal of Tunsia* (With the Research Association ADIT). This issue is a fruitful result of International Cooperation between two Mediterranean Countries.

The numerous papers presented, in the first edition of this conference **ICESD** (2019)and organized by the *High Institute ISETK Hellal of Tunsia* with the partnership of the Research Association (ADIT), enables us to have access to a

important number of submissions from multidisciplinary fields (*Social Sciences e.i. Economics, Finance, etc. and Engineering Sciences*). Following a rigorous double peer-reviewed process of our Journal, and after the selection of the papers submitted, only **07 articles** from 30 papers are accepted after revision for publication in this Special Issue.

The 07 selected research papers were presented at *the 1st Edition of International Congress of Engineering and Sustainable Development (ICESD 2019),* taken place in Sousse, Tunisia, during1-3November 2019. This conference welcomed great number of presenters and attendees, from different countries.

Hence, the current special issue contains 07 articles. We have decomposed in suitable 02 parties. The first one is composed by four research papers who present the economics sustainable development studies in (Microfinance, Behaviour purchase intension, Extra-financial reporting, and Informal economy). The other three research papers investigate mathematic models in engineering sciences technical innovation, in the second party.

In the first party, the article n°1, co-authored by Amel BEN CHEIKH et al., entitle **Purchase intention of green personal care products for youth in Tunisia**, is a textual analysis of investigating and testing the factors that affect the green purchase intention of young Tunisians, the importance of spreading WOM after their purchase experience. Given the purpose, a quantitative study was conducted by authors through a questionnaire with a sample of 181 respondents. Results indicate that the environmental consciousness was not a strong variable that affects the purchase intention of green products. Findings further suggest that Young Tunisians consider green trust as a major factor when considering purchasing a green product.

The second article, entitled **Microfinance: A tool for reducing unemployment in Tunisia**, by Boudour BZEOUICH, this work is a contribution to the debate on the role of microfinance in the fight against unemployment and the creation of paid employment. In this article, author have chosen the counterfactual approach which consists in comparing the evolution of the situation of the beneficiaries of microcredit with respect to a control group having the same initial characteristics of the group of beneficiaries. Results show the positive effect of access to microcredit on job creation and contribute to the reduction of unemployment. Other funding that access to additional financial resources for their enterprises allows them to offer more jobs in the market.

The Extra-Financial Reporting on the Societal Responsibility of the Company: A practice of Good Governance for Tunisian Listed Companies is the third article presented in this special issue, by Wissem FAKHET and Faycel TOUMI. It focuses on the most significant indicators of good governance mainly the Social and Societal Responsibility of the companies listed in the Tunisian Stock Exchange. An Extra-Financial Reporting would be suggested as a mandatory document to be communicated and published annually by those companies. Authors suggested that the best way to govern nowadays is to listen permanently and actively to all parties involved, whether internal or external, local or foreign, and basically to try to harmonize often contradictory needs and objectives.

The fourth article in this first party, entitled **Impact of the informal** economy on economic growth, by Hassen HAFSI, test the impact of the informal economy on economic growth, Author used the most advanced techniques, GMM-System Method proposed by Arellano and Bover (1995), in the context of a dynamic panel data model, for a panel of 92 advanced, emerging and developing countries, over a study period stretching from 1960 to 2010. The results show a non-linear relationship between the variable IS and economic growth, on the other hand, the variable IS reported to the squares exhibits a negative and statistically significant effect. Indeed, from a certain threshold, the effect of the variable IS changes sign and becomes negative.

The second party composed by three articles in technological innovation in engineering sciences. The fifth article entitled **Design and development of a**

solution for solving electromagnetic problems by the finite element method English, by Thouraya DHIFALLAH and Mohsen OTHMANI, consists of two parts. The first part consists in making an exhaustive study of the finite element method. This study made it possible to understand well the process of resolution of the electromagnetic problems by the method of the finite elements which are summarized in a double discretization. The second part consists in implementing this theory while exploiting the Solid Works environment to grasp the physical structure, define the characteristics of the material, mesh in the first step and in the second step formulate the problem in the form of a system of differential equations. Finally transform this formulation into an integral, interpolate and discretize to arrive at a linear system which will be solved at the.

The sixth article, co-authored by Imen DEBBABI and Hédi BELHADJ SALAH, entitled **The Improved Element Free Galerkin Method for 2D Heat Transfer Problems**. The aim of this paper is studying the efficiency of the IEFG method for 2D heat transfer problems. For this purpose, two heat transfer problems transient and steady states are studied and the performance of the IEFG method is shown using the comparison between numerical and analytic results. IEFG method is presented by authors to treat the steady states and the transient heat transfer problems.

Performance Enhancement of Sliding Mode Controller by Fuzzy Logic with Application to Induction Motor, by Amel FERAHTIA, is the seventh article in which she introduces a new fuzzy-sliding mode controller (FSMC) for regulating the speed of an indirect vector-controlled induction motor (IM). Field oriented control of the induction motor supplied with voltage source inverters, using PI controllers presents some drawbacks such as the sensitivity to parametric uncertainties of the motor and their variations. In order to improve the system performances, she applied robust control techniques such as fuzzy logic, sliding mode and fuzzy sliding mode. The last technique is a hybrid control which combines sliding mode control (SMC) and fuzzy logic control (FLC). Simulation results show that the implementation of the IM fuzzy sliding mode controllers leads to robustness and dynamic performance satisfaction, even when the parameters vary.

Thanks to all the hard work of our international Scientific Committee, Reviewers and Organising Committee.

Our acknowledgements go to all the international contributors of this volume and all the committees, authors and friends of the Journal: Strategy and Development Review (S&DR).

We wish you an excellent reading!

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Dr. Mohsen BRAHMI, Dr. Luigi ALDIERI & Dr. Wissal BEN ARFI

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Purchase intention of green personal care products for youth in Tunisia

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Abstract:

This research aims at investigating and testing the factors that affect the green purchase intention of young Tunisians, the importance of spreading WOM after their purchase experience. Given the purpose, a quantitative study was conducted through a questionnaire with a sample of 181 respondents, using the smart-PLS software as a tool to analyze and interpret the findings. Results indicate that the environmental consciousness was not a strong variable that affects the purchase intention of green products. Findings further suggest that Young Tunisians consider green trust as a major factor when considering purchasing a green product.

Keywords: Green purchase intention, WOM, environmental consciousness, green trust, Young Tunisians

JEL Classification Codes: M31, M37, Q01

1. Introduction

The past decades witnessed a rapid economic growth through the increase of consumers' consumption all over the world. This caused a serious environmental deterioration through over-consuming and mass utilization of environmental resources. As consequences of environmental degradation we can set global warming, depletion of stratospheric ozone layer, the over pollution of sea and rivers (Ramlogan, 1997). Grunert (1993) mentioned that about 40% of environmental degradation has been the result

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of the consumption activities of private households and daily activities. As the environmental issues continue to grow, it has become a major public concern in developed countries and it has awakened also the developing countries to start looking for solutions and implementing some of them. Awareness of the serious issues of natural resources and the environment in general has raised environmental activism and protection, which resulted in creating eco-friendly and responsible new habits of consuming known as "green consumerism" (Moisander, 2007). The environmental protection has experienced an increase, The US consumers' activities has been shaped (Kangun et al., 1991; Martin and Simintiras, 1995; Todd, 2004). Specifically, US consumption demand has resulted in the growth and the availability of eco-friendly products such ''as laundry detergents, personal care products, and energy saving electronics'' (Martin and Simintiras, 1995;Schlegelmilch et al., 1996).

Environmentally friendly products became popular in global markets.More Consumers have demanded more eco-friendly products and more sustainable solutions for their everyday lives and activities (Nimse et al., 2007).

Examples of green products are: the personal care products which have gained one of the main largest portions of sales in the green sector (Organic Trade Association, 2006). D'Souza et al. (2006) claimed that the environmental concern of consumers would be one of the most important elements in the marketing of green beauty products.

Recently, consumers tend to focus on buying bio and greener everyday products and the products that can help reduce the harm on the environment and have even a minimum social impact. Multiple beauty and personal care brands introduced eco-friendly products, as an example we can state« *American brand Aveda and British brand Body shop »*.

Raising Awareness about the environment and natural issues nowadays added to the encouragement of green consumption is a must and a need for customer development for this important market. Even as thinking "green" isincreasingly entering and establishing in consumers' minds, they still struggle with many issues regarding the green consumption as the trust and eco-labeling and green certifications, in addition to their role in the lifecycle of an eco-friendly product.

Many Research Papers have looked into the issue of consuming sustainable products but not focusing on the cosmetics and hygiene self care products which represent great consumption products in the daily life of the global consumer.

Furthermore, multiple studies all about consumers' buying behaviors of green products done by Chen, (2007);Magnusson et al., (2001); Padel and Foster, (2005) and Zanoli and Naspetti, (2002).The focus was set on organic food products and were done mainly in the United States and developed countries. In this context, the problem statement will be the following:To what extent the purchase intention of green personal care products influences the WOM of youth in Tunisia?

This research paper will consider environmental consciousness, green advertisement and green trust as independent variables, purchase intention of environmentally friendly products as a median and the WOM communication as a dependent variable. This research serves as a continuous research for previous scholars and opens future research opportunities for next researchers.

2. Literature review

2.1. Context of this study

The twenty-first century has witnessed a significant increase in environmental concern and activism, which has ultimately developed into a full trend that companies try their best to integrate in their goals and vision and they developed a whole term named ''green marketing''. As consequences of environmental degradation we can set global warming, depletion of stratospheric ozone layer, the over pollution of sea and rivers (Ramlogan, 1997). As the environmental issues continue to grow, it has become a major public concern in developed countries and it has awakened also the developing countries to start looking for solutions and implementing some of them. The concern and awareness of the consumer for the environment have developed dramatically and the buying decision making of the consumer today is based mainly on the environmental concerns. Companies are somehow obliged to adapt to this shift that is changing the market needs and wants for certain segments of the market; which are the green consumers and try to make value for them in addition to its competitive advantage boost while facing the furious competition in the marketplace. Scholars presented a set of factors that influence the green intention. Candamio et al (2018) stated that environmental education is a determinant of the green intention. Akroush et al (2019) focused on the role of perceived benefits as a powerful factor for the green intention. Culture and gender are explored as green intention determinants by Sreen et al (2018). Nevertheless, few are research papers that emphasize the role of environmental consciousness, green advertisement and green trust as determinants of green intention and the impact of the latter green WOM. A description of the retained variables will be emphasized in the next paragraphs:

- Environmental consciousness: According to Diamantopoulos et al. (2003), environmental consciousness is simply to be knowledgeable of the issues regarding the environment, attitudes towards environmental problems, and levels of environmentally sensitivity. Consumer concerns according to Chitra (2007), about the environment have been increasing in recent years and it now represents an important consideration in making the decision to purchase. Recently, we can observe that today's environmental harsh conditions are threatening consumer health and wellbeing. Therefore, consumers are becoming serious in their environmental practices, preferences and purchases (Sarigollu, 2009). Environmentally conscious consumers believe that environmental problems facing our planet nowadays are a serious problem. However, consumers who don't share this point of view think and advocate that environmental problems will be solved by themselves. As a result, a consumer mindset/ opinion about environmental issues can significantly affect their willingness to pay for green or eco-friendly products.
- Green Advertisement: In the late 1980s and early 1990s, when theenvironmental concern was in its peak, green marketing activities has showed a progress, especially in the environmental

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advertising.Green advertising contains green messages in other words: ecological, eco-friendly, and sustainable to satisfy the needs and wants of environmentally impacted individuals. (Zinkhan and Carlson, 1995). The objective of environmental advertisement was mainly to influence consumers' purchase behavior, to encourage them toward buying ecofriendly products and to direct them toward the positive consequences of their purchase behavior.

Green trust: Green trust according to Chen (2010) is known as the enthusiasm to rely on a brand established by believing its impact from its environmental performance, goodwill and credibility. That's why green should be claimed as clear, true, and especially accurate. Without trusting in the firms' claims, consumers are unsure and indecisive about whether to purchase green or not, as they do not trust the company and its products or not. Therefore, green wash will intimidate the industry for environmentally friendly purchasing behavior and could harm green marketing in various organizations. According to Parguel et al (2011), green wash is the act of deceiving consumers towards the environmental practices of a specific product.

Accordingly, Chen(2010) stated that Green trust is defined as "a willingness to depend on a product or service based on the belief or expectation resulting from its credibility, benevolence, and ability about environmental performance".

- Green Purchase Intention: Green purchase intention is known as the anticipation of consumers to purchase environmentally friendly products as a priority to other ones (Nik Abdul Rashid, 2009). Green purchase intention is a specific kind of environmentally friendly behavior that customers exercise to express their environmental consciousness. Many studies on green purchase intention showed the intention as an important predictor of green purchase act and strongly affected the likelihood of decision to purchase.
- Word of Mouth communication: The word of mouth (WOM) is the unofficial way to deliver ideas, information or point of views between two individuals, neither one of them has a marketing background. It is also described by Kaijasilta (2013) as an oral face to face

communication between a receiver and a communicator whom neither of them are a sales or a commercial person.

WOM gives honest and credible information about a brand more than the official way to communicate. The greater recommendations a particular consumer gets about a product from relatives, the more likely they will be to change their opinion and get influenced to purchase the product.

Furthermore WOM functions as an uncertainty reducer about the brand choice and also comforts the decision that was made by the person. It is an effective communication tool as more than half of all purchasing behaviors are shaped by the recommendation of someone else and this presents the essential act of the WOM in the promotion activities and marketing as a whole. (Solomon et al. 2010).

2.2. Conceptual framework

a) The relationship between the environmental consciousness and the green purchase intention: The intention to buy green or environmentally friendly products or services in relationship with environmental consciousness has been studied and developed throughout the years.

People have shown that the fact that they are environmentally conscious does not mean surely that green consumption is guaranteed, as has been shown by some studies linking environmental concerns with the purchase of green products (Braga Junior & Silva, 2013; Braga Junior et al., 2014).

On the other hand, Alwitt and Pitts (1996) mentioned that environmental consciousness or having a concern that is ecological is related with consumption behavior of green goods.

Respondents from different countries stated that they are very concerned with environmental degradation. That has resulted in more environmental consciousness and a drive to consume green goods, in addition to liking more companies that exercise environmentalism (Roberts,1996; Kalafatis et al., 1999; Laroche et al., 2001).

Kim and Choi (2005) also found that environmental concern has a direct impact on green consumption. Based on the forgoing, the following

hypothesis is presented:

H1: There is a significant relationship between environmental consciousness and the green purchase intention.

b) The relationship between green advertisement and the green purchase intention: Advertisements and especially green ones are designed to shift not only behaviors, but also the beliefs that will result in the changing buying purchase (Coleman, Bahnan, Kelkar & Curry, 2011).

It is proved that most individuals will respond positively for a green advertisement if they can perceive a direct added value for them due to their buying all alongwith generating an environmental impact (Carlson et al. 1993;Nottage 2008; Phau and Ong 2007).

Pickett-Baker and Ozaki (2008) found that individuals that have more consciousness towards the environmental issues and somehow engaged in some environmental activities were generally more aware of green advertisement and communication.

D'Souza and Taghian (2005) studied the green and attitudes, and foundcorrespondinglythatmost individuals with a great level of environmental consciousness have an attitude that's described more positively towards green advertisements than people that are less conscious. This study explores green advertising or communication by examining its effects on consumer purchase intentions.

This analysis continues on the previous literature on eco-friendly advertisement by studying different attitudes towards it and whether it really affects the green purchase intention or not. The second hypothesis is formulated based on the previous theoretical discussion:

H2: There is a significant relationship between green advertisement and the purchase intention of environmentally friendly products.

c) The relationship between green trust and the green purchase intention: As consumer trust increases, risk perception and uncertainty are directly reduced, and the integrity and trustworthiness of the eco-friendly brand or company is powered.

Previous researches argued that customers trust can be influenced by perceivedrisk.In the rise of the environmental trends, customers have more environmental consideration which happened to increase their risk perception (Koehn, 2003; Eid, 2011). Purchase intentions are affected by consumer trust according to Harris and Goode, (2010).

Manyliteraturespositthatcustomer trust is a necessary determinant of consumer purchase intentions (Schlosser et al., 2006). If buyers had a trust experience with the seller, they would definitely possess a higher level of intention to buy. Thus, green trust is an antecedent of green purchase intentions (Van Der Heijden et al., 2003). Based on the forgoing, the following hypothesis was formulated:

H3: There is a significant relationship between green trust and purchase intention of eco-friendly products.

d) The relationship between the green purchase intention and the word of mouth communication: According to Babin et al (2005), there is an effective and a positive WOM communication after the green purchase decision and adoption of the product, which will influence more consumers to purchase the same products and trust the past consumers who are usually friends or relatives.

Although it's Similarity with the traditional approach, electronic WOM (eWOM) has more unique characteristics. The power of WOM or eWOM is that it helps consumers discover the misleading brands and it plays the role of influencing negatively the green purchase intention, consumers nowadays trust opinion leaders and their shared experiences and tend to follow them especially if the product is negatively communicated. It will be featured in different social media platforms to reach as many people as possible.

It is also confirmed by Ahmed et al (2014); this strong relationship between the purchase intention of green products and WOM communication is due to the increased use of the internet and globalization.

The market has many and similar green brands that can confuse the eco-friendly consumer on a daily basis, that's why they usually tend to make purchases after knowing that someone usually an opinion leader has already experienced the same green product. Based on the above rationale, and supporting empirical results, the following hypothesis was developed:

H4: There is a significant relationship between the purchase intention of green products and the WOM communication.

The following figure shows the conceptual model of this research.



Fig.1.Conceptual model

3. Methodology

3.1. Population and sampling

This research paper relies on the nonprobabilistic sampling, specifically the convenience method (also known as availability sampling). Convenience sampling serves as the first available primary data source which will be used in the research without additional requirements.

