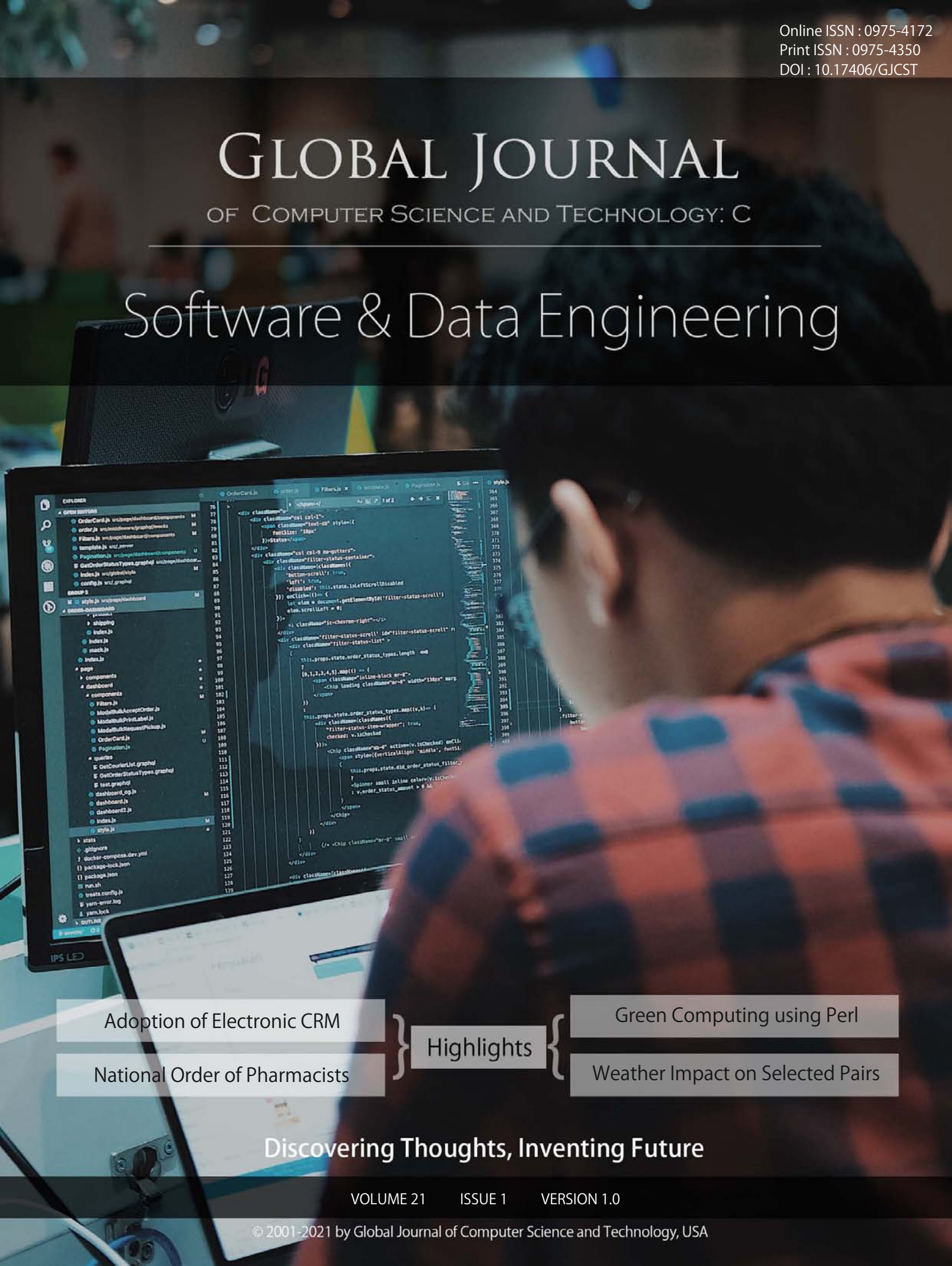
Online ISSN : 0975-4172
Print ISSN : 0975-4350
DOI : 10.17406/GJCST

Global Journal

of Computer Science and Technology: C

Software & Data Engineering



Adoption of Electronic CRM

National Order of Pharmacists

Highlights

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Weather Impact on Selected Pairs

Discovering Thoughts, Inventing Future

VOLUME 21 ISSUE 1 VERSION 1.0

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Volume 21 Issue 1 (Ver. 1.0)

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License No.: 42125/022010/1186
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USA Tax ID: 98-0673427

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Contents of the Issue

Global Journal of Computer Science and Technology: C
Software & Data Engineering
Volume 21 Issue 1 Version 1.0 Year 2021
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Adoption of Electronic CRM in Service Sector: Using an Integrated Model

By Sameh Tebourbi Abbes & Romdhane Khemakhem
Sfax University

Abstract- The main objective of this research is to develop an integrated model of significant success factors of the adoption e-CRM system by determining the intention behavior the user in the service sector.

The proposed research model was constructed based on the innovation diffusion theory (Rogers 2003), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Task Technology Fit model (TTF).

A quantitative study carried out with 340 respondents belonging to Tunisian companies with customer databases "A priori judgment" sample method was chosen.

We used structural equation modeling that is an adequate solution to the design of theoretical models and to test the research hypothesis.

Keywords: integrated model, adoption of e-CRM, the innovation diffusion theory (Rogers 2003), the Unified theory of acceptance and use of technology (UTAUT), and the task technology fit model (TTF).

GJCST-C Classification: K.4.4

Strictly as per the compliance and regulations of:

Adoption of Electronic CRM in Service Sector: Using an Integrated Model

Sameh Tebourbi Abbes [α] & Romdhane Khemakhem [σ]

Abstract- The main objective of this research is to develop an integrated model of significant success factors of the adoption e-CRM system by determining the intention behavior the user in the service sector.

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A quantitative study carried out with 340 respondents belonging to Tunisian companies with customer databases "A priori judgment" sample method was chosen.

We used structural equation modeling that is an adequate solution to the design of theoretical models and to test the research hypothesis.

The results obtained neither support the relevance of the expected effort and social influence on behavioral intention nor the effects of independence between tasks, practical capacity, analytical capacity, and customer orientation on the adjustment task technology. Therefore, only the impacts of the facility conditions, adjustment task technology, perceived risk, testability, and observability intend to use the e-CRM system.

Also, the impact of expected performance and innovativeness on behavioral intention, the impact of the non-routine aspect and the customer relationship on the task-technology adjustment, and the influence of the behavioral intention on the intention to use the e-CRM system was validated.

The managerial and theoretical implications of these results were examined for future research.

Keywords: integrated model, adoption of e-CRM, the innovation diffusion theory (Rogers 2003), the Unified theory of acceptance and use of technology (UTAUT), and the task technology fit model (TTF).

I. Introduction

Currently, the solid metamorphosis of the exchange universe and the spectacular evolution of the market, lead the company to initiate systemic transformations under strong time constraints to prevent customer needs and thus develop personalized offers and superior quality (Cadiat and de Moerloose, 2002) through the electronic customer's relationship management "e-CRM system".

Many of the benefits of this system are that businesses can provide their customers with personalized service, acquire new customers, retain existing customers, and maximize their lifetime value. As a result, acquiring new customers remains a hard task due to the intense competitive environment and complex consumer behavior (Tocquer and Langlois 1992).

Despite the advantages of information technology (IT) and its ability to perform relationship marketing tasks, there is still a lack of empirical data in the field of relationship marketing (RM), customer relationship management. (CRM) and its e-CRM application.

In the literature, studies indicate several failures in the use and adoption of the e-CRM system / The failures are mainly due to employee resistance to change, insufficient training on the e-CRM system, lack of management support, and lack of appropriate IT infrastructure.

Indeed, most of the previous research had not focused on studying user acceptance behaviors or their attitude towards e-CRM adoption. The e-CRM projects have focused more on the application of technology and not on human issues. However, and according to Volle (2003), the gains to be made from the information system no longer come from massive investments in IT infrastructure but from the strengthening of links between people, technology, and the organization.

Big data pose new challenges to traditional data processing methods, because they are not designed for the scale of the web (Chéour, 2019). Given the astronomical amount of potentially exploitable data, it is first necessary to put in place approaches to manage this wealth of information, to store and prioritize this data in an adhesive manner, with a view to their subsequent exploitation (Ghazaleh, 2020).

Many theories try to take advantage of this question by studying the conditions under which the interactions between people, technologies and, customers increase the profitability of the company's merchant portfolio. Specially, the diffusion theory of innovation.

The diffusion theory of innovations has shown relatively dominance over other models that have tried to investigate the field of perceptual characteristics of innovation (Meuter, 1999). It was criticized for its lack of specificity (Chau and Tam, 1997).

Another criticism of the diffusion of innovations theory is its omission of the vital role intention plays in the process of use (Ozdemir, Trott & Hoecht, 2008).

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However, adopting an innovation involves first its evaluation by the consumer, then forming the intention demonstrating the close link between the use of technology and human performance. Yet, it does not specify how this intention is formed or how it results was used or rejected. Several studies have emphasized the role of intentions in user behavior (Anderson & Schwager, 2004; Lin, Chan & Jin, 2004).

Facing his critics, two main theories have recently emerged proposing elements of ramifications. These are the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Task Technology Fit model (TTF), which serves to better explain the adoption of IT.

UTAUT is certainly the most successful explanatory model of the individual adoption of technologies. Explainnearly 70% of the variance in intent and 50% of the variance in usage (Venkatesh et al. 2003).

In addition, there are other significant factors like technological characteristics and task characteristics that are unnoticed in the model (Khoshtinat, Bojei, Ahmadin, 2014).

To assess the successful match between the task and the information technology and character of users, many authors like (Goodhue and Thompson, 1995) suggest a relevant research model that covers most of the factors that explain the adoption decision of electronic CRM. The Task Technology Fit model (TTF), which is an organizational assessment tool for Information Systems (IS) and services (Goodhue,1995).

Despite the importance of the task-technology adjustment model (Goodhue, 1995) in explaining the adoption of IT technological innovation, it does not consider an aspect of great importance; the interaction between the user and the task (Khoshtinat, Bojei, Ahmadin, 2014). Given the contributions but above all to overcome the limits of the theory of diffusion of innovations (Rogers, 2003), the unified theory of acceptance and use of technology (Chong, 2013) and the task-technology adjustment model (Goodhue, 1995), we propose an integration of these three theoretical frameworks to judiciously explain the adoption of e- CRM in service companies.

In light of these findings, we can ask the following question:

What are the determinants of the use and adoption of the e-CRM system in service companies?

Based on the diffusion of innovation theories (Rogers, 2003), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Task Technology Fit model (TTF), our main objective is to develop an integrated model of the main factors of CRM adoption by determining the behavioral intention of marketing managers in the service sector.

II. Literature Review and Hypothesis

The unified theory of acceptance and use of "UTAUT" technology justifies using ICT essentially from four fundamental determinants of behavioral intention: expected performance, expected effort, social influence and, the facilitating conditions. These four elements make it possible to prove using ICT (Venkatesh et al., 2003). The UTAUT model (Venkatesh, 2003) will be enriched by another variable, innovativeness. This extension of the UTAUT model is recommended by Chong (2013).

a) Effort expectancy and behavioral intention

Effort Expectancy is defined as “the degree of ease associated with the use of the system” (Venkatesh, 2003). When companies adopt the e-CRM system, they traditionally compare it with existing systems. If they feel that the system is easily understood and used, their willingness to adopt it will be strengthened (Pai, Tu, 2011).

This finding is confirmed by Park et al. (2007), Tan et al. (2010) and Yu (2012) by applying the UTAUT model. Accordingly, we assume a relationship between effort expectancy and intention to use the e-CRM system in service companies.

H1: Effort expectancy affects significantly and positively behavioral intention.

b) Social influence and behavioral intention

This construct is defined as “the degree to which an individual perceives that important others believe that he or she should use the new system” (Venkatesh,2003)

Pai, Tu, 2011 take into consideration that behavioral intention will be enhanced when the company adopted the e-CRM system, will create a higher social limpact.

H2: Social influence affects significantly and positively behavioral intention.

c) The facilitating condition and intention of adopting the e-CRM system in service companies

Facilitating conditions are defined as “the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system” Venkatesh et al. (2003). They are often theorized to have a direct effect on the intention and use of the information system (Venkatesh et al. 2003). The study by Venkatesh et al. (2003), and Chiu and Wang (2008) found that when users find that they have a fairly high capacity to use and support resources, this results in a more positive acceptance of information technology.

Facilitation conditions in both TAM and UTAUT are a direct determinant of adoption intention. Studies have found that the enabling conditions directly affect

behavioral intention (Thompson et al. 1991, Taylor & Todd, 1995).

H3: The facilitating condition positively and significantly affects the intention to adopt the e CRM system.

d) Performance expectancy and behavioral intention

Performance expectancy is defined as "the degree to which the user expects that using the system will help him or her attain gains in job performance" (Venkatesh et al. 2003). It has been shown by several studies to be a very significant determinant in the explanation of the intention to adopt a technology (Ouedraogo, 2011; Venkatesh et al. 2003). In general, when companies need to invest in technological innovation, the main consideration in system implementation is whether the technology or system can improve overall performance or can effectively perform the defined task (J.-C. Pai, F.-M. Tu, 2011). Indeed, the technological innovation of information systems can only be adopted within service companies if the staff perceive the gains in terms of efficiency, speed and, performance in the execution of tasks, also, if he sees these new tools as real opportunities to ensure not only professional care, but also to promote business activities.

H4: Performance expectancy positively and significantly affects behavioral intention.

e) Innovativeness and behavioral intention

Innovativeness is defined as "the degree of adoption of innovations and highlights the extent to which the organization is receptive" (Venkatesh 2003). Authors such as Roehrich (1994) and Frini and Limayem (2001) have found a prominent positive correlation between innovativeness and the propensity of behavioral intention towards the use of innovations.

H5: Innovativeness has a positive effect on behavioral intention.

f) Behavioral intention and intention to adopt the e-CRM system in service companies

Behavioral intention is defined as "the subjective probability that a person will engage in the behavior in question" (Fishbein &Ajzen, 1975). Indeed, previous research indicates that the user shows a greater willingness to adopt the new system when supported by the organizational or technological structure (Chiu & Wang, 2008; Venkatesh et al. 2003).

H6: The behavioral intention of the adoption the e-CRM system has a positive effect on the intention to adopt it.

The testability of the e-CRM system in service companies and the intention to adopt it Testability is defined as "the degree to which an innovation can be tested over a limited field before its use" (Rogers, 2003). A new idea is generally faster to adopt than other ideas (Rogers, 2003). This possibility would allow the individual or any other adoption unit to better understand how an innovation works and its importance. Thus, an innovation that we can pre-test present less risk to the individual or organization that intends to adopt it (Rogers, 2003). Potential adopters who are allowed to experiment with the innovation will feel more comfortable and be more likely to adopt it (Agarwal & Prasad 1998) and Rogers (2003).

H7: The testability of the e-CRM system has a positive effect on the intention to adopt it.

g) The observability of the e-CRM system in service companies and the intention to adopt it

Observability is defined as "the degree to which the results of new information technologies are visible and accessible". The clearer the results of adopting these systems, the more easily individuals will adopt them (Rogers, 2003). Robertson (1971) points out that observability correlates positively with the adoption of a new system.

H8: The observability of an e-CRM system has a positive effect on the intention to adopt it.

h) The perceived risk and intention of adopting the e-CRM system in service companies

Perceived risk is defined in the literature as "the perceived uncertainty in a purchasing situation that affects people's confidence in their decisions" (Im et al. 2008).

Toufaily, Daghfous and, Toffoli, 2009 confirmed that perceived risk is a determining factor adopting of a new system. The more the manager perceives a high risk in the face of innovation, the lower the adoption rate will be and vice versa.

In this same framework, Robertson (1971) approves the negative correlation between the adoption of innovations and perceived risk. Ostlund (1969) explained, for his part, that the lower the level of perceived risk, the more we see a high adoption rate. The perceived risk is thus a determining factor in the adoption of a new product.

H9: The perceived risk of the e-CRM system has a negative effect on the intention to adopt it.

i) The characteristics of the tasks and the task-technology adjustment

The characteristics of the tasks are those that a user must mobilize. They are measured by the following criteria: the complexity of the task (the routine versus non-routine aspect) and the interdependence between the tasks (transversality) (Goodhue and Thompson, 1995).