In other words, this method involves getting participants (respondents) wherever you can find them and typically wherever is convenient. Convenience sampling is usually used in business studies, for its usefulness and easiness to obtain results compared to other methods (Saunders et al, 2012).

Also, Zikmund and colleagues (2010) have found that convenience sampling is effective in obtaining a large and sufficient number of data quickly and economically. The valid number of responses was 181, reached after setting the goal of the minimum sample which is 100; most of them were females 132 (72, 92%) the restwhichis 49 (27, 07%) are males. Most of the sample was students as it is our main target (youth); 8 respondents are less than 20 years old, 134 respondents are aged between 20 and 25 years old and the restwhichis 39 are aged between 25 and 30 years old.

For the marital status of our respondents most of them are single (176 respondents), the remaining respondents (5 respondents) are married.

3.2. Data Collection Method

In this study, an administered questionnaire method has been applied. The structure of the questionnaire is designed to follow the questions and hypothesis discussed previously; the questionnaire is divided into incoherent sections for the purpose of easy understanding and answering, The questionnaire will be designed to be a Likert scaled one; which one of the most widely used question types in a survey. The next table describes the sources of measures used to design the questionnaire.

Measurement scales	Author and year	
The environment al Consciousness	Diana L. Haytko (2008)	
The green advertisement	Diana L. Haytko (2008)	
The green Trust	Chen (2010)	
The green purchase intention	Habib, et al. (2010)	
Green WOM	Molinari et al. (2008)	

TABLE.1.Measurement scales

4. Findings, discussions and managerial implications:

4.1. Findings

The analysis of the measurement model consists of analyzing the consistency which measured by Cronbach's Alpha, Composite Reliability (CR), Convergent Validity Which Measured in our case by the Average Extracted (AVE) (Hair, Hult, Ringle, Sarstedt, Variance 2017). Beforethatweshould check and confirm the reliability of the items of each variable, which is known as the outer loadings using the PLS analysis. The results of the outer loadings of the reflective constructs show that some items have less than 0,708. The general rule states that the outer loadings should be at least 0.708 or more. For the first variable of this research which is the environmental consciousness, we set four measurement scales to test the variable with. The Third and Fourth items should be rejected in measuring this variable however we will keep the second one because approximately 0, 7 (0,673).

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For the second variable which is the green advertisement, it was measured by seven items, we are going to eliminate item number one, six and seven for the same reason the three mentioned items are less than 0,7.

For the remaining variables which are the green trust, the purchase intention and the WOM all of their items are considered to be able and relevant to the related variables.

	Cronbach' s Alpha	Composite Reliability	Average Variance Extracted
Environmental Consciousness	0,740	0,505	0,334
Green Advertisement	0,816	0,874	0,530
Green Trust	0,811	0,876	0,638
Purchase Intention	0,910	0,943	0,848
WOM	0,942	0,958	0,852

Table 2.ConstructReliability and validity, 1st algorithm

Source: PLS Software

The Cronbach's Alpha and Composite Reliability results should be higher than 0.7 and the AVE should accede 0.50.

The results of Cronbach's Alpha (CR), Composite Reliability and Average Variance Extracted (AVE) have attained the required standard, only for the environmental consciousness which both the CR and AVE are less than the requiredlevel.TheReliability test which is the square value of the items, and which should attain the minimum value of 0.50 that will cover the 50% of the value as the variance extracted from the item (Hair, Hult, Ringle, Sarstedt, 2017). To have results, wemade a second algorithm without the unnecessary items mentioned previously and the software will generate a new specific model as shown below.



Fig.2. Model after 2nd Algorithm

Source: PLS Software

After the display of the new model, a new set of overloading will be developed from the second algorithm whichiswhatweneed to perceive our analysis, using only relevant items for each variable.

The table shows the required items for each variable only and it noticeable that the same items have been adjusted and have new values of outerloading to measure the variable which is believed more adequate for this research. All the values shown in the table are above 0,708 and meansthat it is confirmed and can move to the next step of analysis.

	α	CR	AVE
Environmental Consciousness	0,770	0,885	0,795
Green Advertisement	0,911	0,937	0,789
Green Trust	0,811	0,876	0,638
Purchase Intention	0,910	0,943	0,848
WOM	0.942	0.958	0.852

Table 3.Construct Reliability and validity, 2nd algorithm

Source: PLS Software

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As shown by table 4, we have new results and there's a significant difference between the results especially when it comes to the environmental consciousness and green advertisement.

The results of Cronbach's Alpha have reached up to the required standard for all the variables (the least one is the environmental consciousness 0, 770>0, 7). This shows that there consistency between all the variables that have been studied. For the composite Reliability (CR) it showed significant results for all variables as well (the least one is the green trust value 0,876>0, 7).

This shows a significant level of reliability between latent variables. For the average variance extracted (AVE) it is showing significant relationships for all the studied variables. This shows the validity of the relationship between all variables mentioned and tested.

	R square	R square adjusted
Purchase Intention	0,622	0,616
WOM	0,635	0,633

Table 4.R squared

Source: PLS Software

The R² value for the purchase intention is 0,616> 0, 5 and for the WOM is 0,633>0, 5 which is considered as significant value for both variables. This can be explained as the verification and confirmation of this relationship between the two mentioned variables purchase intention and WOM. After the exploratory analysis which consisted in exploring the relationship between different variables, the next step known as the confirmatory analysis to finally confirm the relationship between the existing variables. The key criteria to determine the structural model in PLS-SEM is the implication of the path coefficients. First, the structural model path coefficients were checked after having 5000 as a sample of bootstrap, the t values and the p values. The critical t values for two tailed tests are 1.96 (significancelevel 10%). The p values are considered, if the significance level is 5% (the margin of error), which has to be smaller than 0.05 to consider the relationship as a significant link at 5% level. The

following table will generate the displayed results from the software and we will compare the findings with the rules discussed.

	Т	P-
	Student	value
Environmental Consciousness Purchase Intention	1,299	0,195
Green Advertising	7,831	0,000
Green Trust Purchase Intention	4,536	0,000
Purchase Intention WOM	22,426	0,000

Table 5.T-Student and P-value

Source: PLS Software

For the first hypothesis, which consists of having a relationship between environmental consciousness and the purchase intention, it isrejected:

The T value 1,295<1,96

The P-value 0, 195>0, 05

For all other variables the relationship between them (green ad, green trust and WOM) and the purchase intention of green products are confirmed. Their T value and P value reached the required value.

 Table.6. The summary of hypotheses tested

<i>v v i</i>	
Hypothesis	Support
H1: The environmental consciousness is affecting the	NO
purchase intention of green products	
H2: The green advertisement is affecting the purchase	YES
intention of green products	
H3: The green trust is affecting the purchase intention of	YES
green products	
H4: The green purchase intention is affecting the WOM	YES

4.2. Discussions

The aim of this research is to test the factors that affect the purchase intention of green products after that the effect of this purchases intention on spreading a green WOM.

Aftertestingthose latent variables with different indicators of both exploratory and confirmatory analysis, we established relevant interpretations and understand the sample (and therefore the whole population) and the Tunisiancontext and its perception of green products; to be more specific the eco-friendly everyday hygiene products.

Environmental consciousness was not a strong variable that affected the purchase intention of green products. From the analysis provided we can conclude that the environmental consciousness and the green purchase intention has no significant relationship.

Tunisian youth consumers are conscious enough about the environmental issues in the country but, still they don't perform or intend to buy green products to save the environment or have a positive impact. There are many reasons for this attitude mainly the unavailability of eco friendly products in the local market even if there's some improvements mainly from new startups, also the culture of using and consuming these green products, Tunisian consumers are not well informed about the advantages of reducing the daily waste and performing some sustainable activities.

For the green advertisement variable, it is shown that it has a positive and a significant impact and the relationship with purchasing green products. It Is Well Known in general that in marketing the communication and promotion has a great impact on consumers especially if the subject is emotional and quite important as the main topic which is green consumerism.

Young Tunisians are impacted by green advertisement because generally they don't know that these products/ services are available that's why they get attached and as a result a purchase of green products can be accrued.

The third variable that was tested as an important factor in purchasing green products is green trust. Products Trustworthiness is a major factor in

purchasing any product, what if the product is green? Consumers will be wondering if this product is really green or it's just a sort of promotion to make more sales and grow.

Young Tunisians consider green trust as a major factor when considering purchasing a green product; they will look for labeling, certifications and reliability of this product. Accordingly, it should be well noted for companies and future projects to consider trustworthiness in their eco-friendly products or services.

Moving to the relationship between the intentions in order to buy environmentally friendly goods with spreading WOM It was found after the data analysis that Tunisian youth will value their purchasing experience and will share it with others using WOM. Accordingly, sharing positive recommendations will help friends and relatives to choose the right product for their consumption.

4.3. Managerial implications

This research provides valuable insights for academic researchers and eco-friendly apparel product producers or retailers. As stated earlier, generally environmentally sensitive behavior like conserving natural resources is a good indicator to intention to purchase environmentally friendly apparel products unfortunately it's not the case for our sample, Tunisian youth affirm their positive attitude and concern towards the environment, however it is not a strong and sufficient reason to make them buy an eco-friendly product especially personal care ones.

Business owners and especially marketers need to motivate consumers to be aware of the importance of environmentally sensitive behaviors and to involve this behavior in their everyday lives or at least try to reduce their everyday waste or even try to participate in environmentally friendly activities.

Marketers in the personal care industry need to consider college students' or more generally the youth environmental concerns and conserving natural resources behavior when they make marketing decisions for environmentally-friendly products. They also need to develop creative and specific green marketing strategies for the eco-friendly products to

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persuade the target consumers. For the second hypothesis, the relationship between the green advertisement and the purchase intention of green products has been confirmed in the Tunisian context. Youth do consider that green advertisement can impact them and can even lead to a purchase behavior of an eco-friendly product, however the problem remains in the lack of this type of advertisement in the tunisian country, that's why we recommend that marketers in the green industry should take their advertisement to the next level by sharing why it is convenient to buy green products, for example sharing information cards, window displays and videos throughout their stores to inform people about the impact of their purchasing behavior on the environment. Marketers should make sure to communicate to the target consumers and persuade them that it's everybody's responsibility to protect the environment and everyone can make a little change or impact. Moving on to the green trust variable and its relationship with the purchase intention of green products was confirmed in our research. Tunisians tend to have trust issues about any product quality or utility, they make sure that the purchase product is totally worth it, and it doubled if the product is marketed as an environmentally friendly one. The major challenge for companies is how to raise green trust in the popularity of greenwash nowadays. Nowadays, companies should exploit popular concerns about environmental issues to position their brands to obtain a new competitive advantage and differentiate itself in the market.

Hence, the ideas of green marketing can become a new way of brand positioning. We recommend that companies should try to formulate and implement long-term strategies to carry out their green marketing, and incorporate it in theircompany's vision to be trustworthy and impactful, ratherthanusing green marketing for tactical and short term goals which will increase the perception of greenwash in the mind of the consumer.Moving on to the next relationship which was strongly confirmed the purchase intention of green products and the WOM after the purchase, Tunisians value the WOM and look for reviews and comments of the previous consumers in order to make their purchase. Tunisian youth will also spread WOM about their purchase and product/ service experience, companies should therefore take that inconsideration and manage to have a positive WOM about their brand/ product, because there is a negative WOM spread too among consumers especially when it comes to the green wash issues. Hence, companies should make sure to take every chance to lower their greenwash and enhance consumer perceptions of green perceived quality and green satisfaction and try to develop a long term relationship with its clients.

5. Conclusion

This study is an extension and continuity of hypothesis and work that was conducted previously and in many countries by many researchers.

As with any research, there were a number of limitations in this study. Environmental consciousness has again come up to the forefront of the mindset and concern in the whole world especially the United States, caused by the price increase of oil and the climate change and other environmental issues (Bush, 2008, Healey and Hagenbaugh, 2008).

Hence, it is necessary to re-understand individual perception on the responsibility towards environmental behaviors and green consumerism. First of all, this research is based on a specific category and sample which is the Tunisian youth and mainly college students. We believe that if another sample was employed for the same research, new and different findings will appear. Second, the type of green product studied was also very specific which is the personal care of everyday hygiene green products, the same remarks will be assigned that if another green product or service would take the place of our specific product, the research findings and interpretations will be different and maybe the environmental consciousness will be confirmed.

Another limitation that should be highlighted is that this research was conducted using a web-based survey, the responses about actual using or purchasing experiences can be somehow biased compared with conducting on-site surveys. The respondents can normally be bored or not interested by the topic itself, so they responded for the sake of responding. In addition, they had to depend on their memories of using experiences to respond to questions.

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Although this method is convenient and prevails in online surveys for consumer research, it might be somehow difficult for respondents to respond to the questions based on their memory. Green consumerism and marketing are new phenomena in our country, that's why it's required to train, inform, and build culture and new technologies around this field to build the necessary awareness around this field. Therefore, we need public figures, consumers and businesses to aid in this area, to move towards a healthier and sustainable production and cleaner future. Future efforts should use a variety of qualitative methodologies or a mixture between both qualitative and quantitative methods (e.g., interviews, qualitative methods) to triangulate the results. Finally, this study provides a general framework and sets the stage for future research that could explore the relevance of other external and internal factors to broaden the examination of green purchase intentions.

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Microfinance: A tool for reducing unemployment in Tunisia

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Abstract:

This work is a contribution to the debate on the role of microfinance in the fight against unemployment and the creation of paid employment. In this article we have chosen the counterfactual approach which consists in comparing the evolution of the situation of the beneficiaries of microcredit with respect to a control group having the same initial characteristics of the group of beneficiaries. Our study is based on a sample of 300 persons divided equally between three categories of respondent (the beneficiaries of the NGO ENDA, the beneficiaries of the AKDI association and the control group). We have shown the positive effect of access to microcredit on job creation. On the one hand, we verified that microfinance contributes to the reduction of unemployment, through the transitions of beneficiaries of microcredit from unemployment to employment status. On the other hand, we have shown that access to additional financial resources for their enterprises allows them to offer more jobs in the market. **Keywords**: Microfinance: Microcredit: Employment: Tunisia

Keywords:Microfinance; Microcredit; Employment; Tunisia **JELClassificationCodes**: G21, J64.

1. INTRODUCTION

Unemployment remains a central issue for Tunisia. In fact, economic growth was insufficient to create enough jobs to absorb new inflows into the labor market. The already large number of unemployed has continued to increase in recent years.

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New government strategies to boost the economy were essentially focused on encouraging investment and employment and promoting of social welfare activities for the poor and unemployed.

However, the economic environment, under the former political system was characterized by anti-competitive policies such as lack of transparency, corruption and cronyism that discouraged entrepreneurship because of the sense of "deprivation of opportunity" that they evoke among private investors.

Tunisia's labor market is characterized by a chronic and structural unemployment. This problem is further accentuated following the revolution of 14 January 2011. Indeed, the disruption of the economic environment following the revolution and the war in Libya induced the destruction of thousands of jobs and an insufficient rate of job creation.

So that one is in a micro or macro perspective, the credit seems to be the best engine of economic development. It is in this sense that the Tunisian public authorities and international organizations are fully aware of the special contribution of microfinance in meeting national objectives in terms of employment, through its role in supporting entrepreneurship and business creation.

The thesis that we defend in this study is that the implication of microfinance as a tool to fight against unemployment in Tunisia. It is in this light that we propose to look, more closely, at the impact of the Tunisian microcredit system on improving work opportunities.

What is the role of microfinance in the fight against the phenomenon of unemployment affecting young Tunisians and which results, among other things, from the stagnation of development?

The next section reviews the previous work has addressed the role of microfinance in the fight against unemployment. Section 3 deals with the formulation of hypotheses of the study and present the research methodology. Section 4 presents the model results and their interpretation. Finally, the last section concludes this work.

2. Literature review

To understand the impact of access to microcredit on the reduction of unemployment, the authors use several criteria that vary according to the perception of the authors and the specificities of the contexts of studies in this field. On the one hand, authors such as Mosley & Steel (2004) propose to evaluate the participation of microfinance in reducing unemployment by measuring the number of transitions from unemployment to employment status. On the other hand, other authors such as Guérin (2002) and Schreiner (2002) focused on the quality of self-employment and the sustainability of the jobs offered. It is in this sense that, in speaking of job creation by microcredit, these authors insist on the condition of considering only permanent, full-time and high-wage jobs.

Several authors have agreed that microcredit provides beneficiaries with the necessary funds nd capital that contribute to both the creation of self-employment and paid job (Neill, Davalos, Kiiru, Manundu, & Sebstad, 1994; Khandker & Chowdhury, 1995; Khandker, Samad, & khan, 1998; Latifee, 2003; Kuiper & Ree, 2005; Panda, 2009...).

The study of Buckley (1996) found that the impact of microcredit on paid employment is mainly due to the introduction of new firms, which was unusual since most microfinance programs tend to support firms already existing and not to finance new businesses. According to Hartarska & Nadolnyak (2008), microfinance has improved access to resources for micro-enterprises and has reduced the constraints on their financing. In this sense, Griffin & Husted (2015) argue that microfinance is a vital source of finance for microenterprises in emerging markets and underdeveloped countries.

In their study on Tunisia, Mahjoub & Bala (2005) show that participation in microfinance program allows the creation of employment through hiring new employees and promotes the reduction of child labor.

Nonetheless, Mosley (1996) showed in his study on Bolivia, that the credit can be used to increase gainful employment only when the company reaches a certain critical size in terms of sales or production. Hulme &Mosley (1996) conclude that the impact on paid employment is a natural
result of technological change that requires more work. According to these authors, this impact is minimal for poor borrowers and for those who borrow for the first time, while borrowers whose business size is greater have more opportunities to create paid jobs. Before completing these conditions, the increase in employment is limited to family work.

Other results of the studies that have examined the effect of microcredit on paid employment show that this effect, despite being positive, is very low and that the role of microcredit in the field of self-Employment, is limited to the increase in working hours and, as the case may be, to the use of family labor.