The task-technology fit "is the degree of correspondence between the functional need for the task, the individual capacities and the technical functionalities offered by the system" (Goodhue and Thompson, 1995). In this regard Goodhue and Thompson (1995), assert that the characteristics of the

task are directly affected by the characteristics of a specific system, or the efficiency of the use of information technologies and the technical functionalities of the system. The study by Dishaw and Strong (1999) shows that the characteristics of the tasks will directly influence the task-technology fit.

H10: The characteristics of the tasks positively affect the task-technology fit.

j) The characteristics of the technology and the task-technology fit

Dishaw and Strong (1999), have shown that workgroups and characteristics of technology directly influence task-technology adjustment. Likewise, the task-technology fit will be improved when technological performance increase (Goodhue and Thompson, 1995). The fit between the tasks to be performed and the technology used in organizations has a direct influence on the use (Dishaw and Strong, 1999), Venkatesh (2003).

H11: The characteristics of the technology positively affect the task-technology fit.

k) The characteristics of the technologies and the intention of adopting an e-CRM system in service companies

Research by Goodhue and Thompson (1995) found that the user's cognition and belief determine the strength of behavioral intention, subsequently affecting the final performance of the current behavior.

H12: The task-technology fit significantly and positively affects behavioral intention.

l) The influence of moderating variables

We retained the two demographic variables: sex and age, as two moderating variables in our study.

m) The influence of age

Rogers (1995) has shown that “adopters are usually younger”. Igbaria and Parasuraman (1989) note that “older people tend to be less exposed to ICTs, therefore less flexible and more resistant to change. As a result, their anxiety about computers increases and thus reduces their likelihood of using these systems. " Zoltan and Chapanis (1981) show that “the attitudes of older people towards computers are more negative than those of younger people”. Moreover, "the oldest have a weaker perception of the usefulness of personal computers" (Igbaria, 1993).

H13: The age of the user of an e-CRM system has a moderating effect on the relationship between the determinants of e-CRM system adoption and the intention to use this system.

n) The influence of sex

The influence of sex on the use of technologies is tested by several studies in the field of the acceptance of various technologies: the microcomputer (Igbaria and Parasuraman, 1989), e-mail, m-commerce (Chong, 2013), online banking services (Martins et al. 2013) and mobile banking services (Yu, 2012).

H 14: The sex of the user of the e-CRM system has a moderating effect on the relationship between the determinants of adoption of the e-CRM system and the intention to use these systems.

The conceptual model which summarizes all the assumptions made is as follows:

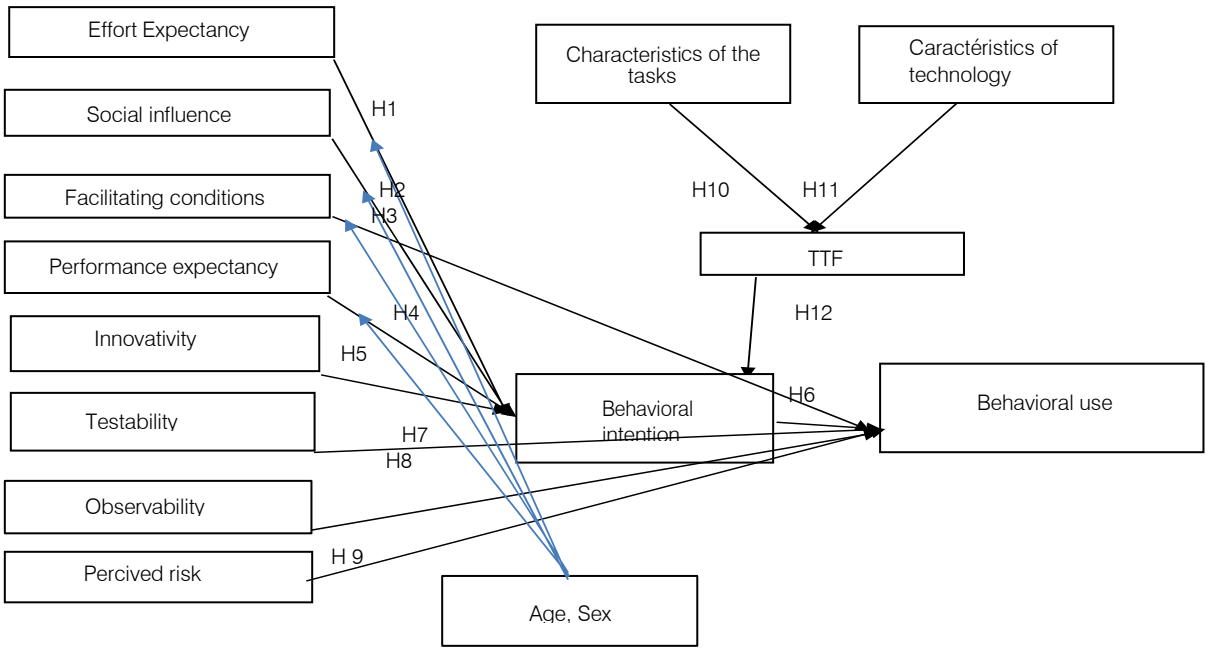

Figure1: Conceptual model of research

III. Research Methodology

This research was conducted in the context of the Tunisian market. A quantitative questionnaire study was used in this research.

a) Data collection

In CRM research in general, the sampling populations under study are companies with large customer databases operating in sectors with great competitive pressure that pushes them to differentiate themselves, in particular companies operating in the B to C sector (Coltman et al., 2011).

Our choice focused on Tunisian companies with a customer database (Coovi 2010), particularly the service sector. "A priori judgment" sample method was chosen since the companies selected to be part of the sample are those which think, before questioning them, that they may have crucial information for the study (Giannelloni et al. Vernette, 2012, p.284). We use the "prior judgment" sampling method when we take a sample based on certain judgments about the whole population. The assumption underlying its use is that the enumerator will select units that will be characteristic of the population.

Table 1: Characteristic of the population

Sectors		Respondents	%
	Financial services sector	160	47,1
	Telecommunication sector	117	34,4
	Sector NTIC	63	18,5
	Total	340	100,0
Post	Member of leader	16	4,7
	Marketing Manager	160	47,1
	Sales manager	134	39,4
	Other	30	8,8
	Total	340	100,0
Number of permanent employees			
	Less of 20	150	44,1
	Between 20 et 49	8	2,4
	Between50 et 99	44	12,9
	100 and more	138	40,6
	Total	340	100,0
Experience			
	Aucune	18	34,7
	For less than 1 year	66	19,4
	For a period of between 1 and 5 years	145	13,2
	For a period between 5 and 10 years	107	31,5
	For more than 10 years	4	1,2
	Total	340	100,0

b) Measurement of variables

All items are measured on a 5-point Likert scale.

The measurement scales used have been adapted from previous research where they have shown good validity. To ensure content validity, the vocabulary of these scales has been adjusted to the context using the CRM system.

Table 2: Measurement scale

Concepts	Number of items	Authors
Expected effort	4items	Venkatesh et al. (2003)
Social influence	4 items	Venkatesh et al. (2003)
Facilitate condition	4 items	Venkatesh et al. (2003)
Expected performance	4 items	Venkatesh et al. (2003)
Innovatively	3 items	Jones et al. (2002)
Testability	6 items	Rogers (2003)

Observability		9 items	Rogers (2003)
Perceived risk		2 items	Ozdemir et trott (2009)
		1 items	Im (2008)
Caractéristics technology	Practical CRM	4items	(Greenberg 2002, v kumar et reinartz 2006 Payne 2006, payne et flow 2005)
	Analytical CRM	3items	
	Strategic CRM	5items	
	Customer relation	6items	
Caracteristics task	Task complexity	2items	(Goodhue et Thompson, 1995)
	independence of task	2items	
TTF		2 items	(Nienhuis, 2014)
Behavioral intention 3 items		3 Items	(Venkatesh, 2008)
Behavioral use		2 items	(Venkatesh,2008)

c) Method of data analysis

We used the method of structural equations, which are confirmatory techniques that aim to validate hypotheses using SPSS 20 and AMOS20 software.

IV. Search Results

a) Purification and reliability of measurement scales

A confirmatory factor analysis was performed to assess the psychometric qualities of the scales for measuring latent variables and to test research hypotheses.