For Sebstad & Chen (1996), this effect is manifested by a small number of people employed through the creation or development of microenterprises. According to Nelson (1984), microcredit tends to have more impact on job stability, and on improving labor productivity rather than on job creation. Similarly, in examining the impact of access to microcredit on employment, Jia, Xiang & Huang (2013) show that the use of credit increases the time for self-employment of rural farmers, In particular for poor households. Similarly, Sebstad & Chen (1996) indicate that the greatest employment impacts are generally related to the increased use of family labor and the increase in hours of work by home owners and Workers.

3. Methodology

The literature review allowed us building the following assumptions:

 H_1 : Access to microcredit has a positive effect on employment through the transition of the beneficiary from unemployment to employment (self-employment).

H₂: Access to microcredit has a positive effect on employment by increasing the number of employees of the funded firm (job creation)

To verify our assumptions and to understand the change that can induce access to microcredit in Tunisia, we have resorted to the "counterfactual" approach that seeks to compare the results of the access to microcredit with a simulation of what the results would have been In case of non-access. We chose to use the control group method. In fact, the choice of this approach is justified by its comparative feature which places it among the most robust methods of impact assessment (Hardy & Koontz, 2009; Yin, 2003). To construct a control group formed by individuals who would have had similar results to those achieved by the treatment group members, if they had not borrowed, we used the simplest approach that consist to include, in the control group, individuals whose credit application is approved but who have not yet received the loan amount.

In this study, we intend to assess the impact of microfinance in the governorate of Kairouan. Our comparison will focus on microcredits given by the development association AKDI and those distributed by the NGO ENDA. We chose, deliberately, to carry our study on a large sample size (300 people) to ensure its representativeness and to maximize the quality of the results that will be provided by the estimates. We used the survey as a data collection means, which cover the period 2013-2014.

The impact of microcredit is estimated by a single equation that links the exogenous variables (related to creation of employment) with the explanatory variables. Our model to estimate is the following:

$$y_{ki} = C_0 + \alpha A_i + \beta X_i + \gamma Z_i \qquad (1)$$

 Y_i is the vector of exogenous variables (self-employment, job creation). They are qualitative data collected from questions with dichotomous answers. These variables take the value of 1, if there is job creation and the value of 0, if none.

 A_i is a dummy variable that discerns access and use of microcredit. It takes the value 1 if the individual belongs to the treatment group (borrower since 2013) and 0 if it belongs to the control group (not yet having access to the microcredit). The confirmation of our main hypothesis, assuming that access to microcredit has a positive effect on both job creation measures (the Yi), requires that the coefficients α_i , estimated on variables Ai be statistically significant and positive.

 X_i is a vector of variables that characterize the individual (age, gender, educational level, place of residence ...) and his household (household size,

poverty level (measured by the average household expenditures) ...) and which are likely to influence the results.

 Z_i is the set of variables related to microcredit when it exists (credit institution, amount of credit and ancientness of credit relationship). Indeed, in addition to access to credit, factors related to the degree of participation in the microcredit program are also likely to influence the variables of interest.

However, the correlation matrix revealed a perfect correlation between the variable access to credit (A_i) and the characteristic variables of the microcredit (Z_i) . To solve this problem and improve the significance of the model, we opted for the following solution:

In a first step, we estimated a first model (general model) with only the variable access to credit (A_i) and the personal characteristics of the respondents (X_i) to verify the signification of the granting of credit.

$$y_{ki} = C_0 + \alpha A_i + \beta X_i \qquad (2)$$

For this model, it will be sufficient to check the significance of the variable access (A_i) to say that the granting of the MC plays a role in the creation of employment. The other explanatory variables (X_i) are used to improve the model.

In a second step, and once the significance of the access variable is verified, we will specify a model with only the individual variables of the beneficiaries (X_i) and the variables related to the credit characteristics (Z_i). This model is estimated only for beneficiaries (that is, for whom $A_i = 1$).

$$y_{ki} = C_1 + \beta X_i + \gamma Z_i \qquad (3)$$

The purpose of this specification is to explain the other factors that participate to the creation of employment by microcredit and to check the importance of the characteristics related to the credit in the achievement of the impact.

Since our dependent variables are dichotomous, we used logistic regression to estimate our models. In the end, the data from our field survey are processed using the STATA software. For each estimated model, the overall significance and the fitting quality are tested, respectively, using the Wald chi-square statistic and the McFadden Pseudo-R2.

4. Results

4.1. Effect of Access to Microcredit on self-employment

For a more general idea of the role of microcredit in promoting the self-employment of the beneficiary, firstly, we have, regressed the "selfemployment" variable (which takes the value "1" if the respondent was unemployed and "0" If not) on the set of explanatory variables (already presented in the previous paragraph).

EIVIT LO I MEN I								
Dependent variable : Self-employment								
Independent variables	1st model	2nd model						
ACCES	1.08*** (3.91)	-						
AGE	-0.04** (-2.29)	-0.11*** (-3.62)						
GENRE	0.89*** (3.19)	1.81*** (4.31)						
NIVEDU	0.52 (1.63)	-0.14 (-034)						
ETATMAT	-0.30 (-1.11)	-0.60 (-1.35)						
MILGEO	-0.01 (-0.05)	-0.15 (-0.30)						
TMENG	0.09 (1.12)	0.03 (0.31)						
NIVPAUV	0.27 (1.00)	-0.30 (-0.81)						
SECTACT	-0.17 (-0.61)	-0.08 (-0.17)						
Const 1	0.34 (0.38)	-						
INSTITMC	-	-1.46*** (-3.36)						
MTCDT	-	0.00*** (3.22)						
ANCNT	-	0.07 (0.32)						
Const 2	-	3.28** (2.23)						
Statistical Z-values in brac	Statistical Z-values in brackets							

TABLE1. EFFECT OF ACCESS TO MICROCREDIT ON PROMOTING THE SELF-EMDI OVMENIT

*** :Significant at the 1% level (p < 0.01)

** :Significant at the 5% level (p < 0.05)

*: Significant at the 10% level (p < 0,10)

Source: Author's own calculation using STATA software

The results of the estimation show that access to MC (ACCES) is a significant variable at the 1% level of significance in the statistical model. The positive correlation between the self-employment variable (AUTO_EMPL) and the variable (ACCES) shows that access to microcredit allows beneficiaries to create their own job and to escape unemployment. This confirms the theoretical model affirming the role of the MC in the promotion of employment).

The positive effect of the main variable (ACCESS) being verified, let us pass to the results of the second specification, dedicated only to beneficiaries, to determine the personal characteristics and those of the MC that influence the promotion of self-employment.

The variable (AGE) plays an important role in the creation of selfemployment, since it is significantly (at 1% level) and negatively correlated with the dependent variable (self-employment). This means that the younger the respondent, the greater the likelihood that he or she will create his own job. Regarding the gender of the respondent, we find that it is a significant variable in the 1% level of significance, which is positively correlated with the dependent variable. We can therefore say that the possibilities for promoting self-employment are greater for women than for men. The other variables related to the characteristics of the beneficiaries and their activities are not significant.

However, among the characteristics of the microcredit relationship variables (INSTITMC) and (MTCDT) are significant at the 1% level. For the variable "microfinance institution" (INSTITMC), we find a negative correlation between this variable and the variable "self-employment", which means that the chances of transition from unemployment to employment status are less important for clients of the ENDA institution. This is explained by the fact that ENDA grants its loans to micro-enterprises already installed. It may be noted that the aim of this MFI is not to help the unemployed to create their own projects, but to provide microentrepreneurs with opportunities to develop their activities. For AKDI association, the opposite is true, since, according to our results, being a client of this association (INSTITMC=0) increases the chances of promoting self-employment. This means that most of the beneficiaries of the "associative" microcredit were unemployed before accessing it, and, thanks to this access, they became able to create their own activities.

The amount of credit is positively correlated with the creation of selfemployment. This shows that the beneficiaries who have accessed the largest amounts of credit are those who have been able to create their own jobs.

The credit relationship seniority variable (ANCNT), which refers to the number of credits received, in the self-employment estimation model is not significant.

4.2. Effect of Access to Microcredit on job creation

Secondly, we have examined the variable "Job creation" makes it possible to complete the information sought on the role of microcredit in the promotion of employment and the fight against unemployment.

Dependent variable : Self-employment							
Independent variables	1st model	2nd model					
ACCES	0.69** (2.56)	-					
AGE	0.02 (1.13)	-0.00 (-0.11)					
GENRE	-0.88*** (-3.23)	-1.17*** (-2.78)					
NIVEDU	0.11 (0.40)	-0.23 (-0.57)					
ETATMAT	0.09 (0.36)	0.08 (0.23)					
MILGEO	0.12 (0.47)	-0.24 (-0.52)					
TMENG	0.04 (0.58)	0.00 (0.02)					
NIVPAUV	0.09 (0.35)	-0.47 (-1.32)					
SECTACT	0.81*** (2.89)	1.28*** (2.65)					
Const 1	-1.35 (-1.62)	-					
INSTITMC	_	-0.63* (-1.72)					
MTCDT	-	0.00*** (3.33)					
ANCNT	-	0.63** (2.53)					
Const 2	-	-1.59 (-1.37)					
Statistical Z-values in brac	kets						
*** :Significant at the 1% level ($p < 0.01$)							

TABLE 2. EFFECT OF ACCESS TO MICROCREDIT ON JOB CREATION

** :Significant at the 5% level (p <0,05)

*: Significant at the 10% level (p <0,10)

Source: Author's own calculation using STATA software

The results of the estimation show that the variable (ACCES) is significant at the 0.5% level of significance. Indeed, being a beneficiary of microcredit increases the chances of job creation to 69.2%, which is very important. This can be explained by the fact that access to microcredit allows the entrepreneur to expand his activities and resort to more workers.

Moving to the second specification, we noted that the gender variables (GENRE) and sector of activity (SECTACT) are the individual characteristics that affect job creation. The gender (GENRE) is a significant variable (at the 1% level) in the model. However, this variable is negatively correlated with the variable explained, which means that being a woman reduces the chances of creating new jobs in the microenterprise funded. So men have more opportunities to offer jobs to others than women.

The sector variable (SECTACT) is significant at the 1% level, it is positively correlated with the variable of interest. Thus, when the respondent operates in the agricultural or production sector, he is more likely to create jobs than when he develops a service or trade activity. This may be justified, since agricultural or production activities require more labor than activities in the tertiary sector, which are often limited to the entrepreneur or, in some cases, to a few collaborators.

Additionally, variables related to credit characteristics introduced in the second specification are all three significant.

The microfinance institution (INSTITMC) is a significant variable in the 10% level and it is negatively correlated with the dependent variable. So being a client of the NGO ENDA, decreases the probability of offering employment. In contrast, being a client of the AKDI association increases the chances of job creation by 63.9%. This can be explained by the fact that AKDI's clients belonging to the agricultural sector are more numerous than those of ENDA. Similarly, the number of beneficiaries "men" is more important for AKDI than for ENDA.

As for self-employment, the estimate of the variable "amount of Microcredit" (MTCDT) is significant at the 1% level. It has a positive

coefficient in the equation. So the greater the amount of credit, the more the beneficiary will be able to offer jobs in the market. This can be argued by the expansion of the activity through the access to microcredit, which requires new recruitments.

On the other hand, we have shown that the role of microfinance in the fight against unemployment is not limited to the creation of employment for the beneficiary of microcredit. Indeed, access to additional resources for his company allows the beneficiary to offer more jobs in the market. When credit is used to improve the company's production and sales or to improve technological conditions, the increase in paid employment offered by the concerned firms seems to be a natural product of the development of the activity.

Our study on Tunisia has shown that the creation of paid employment is more important for borrowers with agricultural or industrial activities, which are often larger than commercial ones and for which access to microcredit in most cases involves technological change.Moreover, we have shown that women are more likely than men to create their own jobs through microcredit. Indeed, as indicated by Rosintan & Cloud (1999), poor women around the world have created their own jobs with access to productive capital offered by MFIs. They often develop small-scale activities in In this model, ancientness is a significant variable in the 10% level. It is positively correlated with the dependent variable. Therefore, beneficiaries who have a long relationship with microcredit, that is to say those who received more microloans, are more likely that new borrowers to provide employment. Indeed, the seniority of the entrepreneur confirms the effect of microcredit since a first loan may not give the expected results in terms of development and promotion of the activity financed. But, additional credits can help entrepreneurs meet their profitability and expansion goals, which create the need for new employees.

5. DISCUSSION AND CONCLUSION

This study has demonstrated the positive effect of access to microcredit on job creation. On the one hand, we verified that microfinance contributes to the reduction of unemployment, through the transitions of beneficiaries of microcredit from unemployment to employment status. Indeed, 69% of the beneficiaries surveyed were unemployed before accessing microcredit. So access to microcredit has allowed them to create a new activity that represents a new source of employment and income.

This is mainly due to the fact that the impact of microcredit on paid employment is mainly due to the creation of new enterprises (Buckley, 1996), the general objective of microcredit being the generation of selfemployment through The creation of micro-enterprises (agriculture, smallscale dairy production, food processing and petty trade). In the same way, we noted that job creation is much more important for the beneficiaries of the AKDI association than for those of ENDA institution, and specifically for those with a longer credit relationship and a more important amount of credit.

So, as did Hulme & Mosley (1996), we can conclude that the impact of microcredit on job creation is greater when the size of the firm is large. Finally, our results confirm those confirmed by Mahjoub & Bala (2005) on Tunisia which confirmed that participation in microfinance programs allows the creation of employment through the hiring of new employees.

For microcredit that aims to support small activities already existing, they tend to develop the size of these activities and ensure their continuity and thereafter improve the quality of the jobs they generate. In other words, it is about ensuring full-time employment and good pay. At the outset, these activities did not provide stable jobs, were not well paid, and therefore did not represent sources of employment. Indeed, they are small occasional commercial activities or agricultural activities of animal breeding or gardening.Nevertheless, the results of our analysis must be taken with great caution, since it is necessary to consider that the specificities of the Tunisian context (revolution and upheaval of the socio-economic landscape) make our findings not necessarily adaptable for other contexts.

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The Extra-Financial Reporting on the Societal Responsibility of the Company: A practice of Good Governance for Tunisian Listed Companies

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Abstract:

Partnership governance is taking over on the classical way of governance mainly, the shareholder governance consequently, a special attention is given to the ecological environment, to civil society and to conditions of work. Having an economic, social and societal commitment altogether is not really an easy task for the company.

The aim of this study would be to point out the most significant indicators of Good Governance mainly the Social and Societal Responsibility of the company. The study would focus on companies listed in the Tunisian Stock Exchange. An Extra-Financial Reporting would be suggested as a mandatory document to be communicated and published annually by those companies. The best way to govern nowadays is to listen permanently and actively to all parties involved, whether internal or external, local or foreign, and basically to try to harmonize often contradictory needs and objectives.

Keywords: Governance; Corporate Social Responsibility (CSR); Tunisian Listed Companies; Extra-Financial Reporting.

JEL Classification Codes :M14, O16

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1. Introduction

In France since 2017, writing a CSR Report is mandatory for listed companies. In Tunisia, Act 35-2018 has the aim of putting into practice the principle of reconciliation the company to its ecological and social environment through its participation in the process of sustainable development and Good Governance. The provisions of that law apply to public as well as to private companies.

According to the study, the causal relation between Social Responsibility and Good Governance has a double meaning. On the one hand, the Social Responsibility of the company is a necessary condition, but it is not enough to get a Good Governance. On the other hand, a company cannot have a real and effective practice of its Social and Societal Responsibility if it is "badly governed".

The paradox is that when practising its societal responsibility, a company commits considerable funds which are in a total contradiction with the objective of maximising profit, generated by a reduction of charges sought traditionally by shareholders.

The question then would be: In what circumstances would listed companies publish information concerning their practices in societal responsibility and how would this communication be?

This piece of research is interesting because of the sample chosen, as well as the long period of study, which have not been subject to prior investigative work. Furthermore, the question of acquiring Good Governance practices worries nowadays a large number of decision makers and leaders of companies.

The study would serve as a model for unlisted companies which intend to list in the stock market, as well as those listed but would like to acquire recent governance practices.

2. Governance and Good Governance in listed companies

2.1. The Corporate Governance

Cadbury in 1992 gave the most known definition of governance: "Governance is the system by which companies are ruled and controlled".

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A broader definition given by the OECD stipulates that "Corporate Governance means the set of relations between the company managers, its board of directors, shareholders and other parties involved. The company's governance provides equally the frame within which the company's objectives are fixed and defines the means to reach and to supervise the achievements.

Starting from those definitions, two key words concerning the company's governance emerge: Management and Supervision.

2.2. The "Good Governance"

Good Governance means the best way with which we rule a company while taking into account the diversified and sometimes contradictory interests of all the economical actors or even those having no relation with the company.

It means acting "for the benefit" of all,in other words, governing while respecting certain rules of good conduct set by good governance codes.

"It means then implementing a system of good governance well adapted to the aims sought", as it has been mentioned in Wikipedia.

Rating agencies provide nowadays a quality signal for the company's governance which affects the shareholder's investments, their right to vote and the incentives to sanction the bad practices revealed by the rating.

2.3. Importance of Good Governance in listed companies

A good practice of governance should insure a good disclosure of relevant information on the financial situation, the performance and the shareholding structure, and the company's governance. "A high level of transparency attracts investors and allows to maintain market confidence" (OECD, 1999).

Good governance would guarantee the stakeholders have an interest in the company's business and it (good governance) improves the climate of trust with all its partners.

In fact, a company's good governance can:

- Facilitate the access of the companies to external financing;
- Reduce the cost of the capital and boost the company's value, by making investments more attractive;
- Strengthen relations with the different parties involved mainly the environment;

Reduce financial risks due to a better forecasting and management by a specific risk committee.

2.4. The "Code of Good Practices of Governance of the Tunisian Listed Companies"

During an end-of-studies project traineeship in the Tunisian Stock Exchange, we had the opportunity to draft in partnership with the Department of Communication of the Tunisian Stock Exchange, "a code of good practice for Tunisian listed companies' governance", which was updated in May 2018.

The above-mentioned code stipulates eight criteria defining the good governance; the most important among them is the "Corporate Social Responsibility".

3. The relation with stakeholdersas a pillar of the CSR of listed companies

A stakeholder can be an individual or a group of individualsbeing, directly or indirectly, a part of the sphere of influence of the company and is likely to create value for it.

3.1.Identification of parties involved for listed companies

The technique of Brainstorming allows listing the name of all involved parties that can:

 \checkmark Be interested in anyway in the company;

- ✓ Have a position of influence;
- $\checkmark\,$ Be affected by the problems which face the company.

We distinguish, thus, two types of parties involved:

3.1.1.Internal parties involved: they include shareholders, leaders, employees and unionists.

3.1.2.External parties involved: they include customers and suppliers, competitors, banks, the State, Stock Market brokers, investors,

citizens and the environment.

3.2 The Corporate Social and Societal Responsibility

3.2.1. Defining the concept: The CorporateSocietal Responsibility (CSR) can be defined according to the ISO 26000 as the "responsibility of an organization in relation to the impacts its decisions and activities can have on society and the environment shown through an ethical and transparent behaviour that:

- contributes to sustainable development including the health and the well-being of the society;

- takes into consideration stakeholders' expectations;

- respects the laws while being in accordance with international codes of behaviour:

- is integrated with the organization and implemented in its relations.

The company's social responsibility has become an important issue in management of organizations so much for practitioners as well as for rhetoricians.

A new proof has emerged nowadays: the company is not only accountable to its shareholders but also more to the economical actors in relation with it. Besides, the CSR has become nowadays the indisputable condition to the sustainability of the company.

3.2.2. The steps to CSR:

Implementing a SCR implies respecting the following steps:

- CSR diagnosis;
- Employers' and employees' commitment;
- Preparing a preliminary draft;
- Planning and carrying out the training and sensitisingabout CSR;
- Creating plans of internal and external communications;
- Evaluating, measuring and monitoring progress;
- Regular reporting on progress;
- Identifying opportunities of improvement.

3.3. CSR and Good Governance: Advantages for the company:

Implementing CSR's steps generates additional expenses for the company but brings in huge advantages such as:

- A competitive advantage;
- An improvement of the trademark;
- An improvement of the work climate;
- Customers loyalty;
- Conforming to foreign customers requirements;
- An improvement of internal communication;
- New openings and better employees;
- Access to new financial resources;
- Higher profitability and lower costs;
- An improvement of relations with parties involved and the community;
- Lesser intervention of the state;
- A stronger capacity of innovation;
- A sustainability of activities.

3.4. Good Practices of CSR

The best practices of SCR are those that respect the principles of the United Nations world Chart or simply the requirements of ISO 26000 standard.

3.4.1. The ten principles of the United Nations Chart:

- Promoting and respecting human rights;
- Not taking part in human rights violations;
- Respecting the freedom of association and recognizing the right of collective bargaining;
- Abolishing all forms of forced labour;
- Abolishing child labour;
- Abolishing discrimination in employment;
- Applying the precautionary approach towards problems concerning the environment;
- Promoting a greater responsibility for the environment;

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- Encouraging the development and diffusion of environmentallyfriendly technologies;
- Fighting corruption.

3.4.2. The seven principles of ISO 26000 standards:

- The organisation's governance;
- Human rights;
- Work conditions and relationships;
- The environment;
- Fair practices;
- Consumer issues;
- Community and local development.

4. Extra-Financial Reporting on CSR as a practice of Good Governance for Tunisian Listed Companies

4.1. Methodology of research

- Kind of research: it's an empirical research: we intend to test samples of companies, so it is a microeconomic study.
- Approach: approach by indicators: used indicators have two types: qualitative and quantitative.
- Period of research: the period of study covers six years: from 2013 to 2018.

The first semester of 2019 would be added to provide more recent data.

• Sample choice: we have chosen 06 listed companies and 03 unlisted ones which apply CSR.

4.2. Measurement Indicators

Indicators serve to guaranteethe implementation of the seven principles of ISO 26 000 standards and to evaluate the CSR-related communication of the companies subject to the study.

• In our study, we distinguish six classes of indicators relating to extra-financial reporting on CSR: (1) economic indicators, (2)

governance indicators, (3) social indicators, (4) societal indicators, (5) environmental indicators, (6) extra-financial communication indicators.

- Within these six classes we can find qualitative indicators and quantitative ones.
- We have opted for 15 indicators which provide an acceptable limit to feed our CSR's Report.

5. Recommendations and model of an extra-financialCSR reporting 5.1. Development of a Responsible Business Charter

It is a formal statement of the company's philosophy, its goal, its principles and its values. More or less detailed, it can be in a few lines or be the topic of a book.

The corporate charter describes the role it wants to play in society, what it does, how it does it, with whom it does it; what its resources are, its priorities and what it ultimately wants to accomplish.

Today, such a charter should not simply be limited to what stakeholders, including shareholders, want to read. On the contrary, it must reflect the daily life of the company and what it wishes to accomplish in and for its environment.

It allows teams to exercise their profession with full knowledge of their rights but also their duties. It must apply to all activities that the company controls. It is applicable to all managers and employees.

Management is responsible for ensuring that it is implemented at all levels. The charter must be translated into several languages, and associated with compliance with the law and regulations, the values, principles of action and rules of business conduct.

5.2. Developing a carbon footprint

The carbon footprint is a tool developed by L'ADEME (French Environment and Energy Management Agency). It makes it possible to account for direct and indirect greenhouse gas emissions, according to a method whose rules are public and thus establish carbon accounting for its activities.

It applies to any activity: an industrial or tertiary enterprise, an administration, a community and even the territory managed by communities.

More than just a technical tool, the Carbon Report is, above all, a part of an eco-responsible long-term approach. The process takes place in 6 points:

- ✤ Awareness of global warming and its effects;
- Establishment of the scope of the analysis;
- Collection of information to be taken into account;
- ✤ Use of the data collected;
- Definition of the action plan for reducing emissions;
- Putting the decided measures into practice.

5.3. Social report

The social balance sheet is an instrument for measuring the social field in the company. In other words, it is a single document which summarizes the main figures, thus making it possible to assess the situation of the company in the social field, to measure the changes which have occurred during the past year and the two preceding years and so to record the achievements made. The social balance sheet of the company has the same principle as the accounting balance sheet except that for this one we do not treat the balance sheet accounts but the needs of the employees in the company.

It involves everything that has a direct relationship with the employee in the company i.e. his motivations, his salary, his years of seniority, the course followed by the employee in the company, the reputation of his employer in relation to his work, etc.

There are various sections, from which the social report includes information on employment, hygiene, health and safety conditions, remuneration and ancillary costs, other working conditions, training, professional relations, the number of posted employees and the number of reintegrated posted workers, as well as on the living conditions of employees and their families insofar as these conditions depend on the company. It also makes it possible to identify areas for improvement and to define the actions to be taken in the future.

These will allow knowing:

• The social situation of the company,

• The achievements made in the social field,

• Appreciate the changes made during the past financial year.

5.4.The need to draw up a CSR report

Listed companies are required to prepare a CSR report periodically (for example annually) to report on their CSR actions and results.

The aim of a CSR report is to improve transparency on the activity of the company. The goal is two-fold:

First, internally, the usefulness of the CSR report is the fact that it allows companies to measure the consequences of their activities on their environment, on society and on the economic ecosystem and even to improve their processes. in order to have a more positive impact.

Externally, the CSR report allows the company's stakeholders to better understand the involvement in sustainable development and the CSR of the company and possibly better assess the medium and long-term consequences of its activities.

As a result, these stakeholders can make more informed choices about the business.

In the same way, consumers or potential customers of the company can, thanks to the CSR report, know more precisely the consequences of their purchases in environmental, social and economic terms.

6. Conclusion

A major challenge facing CSR is the fact that leaders are not ready to engage in a process that risks making them less money.

The CSR approach can therefore only be carried out in its social and environmental aspects if this approach does not prevent profits; hence the slogan CSR, doing well by doing good.

Tunisian listed companies are fairly transparent regarding communication on their actions which affect the social and especially societal aspect of their CSR approach. This communication takes the form of advertising rather than extra-financial reports.

As for the environmental component, figures on CO2 emissions, greenhouse gas emissions, energy consumption, etc. remain almost absent and not communicated by the companies; and sometimes even not calculated within the company, either by negligence, or by lack of measurement means, or by fear of non-compliance with standards.

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Impact of the informal economy on economic growth

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Abstract:

In order to find and test the impact of the informal economy on economic growth, we will use the most avanced techniques, such as the GMM-System Method proposed by Arellano and Bover (1995), in the context of a dynamic panel data model, for a panel of 92 avanced, emerging and developping countries, over a study period stretching from 1960 to 2010. The results show a non-linear relationship between the variable IS and economic growth, on the other hand, the variable IS reported to the squares exhibits a negative and statistically significant effect. Indeed, from a certain threshold, the effect of the variable IS changes sign and becomes negative.

Keywords: Informal economy; economic growth; PRE (high income countries); PRM (middle income countries); PRF and IS.

JEL Classification Code: E26

1. INTRODUCTION

Our work aims to test the impact of the informal sector on economic growth. To our knowledge, the number of empirical work that has addressed the subject is very limited. To fill this gap, we will test the impact of the informal economy's presence on economic growth for a panel of 92 advanced, emerging and developing countries. The study period runs from 1960 to 2010. We will use more advanced techniques such as the GMM-

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system method proposed by Arellano and Bover (1995), as part of a dynamic panel data model.

Our work will organize as follows: in the first section we will provide a review of empirical literature that has dealt with the subject. In the second section we will present the econometric techniques that will be used in this work. The third section will focus on the presentation of the different models and the variables that make them up. The fourth section will present key economic outcomes and lessons learned.

2. Review of Empirical Literature

The empirical literature, which has examined the growth-informal sector relationship, has been characterized by controversy in terms of results obtained: a set of studies that suggest that a broad informal sector is associated with low levels of growth. On the other hand, other work has shown otherwise. Sarte (2000); Loayza, Oviedo and Serven (2004) suggest that too much regulation can lead to an increase in the informal economy by reducing economic growth. The state finds it difficult to cover its education, health and investment costs.

For a sample of Latin American countries, Loayza (1997) showed that expanding the informal sector only undermines economic growth by increasing the inefficient use of public services. In a similar way, Johnson et al. (1997) have shown a negative association between the informal economy and the economic growth of countries in transition.

Other work has looked at microeconomic evidence. De Soto (1989) suggests that companies, and for the purpose of escaping state control, find themselves forced to operate on a very small scale. Such behaviour deprives them of reaching the optimum ladder by limiting growth opportunities.

Using data from 6797 belonging to the Indian state of Kerala, Raj and Seethamma (2007), showed that manufacturing firms operating in the informal sector, suffer from technological inefficiencies and are only able to produce 48% of its output potential. More recently, Benjamin and Mbaye (2010) have shown that companies operating in the formal sector are more productive than those active in the informal sector. The study is based on a sample of 900 companies in Benin, Burkina Faso and Senegal. The same result was obtained by Byiers (2009) for Mozambican companies.

With regard to Turkish companies, Taymaz (2009) has proven the existence of a productivity gap between firms that are active in both sectors: formal and informal. This gap is due to limited access to public services and markets.

Finally, Amin (2009) has shown that firms operating in the informal sector are less productive than those that produce in the formal sector, because of their limited access to credit.

Similarly, Gatti and Honorati (2008) focused on firms from 49 developing countries. The author used tax compliance as a measure of the formal economy. The results converge on a positive correlation between tax compliance and credit, which is one of the fundamental sources of growth.

In the same vein, Melendez (2012) found that the variable measuring the informal economy is negatively correlated with access to credit, the employment growth rate of the Colombian economy. The same result was found by Salgado and Seminario (2012) for the case of Peru.

On the other hand, some economists suggest that the informal economy can be beneficial for better economic growth. Indeed, firms operating in the informal sector would employ low-skilled workers, use less capital, and absorb operating costs in the formal sector (Levy 2008; 2008 Porta and Shleifer). This could increase productivity levels in economies with a large informal economy. (D'Erasmo and MoscosoBoedo, 2011).

In the same vein, Eliat and Zinnes (2000) have shown that a large size of the informal economy could be accompanied by higher growth rates and productivity in the formal sector.

Our work will contribute to the empirical literature existence by estimating a dynamic panel data model by breaking down our sample into three groups: low-income, middle-income and high-income countries. The classification is adopted by the World Bank. We will also try to detect a non-linear relationship between growth, employment and informality. The weight of the informal economy is measured by Elgin, C.,'Oztunali'(2015), and this using a dynamic general equilibrium model.2.

²https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

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3. Methodology: Introducing econometric techniques:

Dynamic panel data modelling allows the introduction, as explanatory variables, an endogenous variable delayed by several delays. In this case, estimators derived from MCO methods and generalized square (MCG), are biased and suffer from non-convergence problems. In the same context, these estimators do not address the problem of simultaneous and causal relationships between the explanatory variables and the dependent variable, as well as they do not address heterogeneity bias.

A dynamic panel data model (which has only one delayed endogenous variable) can take the following form:

 $y_{it} = \rho y_{i,t-1} + X'_{it} \beta + \alpha_i + v_{it}$

(1.1)

Where $v_i \wedge N(0, \sigma^2)$ and $|\rho| < 1$

X: the vector of explanatory K variables

 β : Unknown parameters for independent variables.

 ρ : The parameter to be estimated for the delayed endogenous variable.

 α_i : The individual specific fixed effect.

Arellano and Bond (1991) proposed to eliminate the term individual heterogeneity by moving to the primary differentiation of the equation (1.1). As a result, we get the equation (1.2)

$$y_{it} - y_{it-1} = \rho (y_{it-1} - y_{it-2}) + \beta (X_{it} - X_{it-1}) + v_{it} - v_{it-1} (1.2)$$

$$\Delta y_i = \Delta W_i \theta + \Delta v_i$$

Where, θ is a parameter vector to be estimated, (*W*) is a matrix of explanatory variables.

It is clear that conventional estimators (MCO and MCG) remain biased and non-convergent, to the extent, where there is dependence between the primary differences of the delayed endogenous variable and the error term. To get around this problem, Arelano andBond (1991) proposed the Moments method, which is based on the technique of instrumental variables. Indeed, it is necessary to find valid instruments that are not correlated with the term error but are correlated with the delayed endogenous variable.

Thus, next to $(\mathcal{Y}_{i\,t-2})$ the endogenous variable of an order greater than two are valid instruments for the equation in raw differences (3.2)

Arellano and Bover (1998) have proposed two examples for the choice of instruments

The table above traces the choice of instruments used for each moment (t).

Equations Inrawdifferences	The right instruments
$\Delta y_{i3} = \rho \Delta y_{i2} + \Delta v_{i3}$	\mathcal{Y}_{i1}
$\Delta y_{i4} = \rho \Delta y_{i3} + \Delta v_{i4}$	y_{i1} , y_{i2}
Ν	Ν
Ν	Ν
$\Delta y_{iT} = \rho \Delta y_{iT-1} + \Delta v_{iT}$	$y_{i1}, y_{i2}, \dots, y_{iT-2}$

With: Z is the matrix of instruments.

Ζ

$ \begin{pmatrix} y_{i1} \\ 0 \end{pmatrix} $	X_{i1} 0	X_{i2} 0	0 y_{i1}	0 y_{i2}	0 X_{i1}	0 X _{i2}	0 X _{i3}	K K	0 0	K K	0 0	0 0	K K	$\begin{pmatrix} 0 \\ 0 \end{pmatrix}$
.														
.				•	•				•					-
0	0	0	0	0	0	0	0	Κ	y_{i1}	Κ	$\mathcal{Y}_{i(T-2)}$	X_{i1}	Κ	$X_{i(T-1)}$

With X it is the matrix of explanatory variables.

Finally, Arellano and Bond (1991) obtained the FMM estimator in two steps:

$$: \hat{\theta}_{GMM} = \begin{pmatrix} \hat{\rho} \\ \hat{\beta} \end{pmatrix}$$

$$(1.3)\left[\left(\sum_{i} W_{i}^{*'} Z_{i}\right) A_{N}\left(\sum_{i} Z_{i}^{'} W_{i}^{*}\right)\right]^{-1}\left[\left(\sum_{i} W_{i}^{*} Z_{i}\right) A_{N}\left(\sum_{i} Z_{i}^{'} y_{i}^{*}\right)\right]$$

Where, $(.W_i^*)$ and (y_i^*) represent respectively the transformations of W_i and y_i in first difference

Blundell and Bond (1998) proposed an extension of this estimator, exploiting all the orthogonality conditions of the equations in first and in level difference. The instruments are chosen for twoequations:

$$y_{it} = \rho y_{i,t-1} + X'_{it} \beta + \alpha_i + v_{it}$$

$$y_{it} - y_{it-1} = \rho (y_{it-1} - y_{it-2}) + \beta (X_{it} - X_{it-1}) + v_{it} - v_{it-1}$$

Of course, two tests are required to ensure the effectiveness of the GMM estimator: the Sargan/Hansen instrument validity test and the 2-order serial correlation test between the residues.

Indeed, the 2-order serial correlation test between the residues is based on the following statistic that follows the normal law centered and reduced.

$$m_2 = \frac{\Delta v_{it} \,\Delta v_{it-2}}{\sqrt{(\Delta v_{it})}}$$

The null hypothesis of the existence of a 2-order serial correlation should not be rejected in order 2 for GMM estimators to be valid.

The Sargan/Hansen test is a test that tests the validated instruments proposed by Arellano and Bond (1991). Sargan's statistic follows a chi-two law to P-K-1 degree of freedom, with K it's the number of instruments and P designates number of regressor.

The estimate is made via the command xtabon2 under Stata 15.0 software, using the data of 92 advanced (PRE), emerging (PRM) and developing countries (PRF), the study period runs from 1960 to 2010. We

will use more advanced techniques such as the GMM-system method proposed by Arellano and Bover (1995), as part of a dynamic panel data model.