Table 3: The psychometric quality of scales

Concepts/ Numbers of Items		Items eliminated	Factors	Items after ACP	Reliability
Expected effort (3items)		EE1 EE4	F1	EE2 EE3	0.645
Social influence(4items)		SI1 SI4	F1	SI2 SI3	
Facilitate condition(4items)		FC3	FC1 FC2 FC4	F1	0.633
Expected performance (4 items)			F1	EP1 EP4	0.835
			F2	EP2 EP3	
Innovativity (3items)		I3	F1	I1 I2	0.658
Percived risk (3items)			F1	PR PR2 PR3	0.645
Technological characteristics (2items)			F1	INT1 INT2	
	practical CRM (4 items)	PCRM4	F1	PCRM1 PCRM2 PCRM3	

	Analytical CRM (3items)		F1	ACRM1 ACRM2 ACRM3	
	Strategic CRM(3items)	SCRM1	F1	SCRM2 SCRM3	
	Customer relation (5ite ms)	RC3, RC5	F1	RC1 RC2 RC4	0.697
Task caracteristics	Task complexity		F1	TC1 TC2	
	Independence of task		F1	IT1 IT2	
TTF			F1	TTF1 TTF2	
Behavioral intention(3items)				BI1 BI2 BI3	
Behavioral use (2items)				BU1 BU2	

We made the modifications by adding covariance links between the errors in order to improve the goodness of fit of our measurement model.

Table 4: Goodness-of-fit of measurement model

Indice	Chi-deux	DL	Chi-deux/ DL	P	GFI	AGFI	NFI	TLI	RMR	RMSEA
Valeur	681.14 9	479	1,42	,075	0,9	0,9	,783	,90	,064	, 044
Seuil	-----	----	<2	>0.05	≥0.9	>0.9	>0.9	>0.9	0	<0.08

Table 5: Construct reliability indicators (n = 340)

Items	CF EST	Variance des erreurs	Rho de Jöreskog VME	
EA2	1	0.325	0.871	0.772
EA3	1	0.264		
Somme	2	0.589		
IS2	1	0.738	0.695	0.533
IS3	1	1.011		
Somme	2	1.749		
CF1	1	0.026	0.915	0.801
CF2	0.475	0.14		
CF4	0.55	0.21		
Somme	2.025	0.379		
I1	1	0.236	0.881	0.787
I2	1	0.303		
Somme	2	0.539		
O9	1	0.986	0.66	0.5

O10 Somme	1 2	1.068 2.05		
O5 O6 O7	1 1.23 0.898	0.916 0.359 0.84	0.822	0.61
Somme T1 T2 T7	3.128 1.106 1.068 1	2.115 0.007 0.08 0.137	0.97	0.93
Somme	3.174	0.224		
RP1 RP2 RP3	1 1.459 1.023	1.623 0.82 0.893	0.813	0.6
Somme	3.482	2.775		
ORI2	1	0.511	0.662	0.66 2
Somme				
CP2 CP3	1 1	0.865 1.239	0.655	0.5
Somme	2	2		
CA1 CA2 CA3	1 1.339 0.824	0.833 0.746 1.085	0.806	0.58 6
Somme	3.335	2.664		
RC1 RC2 RC	1 1.034 0.824	0.927 0.955 1.286	0.686	0.52 3
Somme	2.858	2.23	0.785	0.55 2
NRIT2 NRIT1	1 1	1.239 1.198	0.621	0.45
Somme	2	2.437		
IT2	1	0.637	0.61	0.61
Somme				
TTF2 TTF1	1 1	0.789 0.944	0.697	0.53 5
Somme	2	1.733		
PA4	1.063	0.922	0.651	0.5
PA1	1	1.35		
Somme	2.063	2.2		
IC1 IC2 IC3	1 0.902 0.972	1.024 0.9 0.728	0.756	0.50 9
Somme	2.874	2.652		

Table 6: Construct reliability indicators (n = 340)

Concepts	Rho de Joreskog
Compatibility	0.73
Perceived utility	0.9
Perceived ease of use	0.63
Trust	0.79
Perceived risk	0.98

The reliability of the scales is satisfied (ρ of Jöreskog and α of Cronbach> 0.7).

The convergent validity of the scales is satisfactory (ρVC> 0.5) according to the criterion of Fornell and Larcker.

Table 7: Construct validity indicators (n = 105)

Concepts	VME
Compatibility	0.7
Perceived ease of use	0.9
Perceived utility	0.64
Trust	0.89
Perceived risk	0.72

The results also show that the discriminant validity is satisfied.

Table 8: Discriminating validity indicators of buildings (n = 105)

	EA	IS	CF	I	O	OO	T	RP	ORI	CP	CA	RC	NRIT	IT	TTF	PA	IC	IU
EA	0.8785																	
IS	-0.084	0.730																
CF	0.468	-0.21	0.894															
I	0.388	- 0.202	0.302	0.887														
O	0.119	- 0.109	0.131	0.059	0.707													
OO	-0.018	0.135	0.205	-0.01	0.485	0.775												
T	-0.67	0.005	-0.092	-0.041	-0.216	-0.171	0.964											
RP	-0.033	0.119	0.055	0.019	0.151	0.112	-0.159	0.774										

ORI	0.1	0.1	0.2	0.2	0.1	0.3	0.1	0.3	0.813									
CP	0.01	0.274	0.008	0.09	0.055	0.228	-0.011	0.256	0.3	0.707								
CA	-0.157	0.497	-0.081	-0.087	-0.034	0.107	-0.025	-0.085	0.2	0.15	0.765							
RC	-0.24	0.478	-0.188	0.26	-0.017	0.294	-0.055	0.013	0.1	0.358	0.506	0.742						
NRIT	-0.293	0.058	0.022	-0.069	-0.227	-0.128	0.122	0.021	0.01	-0.138	0.338	0.011	0.707					
IT	0.027	0.0129	0.089	0.194	0.018	0.031	0.049	-0.245	0.01	0.019	-0.019	-0.326	0.165	0.775				
TTF	0.209	- 0.111	0.239	0.194	-0.072	0.019	-0.043	-0.164	0.02	-0.003	-0.059	-0.457	0.065	-0.515	0.731			
PA	-0.106	0.091	-0.305	-0.328	-0.174	-0.217	0.302	-0.163	0.01	-0.05	0.013	0.179	0.175	-0.117	0.012	0.707		
IC	0.142	-0.11	-0.102	0.154	0.082	0.198	-0.071	0.024	0.1	0.276	-0.293	-0.164	-0.333	0.455	0.635	-0.08	0.509	
IU	0.161	- 0.177	0.342	0.458	0.058	-0.04	-0.116	0.102	0.2	0.048	-0.173	-0.151	-0.178	0.135	0.166	-0371	0.158	0.713

The discriminant validity of all the constructs is verified.

b) Testing hypotheses

To judge whether the hypothesis is supported or not, we need to move on to studying regression links. To judge a relationship like significant, it should be checked that the CR is greater than 1.96 with a significant p (p must be less than 5%).

Table 9: Verification of the assumptions about the regression relationships

			Estimate	S.E.	C.R.	P	H
IC	<---	EA	,019	,381	,049	,961	Not confirmed
IC	<---	IS	,067	,195	,344	,731	Not confirmed
IU	<---	CF	2,069	,544	3,802	***	Confirmed*
IC	<---	PAa	,579	,245	2,361	,018	Confirmed *
IC	<---	I	,797	,181	2,124	,001	Confirmed *
IU	<---	T	-,076	,056	-1,971	***	Confirmed *
IU	<--	Oo	-,165	,083	-1,992	,046	Confirmed *

	-						
IU	<-- -	O	-,097	,062	-1,570	,116	Not confirmed
IC	<-- -	RP	-,185	,093	-2,002	***	Confirmed *
TTF	<-- -	CA	,092	,115	,799	,425	Not confirmed
TTF	<-- -	RC	-,258	,075	-3,422	***	Confirmed*
TTF	<-- -	NRIT	-,056	,162	-,346	,730	Not confirmed
TTF	<-- -	IT	,641	,092	6,956	***	Confirmed*
IU	<-- -	IC	,098	,021	4,632	***	confirmed*
EA	<-- -	Sexe	,029	,017	1,672	,095	Not confirmed
IS	<-- -	Sexe	,042	,063	,677	,499	Not confirmed

c) Discussion and implications

The results show that expected effort and social influence have a positive effect on behavioral intention are rejected. These results are surprising contradict with the results of previous research, whether in the context of UTAUT (Venkatesh et al., 2003).

Also, the results of the current study show that there is a significant positive relationship between the facilitate conditions and the intention to adopt the e-CRM system.

This result is consistent with the work of Venkatesh et al. 2003.

Facilitating conditions are often theorized to have a direct effect on the intention and use of SI (Venkatesh et al. 2003).

Venkatesh et al. (2003) and Chiu and Wang (2008) found that when users have high utilization capacity and support resources, they show more positive acceptance of information technology.

It is recommended that marketing managers integrate the e-CRM system. Since it is easy to use, it does not require strong computer skills.

Then, there is a significant and positive relationship between expected performance and behavioral intention. This result is consistent with the work of Wang2008.

Indeed, performance expectancy is one of the most powerful predictors of intention built into the UTAUT model as this system is seen as useful for marketing functions.

In addition, it is supposed to provide assistance to different managers (regardless of their level) for the analysis of daily activity and decision-making. The software is supplied monthly for weekly management of the activity (schedules and promotion).

The effect of innovativeness on behavioral intention is confirmed.

This result is consistent with the results of previous research, Venkatesh 2003, Roehrich 1994 and, Frini and, Limayem 2001.

It is recommended to use the e-CRM system since it is seen as useful for marketing functions; It can manage business problems and help improve performance, it is assumed assist to various managers (regardless of their level) for the analysis of daily activity and decision-making.

The behavioral intention of implementing an e-CRM system to have a positive effect on the intention to adopt it is validated.

This result is consistent with the work (Chiu & Wang, 2008; Venkatesh and Davis, 2000; Venkatesh et al. 2003), which shows that from a certain level of experience, the intention was a better explanatory variable of the intention of use.

About this outcome, service companies must support leaders with a technology or a solid organizational structure that meets their expectations.

If the leader is well trained the e-CRM system, it will have a positive effect to adopt this system.

If the leader is well trained while the company implements the CRM system, it will produce a positive effect on the use of CRM.

The testability of the e-CRM system effects the intention to adopt the e-CRM system; it is best for marketers to test the system before adopting it.

Exploratory and confirmatory factor analysis decomposed this concept into two dimensions: The rejection of the first dimension can be explained by the fact that observability of the system by other users and observability outside the company do not affect the intention to adopt the system.

The acceptance of the second dimension is explained by the fact responds to the real needs of customers and allows the rapid flow of data.

The perceived risk has a negative effect on behavioral intention is validated. This result confirmed by previous studies (Im et al., 2008; Pavlou, 2003; Toufaily, Daghfous and Toffoli, 2009; Robertson, 1971; Ostlund, 1969).

As a result, service companies must ensure that customer personal information is not disclosed while using this system.

According to Goodhue and Thompson (1995), the characteristics of the technology are measured by the functionality of e-CRM system:

The exploratory and confirmatory factor analysis allowed us to identify two dimensions, analytical capacity and customer relationship.

The results showed that only the customer relationship determines the task-technology fit. This result is consistent with the work of (Payne 2006).

The e-CRM system integration helps marketers maintain relationships with customers and provide a single view of the customer through the match between task and technology.

The results of the current study show that there is a significant and positive relationship between task-technology fit and behavioral intention. This result is consistent with the work of Goodhue and, Thompson (1995).

The age of the marketers has a moderating effect on the relationship between the expected effort and the intention to use an e-CRM system. Our results show that the youngest respondents think that using the e-CRM systems will be easier. We can therefore conclude that older leaders are ready to use these systems, but they are more sensitive to the difficulty of learning to use these systems. This confirms the results of Venkatesh and al. (2003), Venkatesh and, Zhang (2010), Cruz et al. (2010), Yu (2012), Riffai et al. (2012) and Martins et al. (2013), who explains that younger users can acquire skills more quickly.

Age also has a moderating effect on the relationship between social influence and intention to use an e-CRM system. Indeed, in our study, social influence was crucial for older respondents. This result is consistent with the results of Venkatesh et al. (2003), this could be ainteresting, especially in the initial phase of the experience when individuals is more likely to rely on the opinions of others (Agarwal & Prasad, 1999). Moreover, they tend to be less flexible and more resistant to change (Igbaria and Parasuraman, 1989).

Age also has a moderating effect on the relationship between the use of e-CRM system and the conditions of facilitation. Our results confirm the results of Venkatesh et al. (2003) and, Venkatesh and Zhang (2010), the literature shows that the youngest are always the most interested in technologies (Rogers, 1995); on the other hand, older people tend to be less exposed to ICT (Zoltan et Chapanis, 1981; Igbaria and Parasuraman, 1989) therefore, they believe that the use of the e-CRM system requires technological resources and knowledge.

In contrast, the gender of the respondents does not affect] the factors influencing intention to use. These are contradictory with the literature (Venkatesh et al., 2003; Garbarino and Strahilevitz, 2004; Nysveen et al., 2005; Park, 2007; Cruz et al. 2010; Riffai et al., 2012). (Venkatesh, 2003) which assumes that men are more likely to rely on the performance expectancy of technology.

d) Conclusion

Based on the diffusion theory of innovation (Rogers, 2003), the innovation diffusion theory (Rogers 2003), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Task Technology Fit model (TTF), our main objective is to develop an integrated model of key success factors of adoption e-CRM system by determining the intention behavioral in the service sector in Tunisia.

The results of our research agree with those of previous research (Venkatsh, 2003; Rogers, 2003; Goodhue and Thompson,1995), which allows us to underline the importance of the variables of the three theories in the formation of intention towards the adoption of CRM system in service sector.

This work is based only on reviewing the literature relating to the main models developed in psychology and sociology (TDI, UTAUT, TTF).

As a future way of research could attempt to invite subsequent studies to integrate other model to explain better the determinants of the adoption of the e-CRM system in service companies.

Such as the Information Systems Success Model (ISSM) (Delone, 2003; DeLone and McLean, 1992).

A second limitation, is the non-integration of certain relevant variables in our adoption model. As a future line of research, we propose to integrate the satisfaction as a variable influencing the intention of adopting the e-CRM system. The results of the work of (Bhattacherjee, 2001) show that satisfaction with the use of an IS is a powerful determinant of the intention to use the system.

We also propose to integrating the culture variable as a moderating variable that can enrich our model since it plays a primordial role in the adoption of technology that makes it possible to change individual belief systems (Venkataesh and Zhang (2010).

A final limitation, given the complexity of collecting data from service companies, we used a single survey to conduct the AFE and the AFC.

As a future avenue of research, it is preferable to use two different samples to increase the generalization of the results

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Global Journal of Computer Science and Technology: C
Software & Data Engineering
Volume 21 Issue 1 Version 1.0 Year 2021
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Green Computing using Perl and Python

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Abstract- Green computing or clean computing is necessary for Software Engineering. Perl and Python are important programming languages for green computing. Perl is regular language. Perl is mainly used for server-side programming because it is a regular language. It a portable and green programming language. It can be used as object-oriented (OO) or non object-oriented (Non-O-O) programming language. Python is preprocessor. It is a portable language for software engineering. It has an import feature for Green computing.

Keywords: *green computing, regular expressions objectoriented, perl, preprocessor, python.*

GJCST-C Classification: *K.7*

Strictly as per the compliance and regulations of:

Green Computing using Perl and Python

Poli Venkata Subba Reddy [α] & Srivibha Vadravu [σ]

Abstract- Green computing or clean computing is necessary for Software Engineering. Perl and Python are important programming languages for green computing. Perl is regular language. Perl is mainly used for server-side programming because it is a regular language. It a portable and green programming language. It can be used as object-oriented (OO) or non object-oriented (Non-O-O) programming language. Python is preprocessor. It is a portable language for software engineering. It has an import feature for Green computing.

Keywords: green computing, regular expressions object-oriented, perl, preprocessor, python.

I. Introduction

Green Computing or Clean Computing is necessary to solve different types of problem solving. The Programming is needed portability of the code, and less computation time. There are different techniques methods are used for Green Computing like recursion, parallelism, regular expression and Object-Oriented. The recursion is the calling function itself. Parallelism is computing the number of tasks at a time. The regular expression is simplifies the code. The Object-Oriented shall made program is independent.