4. Econometric method

4.1 Presentation of model and variables

We will try to estimate a model in the following dynamic panel data:

 $Growth_{ij} = \alpha growth_{ij-1} + \beta_1 IS_{i,i} + \beta_2 IS^2_{i,i} + \beta_3 OUV_{i,i} + \beta_4 URB_{i,i} + \beta_5 GOVPIB_{i,j} + \beta_6 Infl_{i,i} + \beta_7 M2PIB + \beta_8 INV_{i,i} + \beta_9 QUALINS_{i,j} + \delta_i + \lambda_i + \varepsilon_{i,i}$ (1)

 $i = 1, \dots, N; t = 1, \dots, T$

Dependent variable

GROWTH_{i,t}: the country's economic growth rate (i) at the moment (t).

Explanatory variables:

GROWTH_{*i*,*t*-1}:the country's economic growth rate (i) at the moment (t-1). **IS**_{*i*,*t*}: the weight of the informal economy in the country's total economy (i) at the moment (t). This measure, as it was advanced, was extracted from the

Elgin and Birinci database (2015).

OUV *i,t*: the country's trade opening rate (i) at the moment (t).

 $INFL_{i,t}$: the country's inflation rate (i) at the moment (t). This is the growth rate of the consumer price index (2005=100).

 $URB_{i,t}$: this is the rate of urbanization of the country (i) at the moment (t). This is the share of the urban population in the total population.

 $GOVPIB_{i,t}$: the share of government spending in the country's GDP (i) at the moment (t). These are government spending.

 $M2PIB_{i,t}$: the share of the money supply in the country's GDP (i) at the moment (t). This is the variable that measures financial development.

 $INV_{i,t}$: country's investment rate (i) at the moment (t).

 $QUALINST_{i,t}$: the various measures of the institutional quality of the country (i) at the moment (t). The data are obtained from the Polity IV Governance Database. These are six governance measures: voice and accountability, political stability and the absence of violence, the effectiveness of government, the quality of regulation, the rule of law, and finally the control of corruption

 δ_t In: The temporal effect.

 λ_i : The term individual heterogeneity

 $\varepsilon_{i,t}$: The term error

4.2 Unit Root Test Results

To test the presence of Root Root tests, we will use the test of Im, Pesaran and Shin (2003) (IPS below) and Levin, Lin and Chu (2002) (LLC below). The IPS test captures heterogeneity in the term self-regressive and intergroup dependence. ADF regressioniswritten as follows

 $\Delta Y_{i,t} = \alpha_i + \beta_i Y_{i,t} + \delta_i t + \sum_{k=1}^{\infty} \theta_{i,k} \Delta Y_{i,t-k} + \mu_{i,t}$

The altenative hyppothesis H_1 , which stipulates the absence of a unit root may be written as follows:

$$H_0: \beta_i \pi 0$$

The null hypothesis is not based on the existence of a unitary root:

 $H_0: \beta_i = 0$

With the self-regressive term of ADF regression, the terms of errors independently distributed. IPS calculated a statistic (tau) that is equal to the average of individual ADF for each country $\beta_i \mu_{i,t}$

$$\overline{t} = 1 / N \sum_{I+1}^{n} t_{\gamma,i}$$

 $t_{\gamma,i}$ This is the statistic calculated for each individual.

$$t_{ips} = N \frac{\left[\bar{t} - \frac{1}{N} \sum_{i=1}^{N} E(t_{iT} / \gamma = 0)\right]}{\sqrt{Var(t_{iT} / \gamma = 0)}}$$

It is important to note that the IPS statistic follows a normal reduced centred law.

Tables 1, 2, 3, and 4 show the results of IPS and LLC unit root tests are postponed for two specifications: with constant, with constant and trend. The results of the tests show that the null hypothesis of the presence of a unit root can be rejected for the series expressed at the level. Indeed, all the values of the two tests are below the critical values at a significance

threshold of 5%. This result is valid for all countries regardless of their income levels.

Variables	L	LC	II	PS	Conclusion
	С	Ct	С	Ct	I (0)
Corr	-4.00	-1.94	-4.40	-3.39	I (0)
EFFIC	-6.45	-4.61	-4.31	-2.94	I (0)
GDPGROWTH	-41.14	-44.70	-41.58	-43.73	I (0)
GOVGDP	-5.94	-3.72	-4.02	-4.02	I (0)
Infl	-13.12	-16.51	-17.51	-15.14	I (0)
INVPIB	-7.77	-7.60	-9.31	-8.663	I (0)
IS	-14.23	-11.18	-3.52	-1.42	I (0)
LAW	-3.83	-5.37	-2.62	-1.86	I (0)
MONEYPIB	-7.38	-6.35	-7.55	-5.58	I (0)
OUV	-3.26	-3.34	-3.24	-6.17	I (0)
Quality	-21.58	-3.64	-7.81	-12.89	I (0)
Stab	-6.61	-13.64	-3.90	-10.65	I (0)
URBANN	-4.97	-2.78	-4.77	-4.67	I (0)
VOICE	-2.78	-1.36	-4.88	-12.40	I (0)

Table 1: LLC and IPS Unit Root Test Result (Total Sample)

Table 2: LLC and IPS (PRE) Unit Root Test Results

Variables	LLC		IP	S	Conclusion
Corr	-20.22	-18.18	-18.93	-16.46	I (0)
EFFIC	-19.61	-18.65	-1.62	-11.16	I (0)
GDPGROWTH	-20.51	-22.88	-20.06	-22.23	I (0)
GOVGDP	-4.40	-1.28	-2.69	-12.22	I (0)
Infl	-4.25	-7.95	-5.59	-6.76	I (0)
INVPIB	-5.23	-4.92	-5.97	-5.93	I (0)
IS	-7.97	-1.43	-4.79	-3.97	I (0)
LAW	-4.61	-3.09	-2.84	-2.90	I (0)
MONEYPIB	-4.61	-5.05	-4.89	-2.66	I (0)
OUV	-1.91	-2.87	-2.09	-5.08	I (0)
Quality	-5.95	-1.84	-1.23	-8.91	I (0)
Stab	-9.81	-1.70	-1.76	-3.47	I (0)
URBANN	-13.32	-5.80	-1.66	-8.08	I (0)
VOICE	-3.74	-3.97	-4.04	-3.40	I (0)

Tuble 5. LLC unit tool lest result unit 11 S (1 KM)								
Variables	LLC			IPS	Conclusion			
Corr	-0.33	1.30	-2.08	0.31	I (0)			
EFFIC	-2.18	-3.45	-1.35	-2.92	I (0)			
GDPGROWTH	-	-9.18	-12.70	-11.1	I (0)			
GOVGDP	-3.12	-2.56	-3.08	-2.29	I (0)			
Infl	-3.07	-18.8	-6.43	-6.25	I (0)			
INVPIB	-2.10	-3.86	-4.43	-5.37	I (0)			
IS	-3.18	-1.19	6.37	-4.21	I (0)			
LAW	-1.54	-1.41	-1.83	-0.41	I (0)			
MONEYPIB	-4.46	-14.4	-10.3	-5.21	I (0)			
OUV	-2.48	-4.33	-1.45	-4.88	I (0)			
Quality	-2.16	-4.46	-2.89	-3.66	I (0)			
Stab	-1.12	-1.92	-1.28	-2.37	I (0)			
URBANN	-	-12.74	-1.80	-5.27	I (0)			
VOICE	-1.07	-4.46	-1.97	-3.68	$I(\overline{0})$			

Table 3: LLC unit root test result and IPS (PRM)

Table 4: LLC Unit Root Test Result and IPS (PRF)

V	т	1.	T		<u>´</u>
Variables	L		<u> </u>		Conclusion
Corr	-5.08	-3.05	-3.09	-3.63	I (0)
EFFIC	-4.08	-3.91	-2.35	-3.15	I (0)
GDPGROWTH	-24.18	-24.50	-24.31	-24.59	I (0)
GOVGDP	-2.06	-4.01	-4.03	-2.96	I (0)
Infl	-4.01	-24.50	-10.48	-6.22	I (0)
INVPIB	-2.34	-3.40	-3.46	-3.55	I (0)
IS	-9.58	-1.43	-4.80	-2.49	I (0)
LAW	-3.77	-1.21	-3.91	-1.32	I (0)
MONEYPIB	-4.60	-1.65	-2.90	-3.37	I (0)
OUV	-3.1	-4.52	-2.37	-5.05	I (0)
Quality	-4.79	-3.09	-3.61	-3.47	I (0)
Stab	-14.07	-5.98	-1.12	-1.71	I(0)
URBANN	-3.71	-4.44	-14.07	-5.98	I (0)
VOICE	-2.41	-1.24	-2.83	-1.89	I (0)

5. Result of Estimates and Interpretations:

Tables 5, 6, 7 and 8 in appendices track the results of the estimates for the different specifications and for all countries broken down by income class.

The estimate took place using stata 15 softwarevia the Xtabond, command for the GMM system estimation technique.

The results show that the null hypothesis cannot be rejected by the absence of a serial correlation of order 2 of the residues and this for a 10% significance threshold. In the same vein, Hansen and Sargan's tests accept the validity of the instruments used.

The results of the estimates show that the current rate of economic growth depends on the current rate (t-1).

The coefficient for the delayed endogenous variable (GROWTH(t-1)) is negative and significantly negative except for low-income countries. This result confirms the theoretical hypothesis of conditional convergence.

Trade opening is part of the explanation of economic growth by a positive and statistically significant sign at a threshold of 1%, and this is only for the total sample. The effect of this variable is higher for PRF with a coefficient of 0.16 to 0.29. It turns out that PRF are the countries that have benefited from their trade openings. These results confirm that countries with higher opening rates tend to have higher growth rates than countries that have adopted restrictive policies. Developing countries benefit from imports of high-tech equipment goods from developed countries. These products are essential to the domestic production process. This result implies that international trade is a means of technological diffusion for developing countries. This finding corroborates the conclusions reached by Coe et al (1995); Falvey et al (2012). As far as exports of goods are concerned, they help to reduce the trade deficit, and contribute to the fortification of foreign currencies that allow the import of high-tech goods. These results seem to match the results found by Jay (1973), Krueger (1978), Feder (1983) and Kao, Chiang and Chen (1999).

Government spending is negatively correlated with growth for PRF, while it is positively correlated for PRM. This result corroborates the results obtained by Barro (1997), Ghura (1995) and Nuredeen and Usman (2012). In the same vein, Wahab(2011) has shown that the effect of government spending remains negative if it exceeds their trend growth. In the case of PRM, a positive and statistically significant coefficient was found. This result was found by Bose et al(2007) and Ghosh and Gregoriou

(2008). Government spending can positively affect economic growth through three channels: total factor productivity, capital expenditure and increased domestic demand.

The rate of inflation is part of the explanation of economic growth by negative and statistically significant effects. This result corroborates the results obtained by Barro (2013) which confirm that uncertainty and price instability only lowers economic growth.

With regard to the proxy variable of financial development (M2PIB), it shows positive effects for PRE. Indeed, a developed financial system, allows attracting more foreign investment, improving stock markets and boosting growth. (Shahbazand Lean, 2012). On the other hand, this effect remains negative for PRF. For PRM, the effect remains not statistically significant. It turns out that for PRFs, financial markets are poorly developed, so that they contribute to the accumulation of the capital factor. Indeed, Paolo Mauro (2016) suggested that these savings financed unproductive projects.

The investment rate variable has positive and statistically significant effects on economic growth for all categories of countries. This result seems to go hand in hand with the theory that domestic investment is a given factor in boosting long-term growth.

The rate of urbanization only affects the economic growth of PRE, urbanization tends to increase economic growth.

With regard to variables relating to the qualities of institutions, the majority of measures show positive effects on economic growth.

The table above shows the effects of different variables on growth across different country groups.
	PRE	PRM	PRF
Voice	5.776*	Ns	Ns
Stab	Ns	2.28*	Ns
Effective	5.78*	1.86*	Ns
Quality	Ns	1.12*	Ns
Corr	Ns	1.71*	4.45*
Law	8.45*	Ns	Ns

Summary effect of institutional quality variables on economic growth by group of countries

*Denotes a statistically significant impact, ns: not statistically significant.

For PRE, the variables EFFI, VOICE and LAW have positive and statistically significant impacts on growth.

With regard to PRM, political stability, effective government, quality of regulation and corruption control is helping to boost economic growth. For PRF only the CORR variable that exhibits a positive and statistically certain growth effect.

These results are consistent with the results found by Demetriades and Andrianova (2004), which suggest that better political stability and good legal infrastructure can boost economic growth. Indeed, the decline in political instability and corruption is helping to attract more foreign direct investment and long-term productive projects (Cherif and Dreger (2016)).

Growth and informal sector

The results show a non-linear relationship between the IS variable and economic growth in all three groups of countries. Indeed, the effect of the IS variable remains positive and statistically significant. On the other hand, the IS variable reported to the square shows a negative and statistically significant effect in most of the selected specifications. Indeed, at one point at a certain threshold, the effect of the IS variable changes sign and becomes negative.

The optimal IS point is the level of the weight of the informal economy that maximizes growth. This threshold can be deducted from the results of the estimates.

$$\frac{dGROWTH}{dIS} = 0 \Rightarrow \beta_1 + 2\beta_2 IS \quad i,t = 0 \Rightarrow IS^*_{i,t} = \frac{-2\hat{\beta}_2}{\hat{\beta}_1}$$

The optimal thresholds of the informal economy are 51.2% for PRF, 38.1% for PRM and 30.1% for PRE.

The hansen test refers to the instrument validity test (p-value). To test the robustness of these results, graphs should be generated that trace the following smoothed curves:

<u>Chart 1: Non-linear function between the rate of economic growth and the</u> informal economy: PRF



<u>Chart 2: Non-linear function between the rate of economic growth and the</u> <u>informal economy: PRM</u>







The charts above have just confirmed the results obtained previously. Indeed, in the case where the IS variable exceeds a threshold (30% for PRE; 41% for PRF and PRM), the impact on growth is positive. Beyond these thresholds, the weight of the informal economy has negative effects on growth.

6. Conclusion:

This article was dedicated to the study which aims to study the impact of the informal economy on economic growth. The sample consists of 92 countries, which are divided into three groups, depending on their income levels. To address our problem, we have estimated dynamic panel data models. The results converge on a non-linear relationship between the weight of the informal economy and economic growth. The effect of the IS variable remains positive and statistically significant. On the other hand, the IS variable reported to squares shows a negative and statistically significant effect in most of the selected specifications. Indeed, at a party of a certain threshold, the effect of the IS variable changes sign and becomes negative.

Although this paper may prescribe several policy recommendations at the macroeconomic level, it does not say anything about the exact microeconomic mechanisms. This requires an in-depth analysis of businesses and households making decisions about whether to pass informally. We leave that to future research.Unfortunately too, the informal economy size database stops in 2010.

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Appendices

 Table 5: GMM-SYS Method Estimates Results: Variable Dependent On growth Rate (Total sample)

Variable (1) (2) (3) (4) (5) (6) L.GDPGROW -0.321 -0.259 -0.172 -0.477** -0.260 -0.275 TH 0.2300 (0.216) (0.224) (0.290) (0.253) (0.285) OUV 0.195*** 0.213*** 0.219*** 0.169* 0.195** 0.243** 0006811 (0.0817) (0.0842) (0.0936) (0.0953) (0.0997) GOVGDP -0.0251 -0.236 -0.226 -0.172 -0.220 -0.226 Infl -0.0148** -0.0801 -0.0251 -0.127 -0.226 -0.0643 Infl -0.0148** -0.0801 -0.0124** 0.0144 0.0120 0.00474 0.0120 MONEYPIB 0.186** 0.156* 0.164* 0.142 0.217** 0.258** INVPIB 0.0787 0.139 0.113 0.376* 0.183 0.185 Law 0.0170 0.113 0.1251 0.0251 0.02251							
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Sargan test 21.69 19.67 18.98 8.85 11.91 6.90 (0.08) (0.14) (0.16) (0.451) (0.21) (0.648) Hansen test 8.75 8.53 8.68 8.85 5.10 3.09 (0.847) (0.860) (0.851) (0.451) (0.826) (0.961)		(0.58)	(0.46)	(0.35)	(0.883)	(0.50)	(0.587)
Hansen test 8.75 8.53 8.68 8.85 5.10 3.09 (0.847) (0.860) (0.851) (0.451) (0.826) (0.961)	Sargan test	21.69	19.67	18.98	8.85	11.91	6.90
Hansen test 8.75 8.53 8.68 8.85 5.10 3.09 (0.847) (0.860) (0.851) (0.451) (0.826) (0.961)	TT tt	(0.08)	(0.14)	(0.16)	(0.451)	(0.21)	(0.648)
	nansen test	8.73 (0.847)	8.33 (0.860)	8.08 (0.851)	8.83 (0.451)	(0.826)	(0.961)

() and statistical significance of 1%, 5% and 10%, respectively. m1 and m2, respectively, refer to tests of serial correlations of order 1 and 2 between residues. The hansen test refers to the instrument validity test (p-value).