II. Green Computing Methods

Programming is the main component for problem solution. The Green programming has some of the main features.

Portability
Less computing time
Reusability
Green Computing maybe studied with three methods.

a) Analysis

There are different analysis methods. Mainly

Time Complexity
Space Complexity

b) Design

There are different design method are used f

Divide and Conquer
Object-Oriented
Component based

c) Coding

The Programming Languages fall under different paradigms Imperative, Functional, Logical, and Object-Oriented and regular it is difficult to learn all the programming languages. It easy to learn programming languages through common principles like iteration, recursion, control statements, functions, functions, subroutines, Object-oriented, etc. All principles and techniques are not available in single programming language. The selected Programming Languages are discussed for Green Computing.

Programming languages are designed based on Automata. Context-Free Language is the recursively representation of Finite Automata.

For green computing, Recursive Algorithms and Parallel algorithms are used until recently. Programming languages are playing a main role.

We consider Perl and Python for green computing. Perl is the regular language. It simplifies the programming, and it reduces time.

Python is the preprocessing language. It simplifies the with the import feature, it simplify the code.

III. Component Technology

All components are specialized, independently deployed and extendable for the product. These components are also extendable to multi versions of the components. The following are the characteristics of the components.

The components have an externally accessible view.

The semantics such as business rules and regulations are defined for the composition of components.

As Component software extended, the components are extendable.

The component must be relocate and replace a component for other implantations or the development of new software system.

The semantic primitives must be extendable to new components.

The composition of components is tightly coupled.

The components are substituted and integrated into the other systems. Sometimes this maybe referred to as off-the-components.

a) Component Architecture

The component architecture mainly consists of Conceptual component model, infrastructure technologies and structured domain concepts. The

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component architecture comes across distributed, heterogeneous and new infrastructure technology. Integrated component architecture is the mechanism universal Component architecture and it may be referred to integration of independent component architectures. The integration may be loosely coupled and tightly coupled. It Describes implementation of Component infrastructure, Structured conceptual model, and domain concepts.

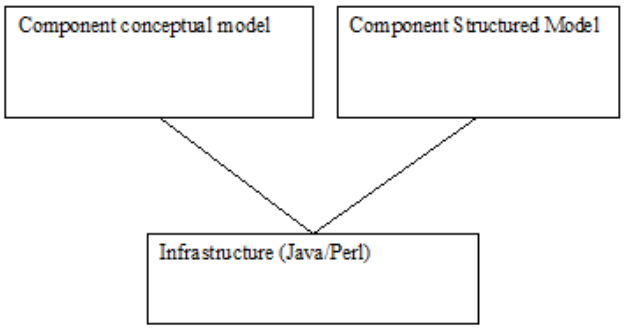

Figure 1: Component Architecture

b) Component Implementation

The component model is translated into component ware with tools for automation and management of components and interfaces. Interface to understand system architecture with the interface specifications that implement, reuse, and replacement of components. They are two types of component ware implementation for products.

Self-development in which component were developed from the scratch.

Off-the-self components in which component ware developed by black box assembling commercially available components and such components are documented, assembled and adapted.

The following are the characteristics of the implementation enterprise model. The components of the product may represent entire system

Generosity: It is stepwise instantiation and controlled processes that use specifications, inheritance, relationships and contexts.

Domain system: It represents a particular area of components.

Domain object: It represents a particular process of components.

Semantic primitives: These are rules and kinds of relationships between objects.

These domain concepts are used to compose domain components of individual components.

IV. Perl Programming

The Programming Languages fall under different paradigms Imperative, Functional, Logical, and Object-Oriented and Regular. It is difficult to learn all the programming languages. It made easy to learn programming languages through common principles like iteration, recursion, control statements, functions, functions, subroutines, Object-oriented etc. All principles and techniques are not available in single programming language. The selected Programming Languages are discussed for Green Computing.

The Programming Languages are constructed mainly based on Finite Automata (FA) and Regular (RE).

The Formal Languages (FL) are simple representation of Context-Free Language) CFL). The CFL is recursion of FA.

$$FA\ M = \{\Sigma, Q, \delta, q0, F\}$$

For instance,

$$\Sigma = a\text{-}z(a\text{-}z, 0\text{-}9)$$

$$Id = \{num, num1, x1, \ldots\}$$

Regular

$$M = \{\Sigma^*, Q, \delta, q0, F\}$$

$$\Sigma^* = \{a\text{-}z, 0\text{-}9\}^*$$

$$Id = a\text{-}z(A\text{-}Z, 0\text{-}9)^*$$

$$Id = \{x, x11, num, sum, sum12, \ldots\}$$

The CFL is defined as

$$M = < V, T, P, S >$$

$$E = E+E/E-E/E*E/id$$

The grammar

$$G = \{ A \Diamond \alpha w\}, \text{ where } \alpha \epsilon V, w \epsilon \{ N \cup \Sigma\}$$

The regular grammar

$$G^* = \{ A \Diamond \alpha w^*\}, \text{ where } \alpha \epsilon V, w^* \epsilon \{ N \cup \Sigma^*\}$$

For instance,

$$\Sigma = a\text{-}z(a\text{-}z, 0\text{-}9)$$

$$Id = num, id = x1 \text{ etc.}$$

$$\Sigma^* = \{a\text{-}z, 0\text{-}9\}^*$$

$$Id = a\text{-}z(A\text{-}Z, 0\text{-}9)^*$$

$$Id = \{x, x11, num, sum, sum12, \ldots\}$$

Perl is only Regular Language. Perl can be used as Non-Object-Oriented and Object-Oriented. Perl is Portable because like Algorithmic language. Perl is green programming longuge. The main concepts of Perl are recursion, regular, parallelism and client/server.

a) Recursion

Recursion is calling function by itself.

For instance,

```
$n=<STDIN>;
$factorial=fact($n);
print "$factorial\n";
```

```
sub  fact($num)
{
 if ($num==1) {return 1;}
else { return $num*fact($num-1);}
}
```

b) Regular

A regular expression is simply Expression of Finite Automate.

Consider the Regular Expression
Id =digit*. digit)+

Regular expressions are used to match the pattern, sting with

"m//", "s///", "qr//" and "split" operators
Simple string matching

c) Object-Oriented

Object are often called instance data or object attributes, and data fields

```
sub teacher ::pvsr{
  print "teaching dbms\n";
}
sub student::syam{
  print "tacking dbms course \n";
}
sub room::cse201{
  print "course in a201\n"
}
teacher::pvsr;
student::dbms;
room:cse201;
```

"Class->method" invokes subroutine "method" in package "Class "

```
teacher->dbms;
student>dbms;
room->cse201;
```

d) Threads

The "use thread" creates one or more threads.

```
 use threads;
$thr1= threads->new(\&ascending);
$thr2= threads->new(\&decending);
my $num ;
sub ascending {
    my $num;
 while ( 10)
   print " $num++\n";
}
sub decending {
   my $num=10;
 while (  0)
   print " $num--\n";
}
$thr1-> join;
$thr2->join;
```

e) Client/Server

Perl is powerful server side programming language because Perl is the only regular language.
For instance,
Computing two numbers at sever side
Client programming

```
 use IO::Socket;
$socket = new IO::Socket::INET (
                PeerAddr  => '127.0.0.1',
                 PeerPort  =>  7008,
                  Proto => 'tcp',
                      )
or die "Couldn't connect to Server\n";
   $socket->recv($recv_data,1024);
   if($recv_data){
   print "Sum is is $recv_data\n";
   }
   else
   {print("Server is not working:Restart the sever and recompile the server program\n");}
   sleep(20);
```

Server Programming

```
use IO::Socket;
$| = 1;
$socket = new IO::Socket::INET (
                      LocalHost => '127.0.0.1',
                       LocalPort => '7008',
                        Proto => 'tcp',
                         Listen => 5,
                         Reuse => 1
                       );
die "Coudn't open socket" unless $socket;
print "\nTCPServer Waiting for client on port 7008";
while(1)
{
        my($new_sock,$buf);
     $buf=sum2();
        $client_socket = "";
        $client_socket = $socket->accept();
        $peer_address = $client_socket->peerhost();
        $peer_port = $client_socket->peerport();
        print "\n I got a connection from ( $peer_address , $peer_port ) ";
     $client_socket->send($buf);
     close $client_socket;
sub sum2() {return 7+3;}
}
```

V. Python Programming

Python is preprocessor and portable language. Python has import and other features for green computing

a) Recursion

```
# factorial
def fact(n):
   if (n <= 1):
```

```
    return 1
  else:
    return n * fact(n - 1)
```

b) Regular

```
#Searching text
txt = "Artificial Intelligence"
x = re.search("Intel", txt)
print(x)
```

c) Object-Oriented

```
print(fact(6))class table():
  # init method or constructor
  def __init__(self, customer, barrar, table):
    self.cust = customer
    self.barrar = barrar
    self.table = table
  def show(self):
    print("customer is", self.cust )
    print("supplier is", self.barrar )
    print("table  is", self.table )
# both objects have different self which
# contain their attributes
table1 = table("rama", "barrar1", "table1")
table2 = table("krishna", "barrar2", "table2")
table1.show()
table2.show()
```

The output is given by

```
customer is rama
supplier is barrar1
table  is table1
customer is krishna
supplier is barrar2
table  is table2
```

Python is portable using import.

```
import string
text = input('text: ')
symptoms = text.split()
symptom1='appreciating-colors'
symptom2='glaring'
symptom3='recognizing-faces'
```

If symptom1 in symptoms and symptom2 in symptoms and symptom3 in symptoms:
Print ('patient diagnosed cateract')

d) Client and Server

Python is portable to use for client/server programming.
For instace,

Server

```
import socket
serv = socket. Socket (socket.AF_INET, socket. SOCK_STREAM)
serv.bind(('0.0.0.0', 8080))
serv.listen(5)
while True:
  conn, addr = serv.accept()
  from_client = ''
  while True:
    data = conn.recv(4096)
    if not data: break
    from_client += data
    print from_client
    conn.send("I am SERVER<br>")
  conn.close()
  print 'client disconnected'
```

Client

```
import socket
client=socket.socket(socket.AF_INET,
socket.SOCK_STREAM)
client.connect(('0.0.0.0', 8080))
client.send("I am CLIENT<br>")
from_server = client.recv(4096)
client.close()
print from_server
```

VI. Green Computing Technology

Green computing technology mainly has two criterions fundamentals of computer science and nature of computer science.

a) Fundamentals of Computer Science

Fundamentals of computer science may be defined as

Finite Automata
Regular Expression
Context-Free Grammar
Turing Machine
Digital Logic

b) Nature of Computer Science

Some of Nature of computer science may be defined as

Nature of Clouds
Nature of Neurons
Nature of Genetics
Nature of Trees and Forest
Nature of Proteins

VII. Conclusion

Perl and Python are best for Green Computing or clean computing. Perl is regular language and powerful at sever side programming. Python is pre-processor and it is portable with import feature. We try to discuss m Perl and Python programming languages for green computing.

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Global Journal of Computer Science and Technology: C
Software & Data Engineering
Volume 21 Issue 1 Version 1.0 Year 2021
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Assessing the Price Relationship and Weather Impact on Selected Pairs of Closely Related Commodities

By Adebanjo Adeniyi, Franklyn Ogbeide Okogun & Olaniyo Opiribo
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Abstract- As indicated by various works of literature, climate change has a significant impact on agricultural commodities resulting in variation between demand and supply. The research study adopted quantitative analysis for comparative analysis of price relationships for three pairs of agricultural commodities against closely related products and how weather impacts them. As an interesting comparison, we also selected a pair of non-agricultural commodities for analysis. Downloaded data for the analysis were daily historical price data for the commodities, and daily summary of weather data for precipitation and temperature for the regions were the selected commodities are most produced. Using programming languages like Python and R, we carried out exploratory data analysis using the following statistics, such as graphs, scatter plots of returns, QQ plots for normality, time series diagnostics (AC, PAC) ARIMA, correlation. An exciting part of our work is our model selection, where we used SARIMAX for regressing endogenous data, i.e., commodity prices and exogenous data weather data.

Keywords: *commodity, weather, python, Q-Q, ARIMA, AC, PAC, SARIMAX, correlation, data.*

GJCST-C Classification: *G.1*

Strictly as per the compliance and regulations of:

Assessing the Price Relationship and Weather Impact on Selected Pairs of Closely Related Commodities

Adebanjo Adeniyi [α], Franklyn Ogbeide Okogun [σ] & Olaniyo Opiribo [ρ]

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I. Introduction

a) Background Study

Agriculture is an activity that involves the "rearing of livestock and cultivation of crops for human need and commercial activity." Agriculture relevance is evident in the economy of a country, primarily through commodity trading [9].

Commodity markets avail traders to buy and sell commodities, which include raw materials or primary agricultural products, which is as a result of what farmers and industry produce or extract. It has a similarity to the equity market. However, in the equity market, investors buy and sell shares.

We can categorize commodities into soft commodities and hard commodities. The soft commodities comprise coffee, cocoa, and heat, while gold, silver, and oil make up the hard commodity. We can further break down Commodity market into four categories; Energy (heating oil, crude oil, natural gas), metals (silver, gold, platinum, zinc), Livestock and meat (poultry eggs, cattle, lean hogs) and, Agricultural (rice, wheat, corn, and soybeans).

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The commodity market can influence the cost of commodity products and also determines the price for some products. Nonetheless, weather can also have a positive or negative effect on the yield of an agricultural product.

The agricultural commodities market is subjected to unavoidable change in prices as a result of seasonal transition due to climate change which give rise to underlying extreme events like heat stress, droughts, floods, hail, frost, pest and disease outbreaks, rising carbon dioxide, which could give rise to adverse effect on agricultural commodity availability. On the other hand, a notable significant effect of weather changes could give rise to critical factors, which include the concentration of carbon dioxide (CO2), which increases light intensity, soil moisture, water availability, soil nutrients, and temperature.

Previous work by Masters had emphasized on some agricultural commodities in specific regions and their relationship to climate change. The work emphasized that "Without doubt, climate change is occurring and is already having a dramatic impact on climatic variability, global temperatures, and sea level. Climate change will have significant impacts on agriculture, reflecting the close link between climate (temperature and precipitation in particular) and productivity, and these effects are likely to have the greatest effect in the least developed countries of the tropical zones where productivity will decrease" [36].

b) Problem statement

Demand and supply, an economic concept, is a conventional fundamental analysis in a market where prices are not regulated. Product availability is substantially controlled by consumption and production at various periods in a calendar year. The agricultural commodity market is not an exception where there are numbers of production and consumption impacting factors. These tend to have demand variation among items of similar class and also causing wide swings in commodity prices.

Majorly, macroeconomic factors ranging from inflation, foreign reserve, and exchange rate are known factors that can cause variation in agricultural products. Nevertheless, seasonal transition as a result of climate change tends to cause a more significant impact, and

this leaves investors with the choice of whether to buy or sell at a given period, mainly due to the weather impact on commodity products.

Climate change has adverse effects on the world and has become a significant barrier to economies; the effect of climate change on agricultural commodities causes volatility, and this causes the commodity price to fluctuate in extreme weather events. Moreover, variation in temperature, precipitation, and the frequency and intensity of extreme weather could have significant impacts on crop yields.

This study seeks to investigate the price relationships between three categories of agricultural commodities and one non-agricultural commodity against closely related products, i.e., Corn/Oat, Soybean/Wheat, Coffee/Cocoa, and Gold/Silver as the non-agricultural commodities.

Furthermore, the study seeks to analyze the impact of weather on Agricultural commodities. It also examines the implications of extreme weather conditions on commodities prices, and to this end, SARIMAX will be used to further check for seasonality in the prices, and the effect temperature and precipitation trend have on the different commodities.

c) *Goals and Objectives*

i. *Goal*

The goal of this research project is to assess the price relationship for three pairs of closely related agricultural commodities and a pair of closely related non- agricultural commodities and also the effect of weather on the commodities.

Corn/Oat, Soybean/Wheat, Coffee/Cocoa, and Gold/Silver

ii. *Objectives*

- To analyze returns to see correlation peak across different differencing intervals: daily, weekly, and monthly.
- To investigate the seasonality in prices of Corn/Oat, Soybean/Wheat, Coffee/Cocoa, and Gold/Silver.
- To compare the trend in temperature and precipitation with price variation of the chosen commodities.
- To determine a suitable model to regress weather data with the commodity data.

d) *Significance of the study*

The research work, when completed, will be useful to institutions, policy-makers, educators, strategists, and researchers with interest in the impact of weather on agricultural commodities. The study, therefore, bridges the research gap with an insight into the quantitative analysis of price variation as a result of weather impact on agricultural commodities.