	(1)	(2)	(3)	(4)	(5)	(6)
L.GDPGRO WTH	-0.196*	-0.248***	-0.337*	-0.78***	-0.402***	-0.319***
	(0.106)	(0.0958)	(0.190)	(0.213)	(0.0505)	(0.0858)
OUV	0.0225	0.0429	0.0660**	0.0261	0.0527***	-0.00321
	(0.0242)	(0.0277)	(0.0267)	(0.0226)	(0.0187)	(0.0317)
GOVGDP	0.971***	0.591***	0.155	0.731*	0.131	0.919**
	(0.282)	(0.208)	(0.428)	(0.439)	(0.238)	(0.376)
Infl	-0.0294	-0.101***	0.00145	0.0192	-0.0379	-0.0959***
	(0.0259)	(0.0295)	(0.104)	(0.0396)	(0.0306)	(0.0178)
MONEYPIB	0.0520	0.0795**	0.0826***	0.0429*	0.0447**	0.00529
	(0.0322)	(0.0385)	(0.0306)	(0.0260)	(0.0185)	(0.0268)
INVPIB	0.117	0.548***	0.527***	0.368***	0.646***	0.492***
	(0.226)	(0.136)	(0.167)	(0.122)	(0.110)	(0.136)
law	8.451***					
	(1.804)					
IS	4.439***	1.968*	3.367***	1.255	1.494	0.700
	(1.258)	(1.032)	(1.202)	(1.158)	(1.016)	(1.194)
ISQUARE	-0.0735***	-0.0339*	-0.0636***	-0.0234	-0.0285	-0.00587
	(0.0218)	(0.0188)	(0.0239)	(0.0210)	(0.0187)	(0.0218)
URBANN	0.273**	0.106	0.0981	-0.00793	-0.0407	0.0654***
	(0.130)	(0.0891)	(0.0691)	(0.0604)	(0.0380)	(0.0188)
Stab		1.462				
		(1.352)				
Corr			0.167			
			(3.077)			
voice				5.765**		
				(2.269)		
Quality					0.357	
					(2.262)	
effic						5.780***
						(1.524)
Constant	-63.16***	-24.88	-44.48**	-6.979	-20.59*	-4.018
	(20.47)	(17.69)	(21.33)	(13.55)	(11.01)	(18.22)
M2	-3.49	-1.59	-0.69	0.45	-1.10	-1.83
	(0.00)	(0.112)	(0.490)	(0.654)	(0.273)	(0.167)
Sargan test	12.31	14.71	8.53	8.94	23.83	88.15
	(0.196)	(0.099)	(0.129)	(0.063)	(0.005)	(0.00)
Hansen test	5.97 (0.743)	7.73 (0.562)	1.80 (0.876)	4.18 (0.382)	5.45 (0.793)	11.19 (0.595)

Table 6: GMM-SYS Method Estimates Results: Variable Dependent Growth Rate (PRE)

() and statistical significance of 1%, 5% and 10%, respectively. m1 and m2, respectively, refer to tests of serial correlations of order 1 and 2 between residues. The hansen test refers to the instrument validity test (p-value).

	(1)	(2)	(3)	(4)	(5)	(6)
L.GDPGROWTH	-0.152***	-0.114***	-0.0990***	-0.111***	-0.358***	-0.265***
	(0.0415)	(0.0426)	(0.0375)	(0.0429)	(0.0552)	(0.0408)
OUV	0.0669***	0.0682***	0.0740***	0.0663***	0.0722***	0.0623***
	(0.0101)	(0.0110)	(0.0106)	(0.0102)	(0.0206)	(0.0141)
GOVGDP	0.134	0.0595	0.144*	0.0395	0.233**	0.0688
	(0.0910)	(0.0851)	(0.0863)	(0.0933)	(0.110)	(0.0843)
INFLDEFL	0.0732***	0.0673***	0.0769***	0.0646***	0.0615***	0.0487***
	(0.00983)	(0.00912)	(0.0104)	(0.00919)	(0.00788)	(0.00581)
MONEYPIB	-0.0161	-0.00128	-0.00238	0.00232	-0.0597***	-0.0267
	(0.0176)	(0.0175)	(0.0185)	(0.0180)	(0.0168)	(0.0236)
INVPIB	0.300***	0.273***	0.259***	0.278***	0.424***	0.363***
	(0.0310)	(0.0338)	(0.0361)	(0.0314)	(0.0418)	(0.0361)
IS	0.877*	0.971**	1.307***	1.139**	0.361	0.378
	(0.454)	(0.452)	(0.465)	(0.465)	(0.757)	(0.631)
ISQUARE	-0.0115*	-0.0132**	-0.0171**	-0.0153**	-0.00509	-0.00445
	(0.00652)	(0.00644)	(0.00675)	(0.00662)	(0.0107)	(0.00901)
URBANN	0.124***	0.102***	0.155***	0.0959***	0.167***	0.0821**
	(0.0245)	(0.0252)	(0.0207)	(0.0248)	(0.0469)	(0.0334)

Table 7: GMM-SYS Method Estimates Results: Variable Dependent On Growth Rate (PRM)

() and statistical significance of 1%, 5% and 10%, respectively. m1 and m2, respectively, refer to tests of serial correlations of order 1 and 2 between residues.

H.hafsi

L.GDPGROWTH	-0.195	0.323**	-0.168	-0.289	-0.0522	0.107
	(0.167)	(0.159)	(0.161)	(0.376)	(0.124)	(0.225)
OUV	0.290**	-0.0719	0.268**	0.302	0.163**	0.180
	(0.114)	(0.101)	(0.108)	(0.291)	(0.0740)	(0.228)
GOVGDP	0.0495	-0.0487	0.0135	-0.130	0.0115	-0.973***
	(0.149)	(0.136)	(0.145)	(0.255)	(0.163)	(0.242)
INFLDEFL	-0.00101	-0.00426***	-0.00176	-0.00326	-0.00215	-0.00442*
	(0.00254)	(0.00158)	(0.00249)	(0.00422)	(0.00317)	(0.00237)
MONEYPIB	-0.137	-0.168***	-0.0929	-0.111	-0.143	-0.0467
	(0.0935)	(0.0281)	(0.0779)	(0.241)	(0.133)	(0.0749)
INVPIB	0.555***	0.150**	0.573***	0.441*	0.737***	0.458***
	(0.0935)	(0.0637)	(0.0999)	(0.254)	(0.119)	(0.162)
IS	8.813**	-3.100	8.036**	8.977	4.937*	4.054
	(3.756)	(1.926)	(3.545)	(8.538)	(2.710)	(5.804)
ISQUARE	-0.0859**	0.0325	-0.0794**	-0.0923	-0.0465*	-0.0389
	(0.0366)	(0.0208)	(0.0349)	(0.0893)	(0.0275)	(0.0605)
URBANN	0.409***	0.0663	0.408***	0.417	0.361***	0.697
	(0.134)	(0.115)	(0.135)	(0.333)	(0.118)	(0.440)
Corr	4.456*	· · · · · · · · · · · · · · · · · · ·				
	(2.635)					
law		-3.459				
		(2.547)				
Quality			3.051			
			(2.357)			
effic		· · · · ·		5.955		
		· · · · ·		(6.309)		
Stab					2.333	
					(1.951)	
voice						0.900
						(1.415)
Constant	-218.5**	74.98*	-198.0**	-206.7	-126.7*	-78.80
	(92.78)	(42.36)	(87.16)	(201.2)	(66.93)	(131.2)
	(°,)				<u> </u>	
M2	-2.38	-3.00	-2.94	-3.00	-1.74	-2.50
	(0.005)	(0.003)	(0.003)	(0.003)	(0.081)	(0.013)
Sargan test	34.42	34.67	31.40	34.76	27.71	25.87
	(0.059)	(0.056)	(0.113)	(0.055)	(0.048)	(0.077)
Hansen test	22.58	25.70	20.98	25.21	20.94 (0.229)	20.56 (0.247)
	(0.465)	(0.313)	(0.382)	(0.340)	(0.229)	(0.247)

Table 8: GMM-SYS Method Estimates Results: Variable Dependent on Growth Rate (PRF)

() and statistical significance of 1%, 5% and 10%, respectively. m1 and m2, respectively, refer to tests of serial correlations of order 1 and 2 between residues.

Design and development of a solution for solving electromagnetic problems by the finite element method English

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Abstract:

The work presented by this article consists of two parts. The first part consists in making an exhaustive study of the finite element method. This study made it possible to understand well the process of resolution of the electromagnetic problems by the method of the finite elements which are summarized in a double discretization: a discretization of the geometry in elements of simple form "Mesh" and a discretization of the fields which are there defined. The second part consists in implementing this theory while exploiting the Solid Works environment to grasp the physical structure, define the characteristics of the material, mesh in the first step and in the second step formulate the problem in the form of a system of differential equations and finally transform this formulation into an integral, interpolate and discretize to arrive at a linear system which will be solved at the. **Keywords:**Finite element method; Mesh; Interpolation; discretization. **JEL Classification Codes**: L96, O31.

1. INTRODUCTION

The analytical resolution of Maxwell's equations is not generally possible for domains of complex geometry. This is due to the fact that the vector fields which intervene in these equations belong to functional spaces of infinite dimension and cannot in general be expressed using known functions (Vincent, 2015).

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To estimate the solution of these equations, we use the finite element method, which allows us to approach these functional spaces by finite dimension spaces, called approximation spaces. The basic functions of these approximation spaces are generally polynomials or vectors whose components are polynomials.

The finite element method consists to bring back the resolution of a problem from continuous space to a resolution of discrete systems (Sascha, Ulrich, 2018). The discretization process is twofold: on the one hand, we discretize the geometry of the domain studied into geometric elements of simple form, that is to say that we mesh the domain and on the other hand, we discretize the fields defined there. These two discretization processes are in fact linked, since it is the spatial discretization which makes it possible to define the basic scalar or vectorial functions giving rise to spaces of approximation of continuous spaces.

2. Principleof the Finite Element Method

The finite element method consists in reducing the resolution of the problem of a continuous to a resolution of discrete systems (Jean-Claude, Jean-Louis, 1987). The principle of this method consists:

- First step: write the problem in the form of partial differential equations describing the behavior of the solid as well as the boundary conditions to be satisfied.
- As a second step: present the variation al formulation or the integral formulation of the problem. The discretization of the variational formulation on a finite number of subdomains, leads to a linear algebraic system and this depends essentially on the behavior of the structure. The resolution of this system provides an approximate solution to the problem

3. Steps

Most physics problems can be formulated as follows: Find a field u(M,t) satisfying a set of partial differential equations and ordinary equations at any point M of a domain Ω and at any time t, and respecting boundary conditions on the $\partial\Omega$ border.

The finite element method consists in searching for an approximate

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solution of the exact solution in the form of a field $\widehat{F}(M, t)$ defined by piece on sub domains of Ω . The n sub domains Ω imust be such that: $\bigcup_{i=1}^{n} \Omega_i = \Omega$ and $\widehat{\Omega}_1 \cap \widehat{\Omega}_1 = \emptyset \forall i \neq j$ where $\widehat{\Omega}_1$ denotes the interior of Ω_i .

To solve a problem by the finite element method, we therefore proceed through these successive steps.



Fig.1.Principle of the finite element method

4. Variation Formulation

To solve a system with partial derivatives modeling a physical system, it is necessary to put it in an integral form also called variational form or weak form. These systems can be deduced by mathematical or physical considerations (Dominique, 2002, Y. Ji, Mohammed et al., 1998).

Generally, we note:

- u (M) the field of unknowns. •
- The differential system symbolized by an operator D •
- The boundary conditions on the edge symbolized by a null • operator C on the border $\partial \Omega$

Finally, the analytical problem is stated as follows: calculate the field u(M) such that:

 $D(u(M)) = 0 \forall M \in \Omega(1)$

And

 $C(u(N)) = 0 \forall N \in \partial \Omega(2)$

4.1 Functional analysis results

In functional spaces of functions defined on a domain Ω , the scalar product between two functions *f* and g is defined by:

 $\langle f, g \rangle = \int_{\Omega} f(M) * g(M) d\Omega(3)$

The scalar product has the following property:

 $\langle f, g \rangle = 0 \forall g \Leftrightarrow f = 0(4)$

Using this property, we will have:

 $\int_{\Omega} f(M) * g(M) d\Omega = 0 \ \forall \ g(M) \Longleftrightarrow f(M) = 0 \ (5)$

4.2 Variational forms

Using the results of functional analysis, a new formulation of the problem consists in finding the field u such that :

 $C(u(N)) = 0 \forall N \in \partial \Omega$ (2)

And

 $\int_{\Omega} \phi(M) * D(u(M)) d\Omega = 0 \forall \phi(M) \Leftrightarrow D(u(M) = 0(6)$ Where $\varphi(M)$ is a test or weighting function.

This formulation is a variational formulation to the initial differential system. You can get more by transforming the integrals. In fact, the operator D involves operations such as the gradient, the Laplacian, the divergence ... all of these operators make it possible to modify the shape of the initial integrals by showing edge integrals defined on $\partial \Omega$.

Finally, the problem can arise in the following form: Find the field u such that:

$$C(u(N)) = 0 \forall N \in \partial\Omega$$
⁽²⁾

$$A(\phi(M), u(M)) = B(\phi(M), u(M)) \forall \phi(M)$$
(7)

Where

- A and B are operators producing the integrals on Ω and $\partial \Omega$ also bearing on ϕ (M) and u (M).
- C is an operator that takes into account the remaining boundary conditions.

The formulation of the problem in variational form does not allow to have the solution, but it makes it possible to reduce the number of unknowns or to decrease the orders of derivation of these in order to improve the efficiency and the numerical resolution.

5. Discretization

5.1 Mesh

A mesh in the sense of finite elements is a tiling of space where the elements which constitute this mesh only coincide according to a facet, an edge, a node or not at all. The geometrical elements considered are either tetrahedra, prisms, hexahedra or pyramids with a square base for three-dimensional meshes, or triangles or quadrangles for two-dimensional meshes (Andre, Jose Manuel, 2010).

The analytical solution of a general problem (7) in a variational form is generally impossible to obtain. Consequently, one is led to seek an approximate solution u^* by the numerical method of the finite elements. The use of this technique requires the decomposition (the mesh) of the domain of study Ω into sub domains Ω_i . These have a simple geometric shape and are linked together by nodes.

5.2 Interpolation

It is recalled that the solutions approached by the finite element method are a juxtaposition of the local fields defined in each mesh. Otherwise, if we consider a point m belonging to an element e (mesh) composed of n nodes, the interpolation of the local fieldu^{*}_e (m) is carried out from the values of the fields at the nodes belonging to the element e and defined by:

 $u_{e}^{*}(m) = \sum_{i=1}^{n} u_{e}^{i} P^{i}(m) = [P]^{T} \{u_{e}\}$ (8) Where, Pⁱ(m) are basic polynomials of the interpolation.

5.3 Discretization

Finally, solving the analytical problem (7) consists in solving the following approximate (or discretized) problem:

$$C(u^{*}(N)) = 0 \forall N \in \partial\Omega$$

$$A(\phi(M), u^{*}(M)) = B(\phi(M), u^{*}(M)) \forall \phi(M)$$
(9)

5.4 Galerkin's method

The application of the Galerkine method to a finite element consists in using test functions $\phi_i(M)$ equal to the interpolation functions $P^i(M)$, Let still be:

$$\varphi_{i}(M) = \frac{\partial u^{*}(M)}{\partial u_{i}} = P^{i}(M)$$
(10)

6. Resolution of the Algebraic System

Whatever the method used, the discretization step used and the operation of assembling the elementary matrices make it possible to reduce the treatment of the initial problem to a resolution of an algebraic equation system [K] [U] = [L].

We used the direct resolution methods that lead to the solution in a finite number of operations. These methods are used for medium-sized systems. The calculation time is substantially proportional to the cube of the number of unknowns (Andre, Sami et al.,2016).

7. Implementation

The physical model was designed using CAD software Solid Works, the exploitation of its APIs (developed in C ++) allowed the recovery of the coordinates of this drawing in implemented objects serving as necessary

information for the mesh module. (Jean-Claude, Jean-Louis, 1987).

The setting up of the mesh module and the resolution module is done via the object oriented language C ++.

7.1 The functions of the mesh module

The main objective of this module is to obtain a mesh domain. Among the operations that must be insured:

- The definition of the geometry of the physical model.
- The characteristics of the mesh elements.

7.2 Geometric model recovery algorithm

Knowledge of the information linked to the mesh module is an essential step for implementing the resolution module. For that, we need to know the various entities of the mesh (tetrahedrons, triangles, segments,...) as well as the nodes which are attached to it. We also need to know the numbers of the different entities, the coordinates of the nodes, etc.

Fig.2. writes the Geometric model recovery algorithm whose main functions are:

- Activation of the solid: the use of the API get_IActiveDoc() is essential to activate the geometric model in order to manipulate it.
- Retrieving the first face: the IGetFirstFace() API allows you to return a pointer to the face of the activated model.
- Calculation of the total number of segments of the recovered face: the GetEdges() API allows to return the segments of a face passed in parameter.
- Recovery of the Start vertex: the Get Start Vertex() API allows to return the Start vertex of a segment passed as a parameter.
- Recovery of the End vertex: the Get End Vertex() API allows to return the End vertex of a segment passed as a parameter.
- Recovery of the next face; the Get Next Face() API allows you to position the pointer on the next face.

Fig.2. Geometric model recovery algorithm

```
Solid activation
Face = Recovery of face1
While (Face) Do
Begin
Calculation of the total number of segments of the recovered face
  For i = 0 to total number of segments Make
       Begin
       Recovery of segment i
              Recovery of the 1<sup>st</sup> Start summit in segment i:
              If Start is not already recovered, we insert it inthe list of
              vertices with a current index
          • Recovery of the 2<sup>nd</sup> End vertex of segment i:
              If End is not already recovered, we insert it inthe list of
              vertices with a current index
       If the segment i defined by Start and End is not inserted in the list
       of segments, we insert it with a current index
       End
  Insertion of parameters relating to this face in the list offaces.
Face = Recovery of the next face
```

End

7.3 Mesh algorithm

The volume of the solid is discretized by linear tetrahedral elements, the faces by linear triangular elements and the edges are meshed by segments at two nodes.

Each of these entities is represented by a class. The set of these classes builds the mesh model of a solid.

Design and development of a solution for solving electromagnetic problems by the finite element method



Fig.3. Mesh algorithm

The role of each class of the diagram is as follows:

• Read_problem_desc(): allows to read the input data stored in the output file of module "recovery of the geometric model" and store it in reserved variables.

- Calcul_Parameters(): calculate the number of the elements for the mesh such as the total number of the nodes, the total number of the cubes, the total number of the tetrahedrons and the total number of the triangles by respecting well determined formulas.
- Memory_allocation (): once the data structures are prepared and the number of the different elements of the mesh is determined, we manage to dynamically allocate the memory everything depends on the need to be able to physically manipulate.
- Global_Coordinates_Node(): allows to determine the Cartesian coordinates of each node of the globally indexed domain in the same order of creation and to store them thereafter in a matrix of coordinates of the nodes.
- Index _Node_Cube(): allows you to gather the nodes so as to form cubes.
- Index_Edge_Cube(): allows to determine the edges of each cube.
- Div_Cube_Tetra(): allows to divide each cube with five tetrahedra while determining the indices of the nodes and edges of each tetrahedron.

7.4Solving algorithm

The role of this module is to solve the problem described above by the finite element methods while transforming the global problem defined by the variational formulation into a discretized formulation. The output of this module is an approximate solution to the exact solution.

The role of each class of the diagram is as follows:

- Tetrahedron _Volume (): calculates the volume of the tetrahedron passed in parameter.
- Tetrahedron _Matrix (): allows to calculate the matrix of a tetrahedron which describes the variational formulation of the problem in a tetrahedron.
- Global_Matrix (): allows to form the global matrix which describes the problem in all the elements of the domain.

Design and development of a solution for solving electromagnetic problems by the finite element method

- Global_Partition_matrix(): decompose the global matrix in the form of a linear system.
- SYS_linear(): allows to solve the linear system obtained.



Fig.3. Solving algorithm

8. CONCLUSION

The finite element method is a powerful and versatile numerical method for solving differential partial differential equations. The particularity of the finite element method lies in the division of the field of study into elements and in the choice of spaces constructed from functions defined on these elements.

The role of a finite element is to interpolate a field in a functional space of finite dimension over a finite portion of space. It is this double discretization, discretization of the functional space and discretization of the space constituting the field of study, which is specific to the finite element method.

In this work, we have implemented software for solving electromagnetic problems with complex geometries and inhomogeneous structures by the finite element method.

In perspective, we will integrate other resolution methods such as the

moments method in order to combine it with the finite element method and to form a hybrid method to take advantage of the advantages of the two methods depending on the geometry of the system and the studied phenomenon.

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The Improved Element Free Galerkin Method for 2D Heat Transfer Problems

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Abstract:

The Improved Element Free Galerkin (IEFG) method is presented to treat the steady states and the transient heat transfer problems. As a result of a combination between the Improved Moving Least Square (IMLS) approximation and the Element Free Galerkin (EFG) method, the IEFG's shape functions don't have the Kronecker delta property and the penalty method is used to impose the Dirichlet boundary conditions. The objective of this paper is studying the efficiency of the IEFG method for 2D heat transfer problems. For this purpose two heat transfer problems, transient and steady states, are studied and the performance of the IEFG method is shown using the comparison between numerical and analytic results.

Keywords:IMLS; the Improved Galerkin method (IEFG); heat transfer problems.

JEL Classification Codes: L69, O33.

1. INTRODUCTION

Analysis of the heat transfer problems is very important because it is in connection with different engineering problems. However solving heat transfer problems analytically is not always possible because of the complexity of the equations involved. In these cases, it is necessary to pass by numerical simulation to find solution. Traditional numerical methods such as finite difference method (FDM) and finite element method (FEM)

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are commonly used to solve heat transfer problems, but the need to mesh and re-mesh the whole domain is always time consuming and always cannot be done automatically. In addition, these conventional methods are not well suited for non linear heat transfer problems (Zhu,1998). Difficulties encountered by traditional methods are always joined to mesh, so to deal with this problem, a number of meshless methods have been developed recently. In these methods a number of scattered, unconnected nodes in the studied domain are used to reach the solution(Debbabi, 2015) many mesh free methods Have Been used to study the heat transfer phenomenon: Heat transfer was studied by Zerroukat using collocation and radial basis functions (Zerroukat, 1998), MLPG method was used by Arefmanesh to treat heat conduction problems(Arefmanesh,2010). Also steady, unsteady and non linear heat transfer problems have been treated by Singh using the EFG method (Singh,2005). The IEFG method, which is a combination between the EFG and the improved moving least square approximation have been used by Zhang to study three dimensional transient heat transfer problems the IEFG method for three dimensional transient heat conduction problems.

In this paper the improved element free Galerkin is presented. First the IMLS approximation is introduced then the IEFG method is discussed for the steady states and transient heat transfer problem. To improve the efficiency of the method in heat transfer problems; 2D numerical examples are presented. Numerical results are in good agreement with those obtained analytically and the performance of the method is approved for both, transient and steady states heat transfer problems.

2. THE IEFG METHOD

2.1 The IMLS approximation

In a defined domain Ω , the IMLS approximation for a field variable u(x) defined in the domain Ω , the approximation of u(x) denoted $u^h(x)$ is

$u^{h}(x) = \sum_{i=1}^{m} p_{i}(x)a_{i}(x) = p^{T}(x)a(x)(1)$

Where p(x) is a vector of monomial weighted orthogonal basis functions, m is the number of terms in the basis and a(x) is a vector of coefficients of the basis functions. The function set $p_1(x), p_2(x), ..., p_m(x)$ is called a weighted orthogonal polynomials set with the weight function $\{w_i\}$ about point $\{x_i\}$ if they satisfy the condition (2) cited below.

$$(p_k, p_j) = \sum_{i=1}^n w_i p_k(x_i) p_j(x_i)$$

=
$$\begin{cases} 0, k \neq j \\ A_k, k = j \end{cases} (k, j = 1, 2 \dots m)(2)$$

The vector of coefficient a(x) is defined by $a^{T}(x) = (a_{1}(x), a_{2}(x), \dots, a_{m}(x))$

To obtain the local approximation of u(x), the difference between the local approximation $u^h(x, x_I)$ and u(x) must be minimized by a weighted least square method.

Define a function

$$J(a, x) = \sum_{I}^{n} w(x - x_{I})[u^{h}(x, x_{I}) - u(x_{I})]^{2}$$
$$= \sum_{I}^{n} w(x - x_{I})[\sum_{i=1}^{m} p_{i}(x_{I})a_{i}(x) - u(x_{I})]^{2}(3)$$

Wherew $(x - x_I)$ is a weight function with a domain of influence, and $x_I, I = 1, 2, ... n$ are the nodes in the domain of influence that coverx. Equation (3) can be written as

$$J(a, x) = (Pa(x) - u)^T W(x)(Pa(x) - u)$$
 (4)
Where

$$u^{T} = (u_{1}, u_{2}, \dots, u_{n}) and u_{i} = u(x_{i})(5)$$

$$P = \begin{bmatrix} p_{1}(x_{1}) & p_{2}(x_{1}) & \dots & p_{m}(x_{1}) \\ p_{1}(x_{2}) & p_{2}(x_{2}) & \dots & p_{m}(x_{2}) \\ \vdots & \ddots & \vdots \\ p_{1}(x_{n}) & p_{2}(x_{n}) & \dots & p_{m}(x_{n}) \end{bmatrix} (6)$$

$$W(x) = \begin{bmatrix} w(x - x_{1}) & 0 & \dots & 0 \\ 0 & w(x - x_{2}) & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & w(x - x_{n}) \end{bmatrix} (7)$$
The minimization condition provines

The minimization condition requires $\frac{\partial J(a,x)}{\partial a} = 0 \qquad (8)$ Which gives the equation system A(x)a(x) = B(x)u (9) Using equation (2), equation (9) can be written as

$$\begin{bmatrix} (p_{1}, p_{1}) & (p_{1}, p_{2}) & \cdots & (p_{1}, p_{m}) \\ (p_{2}, p_{1}) & (p_{2}, p_{2}) & \cdots & (p_{2}, p_{m}) \\ \vdots & \ddots & \vdots \\ (p_{m}, p_{1}) & (p_{m}, p_{2}) & \cdots & (p_{m}, p_{m}) \end{bmatrix} \begin{bmatrix} a_{1}(x) \\ a_{2}(x) \\ \vdots \\ a_{m}(x) \end{bmatrix}$$

$$= \begin{bmatrix} (p_{1}, u) \\ (p_{2}, u) \\ \vdots \\ (p_{m}, u)) \end{bmatrix}$$

$$(10)$$

But the basis functions set is a weighted orthogonal functions set, then equation (10) has this expression

$$\begin{bmatrix} (p_1, p_1) & 0 & \dots & 0 \\ 0 & (p_2, p_2) & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & (p_m, p_m) \end{bmatrix} \begin{bmatrix} a_1(x) \\ a_2(x) \\ \vdots \\ a_m(x) \end{bmatrix} = \begin{bmatrix} (p_1, u) \\ (p_2, u) \\ \vdots \\ (p_m, u)) \end{bmatrix} (11)$$

$$a_i(x)$$
 are then directly obtained from (11):

$$a_i(x) = \frac{(p_i, u)}{(p_i, p_i)}, (i=1, 2, ..., m)$$
 (12)

Then

$$a(x) = \bar{A}(x)B(x)u.$$
(13)
Where

$$\bar{A}(x) = \begin{bmatrix} \frac{1}{(p_1, p_1)} & 0 & & 0\\ 0 & \frac{1}{(p_2, p_2)} & & 0\\ & \vdots & \ddots & \vdots\\ 0 & 0 & \cdots & \frac{1}{(p_m, p_m)} \end{bmatrix}$$
(14)

 $\overline{A}(x)$ is a diagonal matrix and coefficients a(x) are also directly and simply obtained. The approximation $u^h(x)$ has then the expression as follows

$$u^{h}(x) = \overline{\Phi}(x)u = \sum_{I}^{n} \overline{\Phi}_{I}(x)u_{I}(15)$$

Where $\overline{\Phi}(x)$ is the vector of IMLS shape functions defined by
 $\overline{\Phi}(x) = P^{T}(x)\overline{A}(x)B(x)$ (16)

2.2. The weight function

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The weight function has an important effect on the IMLS approximation. This function should be non zero in a small neighborhood of a node xI, and must be null in the rest of the domain. The domain of influence of node xI is the neighborhood where the weight function is non zero. The size of this latter influences the quality of results obtained. In literature there is variety of weight functions such as the exponential weight functionand spline functions, either cubic or quadratic. In this paper the quadratic spline function defined below is used:

$$w(s) = \begin{cases} 1 - 6s^2 + 8s^3 - 3s^4, & |s| \le 1\\ 0 & |s| \ge 1 \end{cases} (17)$$

Where $s = \frac{\|x - x_I\|}{d}$ and $\|x - x_I\|$ is the distance from a sampling point x to a node x_i , and d is the size of the domain of influence of the Ith node. The size of the domain of influence d is defined as $d = a_c d_i$ for circular domain, where a_c is a scalar and d_i is the average distance between nodes. A consideration of $1.2 \le a_c \le 1.4$ gives good results.

2.3. The IEFG method for 2D heat transfer problem

Consider a 2D transient heat transfer problem for an isotropic domain Ω bounded by Γ , governed by the equation given below

$$\rho c \frac{\partial T}{\partial t} = k \,\nabla^2 T + Q \tag{18}$$

Where T is the temperature field, t represents the time, k is the thermal conductivity of the material, ρ define density, c is the specific heat and Q is the heat generation rate. The corresponding boundary conditions are

 $T = \overline{T}, \text{ on } \Gamma_1(19)$ $n\nabla T = \overline{q}, \text{ on } \Gamma_2 \quad (20)$ $n\nabla T = h(T - T_{\infty}), \text{ on } \Gamma_3(21)$ The initial condition is $T(x, y, 0) = T_0(22)$

Where *n* is the outward normal to the boundary $\Gamma . \Gamma_1, \Gamma_2$ and Γ_3 represents respectively the parts of the boundary on which the temperature \overline{T} , flux \overline{q} and the heat transfer coefficient are given. T_{∞} represents the surrounding fluid's temperature.

The variational weak formulation of equations (18)-(22) is

$$\int_{\Omega} \rho c T^* \frac{\partial T}{\partial t} d\Omega +$$
$$\int_{\Omega} \nabla T^* k \nabla T d\Omega = \int_{\Omega} T^* Q \, d\Omega + \int_{\Gamma_2} T^* \bar{q} d\Gamma + \int_{\Gamma_3} T^* h(T - T_{\infty}) d\Gamma$$
(23)

where T^* is the test function.

The dirichlet boundary conditions are imposed by the penalty technique, because of the luck of the Kronecker delta property in the IEFG's shape functions. Then equation (23) becomes

$$\int_{\Omega} \rho c T^* \frac{\partial T}{\partial t} d\Omega + \int_{\Omega} \nabla T^* k \nabla T d\Omega + \alpha \int_{\Gamma_1} (T^* - \overline{T}^*) (T - \overline{T}) d\Gamma = \int_{\Gamma_2} T^* \overline{q} d\Gamma + \int_{\Gamma_3} T^* h (T - T_{\infty}) d\Gamma$$
(24)

 α used in the equation(24) is the penalty factor chosen between 10³ and 10¹³

From the approximation function (15), equation (24) can be written in a system matrix form

 $[C]\{\dot{T}\} + [\bar{K}]\{T\} = \{\bar{F}\} (25)$ $[\bar{K}] = [K] + [H] + [K^{\alpha}](26)$ $\{\bar{F}\} = \{F_1\} + \{F_2\} + \{F_3\} + \{F^{\alpha}\} (27)$

where

$$C_{IJ} = \int_{\Omega} \overline{\Phi_I} \rho c \overline{\Phi_J} d\Omega(28)$$
$$K_{IJ} = \int_{\Omega} \overline{\Phi_I} \rho c \overline{\Phi_J} d\Omega (29)$$

$$H_{IJ} = \int_{\Gamma_3} \overline{\Phi_I} h \overline{\Phi_J} d\Gamma$$
(30)

$$K_{IJ}^{\alpha} = \int_{\Omega} \overline{\Phi_I} \alpha \overline{\Phi_J} d\Gamma (31)$$

$$F_{1I} = \int_{\Omega} \overline{\Phi_I} Q d\Omega$$
(32)

$$F_{2I} = \int_{\Gamma_2} \overline{\Phi_I} \overline{q} d\Gamma (33)$$

$$F_{3I} = \int_{\Gamma_3} \overline{\Phi_I} h T_{\infty} d\Gamma (34)$$

$$F_I^{\alpha} = \int_{\Gamma_1} \overline{\Phi_I} \alpha \overline{T} d\Gamma (35)$$

$$\{\dot{T}\} = \left(\frac{\partial T_1}{\partial t}, \frac{\partial T_2}{\partial t}, \dots, \frac{\partial T_n}{\partial t}\right)^T (36)$$

The Crank-Nicolson schema is used to for time discretization of equation(25). This gives

$$[C]\frac{T^{t+\Delta t}-T^{t}}{\Delta t} + \frac{1}{2}(\overline{K}T^{t+\Delta t} + \overline{K}T^{t}) = \frac{1}{2}(\overline{F}^{t+\Delta t} + \overline{F}^{t})(37)$$

In the case of a steady states heat transfer problem, equation (18) becomes

 $k \nabla^2 T + Q = 0(38)$

Using the same approach mentioned above, equation (25) becomes $[\overline{K}]{T} = {\overline{F}}(39)$

Where $[\overline{K}]$ and $\{\overline{F}\}$ are the same as in the transient heat equation. Temperature field is obtained when solving equation (39).

1. Results :

Consider the transient heat conduction problem in a square domain with essential boundary conditions on all the sides:

 $\frac{\partial T(x_1, x_2, t)}{\partial t} - \frac{\partial T(x_1, x_2, t)}{\partial x_1} - \frac{\partial T(x_1, x_2, t)}{\partial x_2} = 0, \ x_1 \in [0, 1], x_2 \in [0, 1]$ (40) The associated boundary conditions are $T(0, x_2, t) = e^{-2t} \sin (x_2)(41)$ $T(1, x_2, t) = e^{-2t} \sin (1 + x_2)(42)$ $T(x_1, 0, t) = e^{-2t} \sin (x_1)$ (43)

To solve this problem, a distribution of 11x11 nodes is used, the size of



the domain of influence is chosen to be d=0.12mm.

Temperature evolution obtained by the IEFG method is compared to analytic temperature cross different directions.

In figures 2,3,4 and 5 the evolution of the IEFG temperature respectively for $x_2=0$, $x_1=0$, $x_1=0.5$ mm and $x_2=0.5$ mm are dressed with the analytic temperature . It is clear that the IEFG results are in good agreement with analytic ones for the different chosen directions.







Fig.4.Analytic and IEFG temperatures evolution for x₁=0.5mm.



To quantify the absolute error in all chosen directions figures 6,7,8 and 9 are dressed, these figures represent respectively the absolute errors in the directions $x_2=0$, $x_1=0$, $x_1=0.5$ mm and $x_2=0.5$ mm



Fig.5. Analytic and IEFG temperatures evolution for x₂=0.5mm

From the figures of error it is clear that the absolute error is under $3 \, 10^{-5}$ for all chosen directions. These results prove the ability of the IEFG to solve transient heat transfer problems and then it is a mesh free method suitable for transient thermal problems.

4. Conclusion

This paper proposes the Improved Element Free Galerkin method as a mesh free method able to solve transient heat transfer problem. This method is based on the IMLS approximation and the Element free Galerkin method. The efficiency of the IEFG is approved by comparing numerical results to analytic ones. This comparison is made across different directions in the domain and the absolute error, which is under 310⁻⁵ for all directions, proves

that the IEFG is accurate for transient heat transfer problems.

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Fig.8. Absolute error for x1=0.5mm.




Performance Enhancement of Sliding Mode Controller by Fuzzy Logic with Application to Induction Motor

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Abstract:

Although the induction motor has various advantages compared to the DC motor, it is still quite difficult to control, due to the complexity of its model which has non-linearities and a strong coupling between the different variables. This article introduces a new fuzzy-sliding mode controller (FSMC) for regulating the speed of an indirect vector controlled induction motor (IM). Field oriented control of the induction motor supplied with voltage source inverters, using PI controllers presents some drawbacks such as the sensitivity to parametric uncertainties of the motor and their variations. Inorder o improve the system performances, we applied robust control techniques such as fuzzy logic, sliding mode and fuzzy sliding mode. The last technique is a hybrid control which combines sliding mode control (SMC) and fuzzy logic control (FLC). The proposed control law can solve those problems associated with the conventional control by sliding mode control, such as high current, flux and torque chattering, variable switching frequency and variation of parameters, in which a robust fuzzy logic controller replaces the discontinuous part of the classical sliding mode control law.Simulation results show that the implementation of the IM fuzzy sliding mode controllers leads to robustness and dynamic performance satisfaction, even when the parameters vary.

Keywords:Induction motor, field orientation control, fuzzy sliding mode control (FSMC), chattering phenomenon

JEL Classification Codes: C6, C61, C62

1. Introduction:

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Recently, there has been increasing interest for the use of induction motor in many industrial applications. This interest is motivated by the fact that induction motor is reliable, rugged and has relatively low cost. However, controlling induction motors is not a trivial task since it has significant non-linear characteristics and its physical parameters are most often imprecisely known (J.J.E Slotine1991, p. 55). So, many research works are devoted to the important question of synthesizing robust control in face the parametric disturbances.

Indirect field-oriented techniques are now widely used for the control of induction motor (IM) in high performance applications. With this control strategy (Lehonard1996, p. 70) (Vas1994, p. 8), the decoupled control of the IM is guaranteed, and the IM can be controlled linearly as a separated excited DC motor. However, the control performances of the resulted linear system are still influenced by the uncertainties, whichare usually composed of unpredictable parameter variations, external load disturbances, unmodelled and nonlinear dynamics. To offer control robustness with minimum complexity, many strategies have been proposed in literature. See for example, the adaptive control in (Bose2001, p. 101), fuzzy control in (J.J.E Slotine1991)(Baghli1999), and sliding mode control (SMC) in (Baghli1999) (Utkin1978). Recently, intelligent control had been proposed and widely applied to many control application (Bose2001) (Baghli1999) (Utkin1978).

Sliding Mode Control (SMC) was adopted (Utkin1978) (Bühler1986), because it has many good features, such as robustness to parameter variations or load disturbances, fast dynamic response, and simplicity of design and implementation. The control law of the sliding mode technique is discontinuous on the sliding surface. This causes harmful effects such as current harmonics, torque pulsation and acoustic noise. Many researchers have proposed several techniques to reduce these phenomena.

The fuzzy theorywas introduced by Zadeh (zadah1998). According to the fuzzy theory characteristics, the fuzzy approach is applied as an alternative method to handle uncertainty in plant dynamics in the past three decades (Nelson1997, p. 3).

The salient advantages of the designed fuzzy controller on the basis of the SMC system are decreasing the number of fuzzy rules and relaxation of the uncertainty bound requirement (Rong2006, p. 4). The proper design of the fuzzy sliding mode controller (FSMC) system can eliminate the chattering phenomenon and improve the tracking performance despite the small uncertainties in the nonlinear system (S. Ali2014, p. 6) (I. Bendaas2014, p. 5).

Fuzzy sliding control is one of the most common robust controls that combines both techniques: fuzzy logic and sliding mode to exploit the advantages of both techniques at the same time, that is to say, the fuzzy for its rapidity and its ease of implementation, and the regime sliding for its theoretical foundations reassuring from the standpoint of stability and robustness.

This paper is organized as follows: Section 2 introduces the indirect field oriented control of induction motor. Section 3,on the other hand, sheds some light on the proposed sliding mode control. Moreover, section 4deals with a combination of this control with the fuzzy control to have a hybrid control. Some simulation results are presented using Matlab / Simulink software in section 5. Finally, a general conclusion summarizing the presented work is placed at the end of the article.

2. Indirect Field Oriented Control of the IM

The induction Motor Model expressed in terms of the state variables is given by equation (Baghli 1999, p. 16) (Hautier 1995, p. 30) (Baghli 2005) (K. Guesmi 2004, p. 2):

$$\frac{d}{dt}\begin{bmatrix} \dot{i}_{ds} \\ \dot{i}_{qs} \\ \dot{d}_{qr} \end{bmatrix} = \begin{bmatrix} -\frac{1}{d_s} (R_s + \frac{\dot{M}}{L_r}) & a_s & \frac{M}{d_s L_r T_r} & \frac{M}{d_s L_r T_r} & \frac{M}{d_s L_r T_r} \\ -a_s & -\frac{1}{d_s} (R_s + \frac{\dot{M}}{L_r T_r}) & \frac{M}{d_s L_r T_r} & \frac{M}{d_s L_r T_r} \\ \frac{M}{d_s T_r} & 0 & -\frac{1}{T_r} & a_r \\ 0 & \frac{M}{T_r} & -a_r & -\frac{1}{T_r} \end{bmatrix} \begin{bmatrix} \dot{i}_{ds} \\ \dot{i}_{qs} \\ \dot{\phi}_{qr} \end{bmatrix} \begin{bmatrix} \frac{1}{\sigma L_s} & 0 \\ 0 & \frac{1}{\sigma L_s} \\ 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} V_{ds} \\ V_{qs} \end{bmatrix}$$
(1)

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The equation of the couple and that of the movement are defined as follows:

$$\begin{cases} C_{em} = \frac{pM}{L_r} (\phi_{dr} i_{qs} - \phi_{qr} i_{ds}) \\ J \frac{d\Omega}{dt} = C_{em} - C_r - f\Omega \end{cases}$$
(2)

Where $V_{i,\phi}$ are respectively the voltage, the current and the flux; R_s is the stator resistance; L_s et L_r are the inductances of a stator and rotor phase; M is the cyclic mutual inductance between stator and rotor; σ is the dispersion coefficient; T_r is the rotor time constant; ω_s et ω_r are the electrical pulsations of a stator and rotor; J is the moment of inertia of the motor; P is the number of pole pairs; Ω is the mechanical speed of the rotor.

Since it was fully described by the equations system (1 and 2), the motor was ready to be controlled using field oriented control (FOC) method. Nevertheless, it can be seen that the two preceding equations describes the motor by complicate and non linear model. The main objective of this vector control of induction motors is as in DC machines, to independently control the torque and the flux; this is done by using a d-q rotating reference frame synchronously with the rotor flux space vector (Lehonard, 1996)(Vas, 1994), the d axis is aligned with the rotor flux space vector.

Under this condition we have: $\phi_{qr}=0$ and $\phi_{dr}=\phi_{r}^{*}$ (Baghli 1999, p. 50) (Y.H and Kuo 1998, p. 4) (S. Rafa 2014, 5), the equations of the machine become:

$$\begin{cases}
i_{ds}^{*} = \frac{1}{M} \left(T_{r} \frac{d\phi_{r}^{*}}{dt} + \phi_{r}^{*} \right) \\
i_{qs}^{*} = \frac{L_{r}}{p M} \frac{C_{em}^{*}}{\phi_{r}^{*}} \\
\omega_{r} = \frac{M}{T_{r} \phi_{r}} i_{qs}
\end{cases}$$
(3)

For the ideal state decoupling the torque equation become analogous to the DC machine as follows:

$$C_{em} = \frac{p M}{L_r} \phi_r i_{qs}$$
(4)

The stators voltage equations are:

$$\begin{cases} V_{ds} = R_s i_{ds} + \left(L_s - \frac{M^2}{L_r}\right) \frac{di_{ds}}{dt} - \omega_s \left(L_s - \frac{M^2}{L_r}\right) i_{qs} \\ V_{qs} = R_s i_{qs} + \left(L_s - \frac{M^2}{L_r}\right) \frac{di_{qs}}{dt} + \omega_s \left(L_s - \frac{M^2}{L_r}\right) i_{ds} + \omega_s \frac{M}{L_r} \phi_r^* \end{cases}$$
(5)

The torque expression shows that the reference fluxes and stator currents in quadrate are not perfectly independents, for this, it is necessary to decouple torque and flux control of this machine by introducing new variables:

$$\begin{cases} V_{ds1} = R_s i_{ds} + \left(L_s - \frac{M^2}{L_r}\right) \frac{di_{ds}}{dt} \\ V_{qs1} = R_s i_{qs} + \left(L_s - \frac{M^2}{L_r}\right) \frac{di_{qs}}{dt} \end{cases}$$
(6)

Then the voltages, V_{qs}^* and V_{ds}^* imposed by the vector control are obtained by:

Fig.1. Compensation of coupling terms



The system studied is illustrated in figure (2). The induction motor is supplied with voltage at variable frequency and amplitude by a PWM voltage inverter, the excitation circuit of which is supplied by a constant voltage source. The voltage source is obtained by a three-phase bridge rectifier in series with a filtering circuit.



Fig.2. Speed regulation by vector control.

3.Sliding Mode Control

With Sliding Mode Controller, the system is controlled in such a way that the error in the system states always moves towards a sliding surface. The sliding surface is defined with the tracking error (e) of the state and its rate of change (e[•]) as variables. The distance of the error trajectory from the sliding surface and its rate of convergence are used to decide the control input (u) to the system (figure 3).

The sign of the control input must change at the intersection of the tracking error trajectory with the sliding surface. In this way the error trajectory is always forced to move towards the sliding surface. However, the presence of the sign function in the control law causes a chattering phenomenon which can excite high frequencies up to damaging the system (K. Guesmi 2004, p. 4).

Fig.3. Convergence of the sliding system



The control law is given as follows:

$$U = U_{eq} - K \, sign\left(s\right) \tag{7}$$

Where U_{eq} is called equivalent control which is used when the system state is in the sliding mode. *k* is a constant and it is the maximal value of the controller output. Several techniques were then proposed to reduce or eliminate this phenomenon; one solution is to introduce a boundary layer around the switch surface (K. Guesmi 2004, p. 5), Such as replacing the sign function with a saturation function « sat».

$$sat\left(\frac{S}{\Phi}\right) = \begin{cases} \frac{S}{\Phi} & si & \left|\frac{S}{\Phi}\right| < 1\\ sign\left(\frac{S}{\Phi}\right) & si & \left|\frac{S}{\Phi}\right| > 1 \end{cases}$$
(8)

Where: Φ is the constant factor defines the thickness of the boundary layer.

We define the speed regulating surface:

$$S(\Omega) = \Omega^* - \Omega \tag{9}$$

$$\overset{\bullet}{S}(\Omega) = \Omega^* - \frac{p M}{J L_r} \phi_r^* i_{qs} + \frac{f}{J} \Omega + \frac{C_r}{J}$$
(10)

We replace the current i_{qs} by the current i_{qs}^*

$$i_{qs}^* = i_{qseq} + i_{qsn} \tag{11}$$

The equation(9) becomes:

$$S(\Omega) = \Omega^* - \frac{pL_m}{JL_r} \phi_r^* i_{qseq} - \frac{pL_m}{JL_r} \phi_r^* i_{qsn} + \frac{f}{J} \Omega + \frac{C_r}{J}$$
(12)

During the sliding modeand the permanent regime, we have $S(\Omega) = 0$ and consequently $\dot{S}(\Omega) = 0$ and $i_{asn} = 0$, where:

$$i_{qseq} = \frac{JM}{pL_m\phi_r^*} \left[\Omega^* + \frac{f}{J}\Omega + \frac{C_r}{J} \right]$$
(13)

The convergence condition $S(\Omega)$. $\dot{S}(\Omega) < 0$ is satisfied by the following choice:

$$i_{qsn} = K_1 sat\left(\frac{S(\Omega)}{\Phi}\right)$$
(14)

We take the stator current regulation surfaces:

$$\begin{cases} S(i_{qs}) = i_{qs}^{*} - i_{qs} \\ S(i_{ds}) = i_{ds}^{*} - i_{ds} \end{cases}$$
(15)

We replace the currents and i_{qs}^* et i_{ds}^* we obtain;

$$\begin{cases} \mathbf{\dot{s}}(i_{qs}) = \mathbf{\dot{i}}_{qs}^{*} - \begin{pmatrix} -\omega_{s} i_{ds} - \frac{1}{\sigma L_{s}} \left(R_{s} + \frac{M^{2}}{L_{r} T_{r}} \right) i_{qs} \\ -\frac{M}{\sigma L_{s} L_{r}} \omega \phi_{r}^{*} + \frac{1}{\sigma L_{s}} V_{qs} \end{pmatrix} \\ \mathbf{\dot{s}}(i_{ds}) = \mathbf{\dot{i}}_{ds}^{*} - \begin{pmatrix} -\frac{1}{\sigma L_{s}} \left(R_{s} + \frac{M^{2}}{L_{r} T_{r}} \right) i_{ds} + \omega_{s} i_{qs} \\ +\frac{M}{\sigma L_{s} L_{r} T_{r}} \phi_{r}^{*} + \frac{1}{\sigma L_{s}} V_{ds} \end{pmatrix} \end{cases}$$
(16)

By replacing the voltages V_{qs} , V_{ds} with the control voltages V_{qs}^{*} , V_{ds}^{*} , where:

$$\begin{cases} V_{qs}^{*} = V_{qseq} + V_{qsn} \\ V_{ds}^{*} = V_{dseq} + V_{dsn} \end{cases}$$
(17)

During the sliding modeand the permanent regime:

$$S(\boldsymbol{i}_{qs}) = 0 \Rightarrow S(\boldsymbol{i}_{qs}) = 0, \boldsymbol{V}_{qsn} = 0$$

$$S(\boldsymbol{i}_{ds}) = 0 \Rightarrow S(\boldsymbol{i}_{ds}) = 0, \boldsymbol{V}_{dsn} = 0$$
(18)

we have:

$$\begin{cases} V_{qseq} = \sigma L_s \left(\stackrel{\bullet}{i_{qs}} + \omega_s i_{ds} \right) + \left(R_s + \frac{M^2}{L_r T_r} \right) i_{qs} + \frac{M}{L_r} \omega \phi_r^* \\ V_{dseq} = \sigma L_s \left(\stackrel{\bullet}{i_{ds}} - \omega_s i_{qs} \right) + \left(R_s + \frac{M^2}{L_r T_r} \right) i_{ds} - \frac{M}{L_r T_r} \phi_r^* \end{cases}$$
(19)

The convergence conditions must be verified by the following choices:

$$\begin{cases} V_{qsn} = K_{2} sat \left(\frac{S(i_{qs})}{\Phi} \right) \\ V_{dsn} = K_{3} sat \left(\frac{S(i_{ds})}{\Phi} \right) \end{cases}$$
(20)

4. Fuzzy Sliding Mode Controller

In this section, a fuzzy sliding surface is introduced to develop a sliding mode controller. Which the expression $-k sat(s/\Phi)$ is replaced by an inference fuzzy system for eliminate the chattering phenomenon (Bühler 1986, p. 20) (K. Guesmi2004, p. 6) (I. Bendaas2014, p. 5). Figure (4) shows the structure of the fuzzy sliding mode controllers (FSMC) applied to the induction motor.

Fig. 4. Speed control by fuzzy sliding



This controller has a single input S(x) and a single output U_f and its base of rules (data base) is used to establish a connection between S(x) and U_f . This, is interpreted by the rules of the form (If ... Then). The if-then

rules of fuzzy sliding mode controller can be described as (S. Rafa2014, p. 3) (Y.H and Kuo 1998, p. 5) (Ali.S 2014, p. 7):

 $\begin{array}{l} R_1: \mbox{ if } S \mbox{ is } N \mbox{ then } U_f \mbox{ is } N \\ R_2: \mbox{ if } S \mbox{ is } Z \mbox{ then } U_f \mbox{ is } Z \\ R_3: \mbox{ if } S \mbox{ is } P \mbox{ then } U_f \mbox{ is } P \end{array}$

Where N, Z, and P are linguistic terms of antecedent fuzzy set, they mean Negative, Zero, and Positive, respectively.

The basic rule of fuzzy controller are summarized in the following table (1):

Table 1. Base of the fuzzy controller rule.

S(x)	Ν	Z	Р
U_{f}	N	Z	Р

Source: Prepared by researchers.

The membership functions of the input and the output of fuzzy controllers of the speed and current are those represented by the figure (4).

Fig.5. The input membership functions S (x) and the output U_{f} .



5. Results and Discussion

To prove the efficiency of these proposed methods, we apply the designed controllers to the control of the induction. The motor parameters are given: $R_s=4.850 \Omega$, $R_r=3.805 \Omega$, $L_s=0.274 H$, $L_r=0.274 H$, M=0.258 H, f=0.00114Kg.m²/s, P=2.

Performance Enhancement of Sliding Mode Controller by Fuzzy Logic with Application to Induction Motor

The performance of the indirect field oriented control of IM was visualized for the response to a speed step of 100 rad / s with the application of a load torque Cr = 10N.m between 1 and 2 s. The simulation results show the sensitivity of the PI regulation to the external perturbation; it is found that the speed is affected (Figure 6).

To improve the performance of this control, the sliding mode control was used because of its robustness (Figure 7).

Fig.6.Speed regulation using IFO controller, with applying resistant Torque (Cr =10N.m) between [1 2]s.







Figure (8) shows the disturbance rejection of FSM controllers when the machine is operated at 100 rad/sec under no load and a load disturbance torque 10 N.m is suddenly applied between 1 and 2 sec.

The FSMC controllers rejects the load disturbance very rapidly with no overshoot and with a negligible steady state error. A comparison between the speed control of the IM by a SMC and a FSMC shows clearly that the FSMC gives good performances.





6. Conclusion

The field-oriented control using a sliding mode speed was employed to obtain the better performance from the induction motor in a speed control. Also, compared to the classical PI control, a sliding mode approach gives a rather accurate response in face of large plant parameter variations and external disturbances.

The application of the fuzzy sliding control on the IM gave good results while avoiding the chattering problems of the sliding mode control. The control by fuzzy sliding allows to exploit the robustness and rapidity of the sliding mode during the transitional regime, and the flexibility of the fuzzy controller during the permanent regime. The effectiveness of the proposed controllers has been demonstrated by simulation and successfully implemented in an induction motor.

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