II. Literature Review

a) *Introduction*

As outlined in our problem statement, the objective of this study is to analyze daily data of some agricultural commodities against closely related products in certain regions, investigating the seasonality of these prices and the correlation peak across different differencing intervals relative to temperature and precipitation.

This chapter comprehensively summarizes previous research work of literature on methods used over time to measure the effect of climate change on agricultural commodities and the merits and demerits of these methods. The reviews include a survey of scholarly articles, books, and other sources relevant to the impact of weather on commodity products.

b) *Theoretical review*

Masters in their working paper had emphasized on some agricultural commodities in specific regions and their relationship to climate change. The work emphasized that "Without doubt, climate change is occurring and is already having a dramatic impact on climatic variability, global temperatures, and sea level. Climate change has significant impacts on agriculture, and this change cannot be overemphasized on agriculture, considering the correlation between temperature, precipitation, and productivity resulting in a noticeable effect on less developed countries" [36].

Master's work also highlighted how “climate as a condition could give rise to underlying extreme events like heat stress, droughts, and floods, pest and disease outbreaks, rising carbon dioxide levels, which could have both detrimental and beneficial, on crop yields in specific cases." In all, these extreme conditions will hurt the production of agricultural commodities leading to food shortages and food insecurity [36].

Eva et al. in their work pointed out that "the only certainty about climate change on agriculture are increasing uncertainty and variability and an increase in frequency and severity of extreme events (storms, hurricanes, droughts)" They also identified some developed countries with extreme scenarios where production declines severely [8].

Jasmien et al. estimate the consequences of exogenous shifts in global agricultural commodity prices on real GDP for a panel of 75 industrialized and developing countries. In their working paper, "they discovered that increases in global agricultural commodity prices that are caused by unfavorable harvest shocks in some regions of the world significantly curtail domestic economic activity." Jasmien's overall findings imply that the consequences of climate change on advanced economies are likely more significant than previously thought [33].

Munasinghe et al. developed a metric called "record equivalent draws" (RED) based on record-high (low) temperature observations by assessing the impact of climate changes, especially during very high and low temperatures, estimating the frequency of extreme temperatures in the 19th century. The simulated result for the period shows that mean temperature is positively correlated with RED's high temperature while negatively correlated with RED's low temperature. This metric model proved to serve as a precise instrumentation of global warming and cooling [41].

Addison et al. carried out a study on nine African countries that are dependent on a commodity that has a significant effect on their income. "This paper used a quantitative method to measure the effect of commodity price surge using a structural non-linear dynamic model." The paper addresses whether the response of GDP per capita for the selected countries is different from unexpected increases in agricultural commodity prices as opposed to decreases in prices. Hence, it finalized that there is very little evidence that an unanticipated price increase (decrease) will lead to a significantly different response in per capita incomes [1].

Maria et al. considered models to measure the effect of climate change on agriculture. They emphasized that selection of model should consider various aspects which include "specific object of the analysis, the temporal and geographical scales, the specific forms of climate change (climate warming, weather fluctuations or extreme climatic events), the magnitude of the effects expressed according to the agricultural dimensions (biological, social or economic)." Emphasis was laid on the choice of model to implement as one of the vital steps in the assessment. Their work also "considered the lack of information by offering to researchers a useful tool with which to identify all the possible alternatives of models analyzing the effects of climate change on agriculture." Different models where consider, which include the Crop Simulation Models, the Production-Function Model, the Ricardian Model, the Mathematical Programming, the General Equilibrium Model, and the Integrated Assessment Models [35].

c) *Models used to measure the effect of Climate Change*

i. *The crop simulation method*

The crop simulation method focuses on "crop physiological responses to ascertain the potential impacts of climate change on agriculture. It is one of the most popular methods for assessing the impact of climate change on agriculture. The crop simulation approach begins with controlled experiments in laboratories and other controlled settings to describe and model the bio-physical reactions of different crops to changing environmental conditions". In these controlled experiments, researchers attempt to isolate the influence of the various inputs on the actual magnitude of outputs. They attempt to identify the influence of climate, changes in carbon dioxide content in the atmosphere, soil, and management practices on yields of various crops.

These models use the "best available knowledge on plant physiology, agronomy, soil science, and meteorology in order to predict how a plant will respond under specific environmental conditions" [34]. The crop simulation models are calibrated to the selected location for selected crops given a particular management practice. From these experiments, "the yield changes are then extrapolated to the real world and speculate what the experimental results imply for the agricultural systems across the given region. Some examples of crop simulation models include CERES-Maize and CERES-Wheat". The methods are based on detailed experiments to find out the response of specific crops and crop varieties to different climatic and other conditions [42].

A study carried out by Iglesias et al. "estimated the impact of climate change across spatial scales in significant wheat-growing sites of Spain. They used CERES-Wheat, a dynamic process crop growth model for examining wheat growth. Using the model, the authors further examined the response of irrigation, temperature, precipitation, and CO2 concentration on wheat yield. The results from the spatial analysis revealed similar results to the CERES-Wheat crop growth model". The important conclusion from the empirical results is that water (both precipitation and irrigation) and temperature during the farming season significantly affect the variability of simulated crop yield [45].

Schneider et al. used an "Erosion Productivity Impact Calculator (EPIC) crop simulation model to see how farmers respond to natural variability to climate changes in the US Great Plains. They used the EPIC model, under a doubling of CO2 scenario, to calculate changes in crop yields for three groups of farmers in terms of adaptation practices: no adaptation, perfect adaptation, and 20-year lagged adaptation". The 20-year lagged adaptation group is used to mimic the masking effects of natural variability on their ability to notice changes in climate. Adaptation options tested in the EPIC crop model included: varying planting dates, changing crop varieties, and regulating crop growth period. Their findings suggest that the warmer temperatures enabled farmers to plant early in the spring to avoid the risk of damage from high heat levels in critical reproductive periods in mid- summer. Besides, with a longer growing period, farmers were able to attain higher yields by choosing to grow lengthy maturity varieties with more extended grain- filling periods. The results from the EPIC crop model show that adaptation improves crop yields and support findings from other studies that adaptation serves to reduce potential adverse effects from changes in climate. There are

"some critical limitations of crop simulation models. These limitations mostly relate to adaptation. The crop simulation model does not endogenize farmer behavior, and the model does not predict how farmers are likely to change their behavior as climate changes. The weakness of this approach is its inability to modeling the intricate farmer responses to the environment change". The management practice of the farmer is assumed to be exogenous or fixed. If "farmers continue to behave as they did when they calibrated the model, the results are accurate" [48].

Furthermore, crop simulation models have been calibrated only in a limited number of places. The model is associated with a very high cost, and this makes poor and developing countries should rely on experiments conducted in a developed country. If these locations are not representative of all farms, using such approaches in aggregate studies can provide misleading predictions [38].

ii. *Empirical Yield Method*

The empirical yield methods measure the sensitivity of yields to climate by measuring how yields vary under different climate conditions through actual observations. "The basic idea of this approach is that the growth of agricultural production depends on water, soil, economic inputs, and climate variables that the model uses as explanatory variables in estimating the production function for specific crops" [31].

From the empirical production Function, "one can isolate the effects of climate from other factors influencing yields. For example, one can construct cross- sectional studies of actual yields across different climate zones. Another way to empirically measure the sensitivity of yields is to examine the effect of weather on yields over time [40]. The first study in this area relied on a unique weather condition called the 'dustbowl' in the middle of the USA in the 1930s". For a brief period, temperatures were higher and precipitation slightly lower, leading to unusually dry soil conditions in this region. The study measures the reduction in yields of selected grains in this period compared to periods with typical weather across the region.

Poudel et al. attempted to investigate the effects of rapid change in climate patterns driven by global warming on agricultural production in Nepal with a focus on whether the impacts vary across seasons, altitudes, and the types of crops. Their work empirically identified the "changes in climate condition and its effect on agricultural production from the data of rice, wheat, and climate variables in Nepal." They employed a stochastic production function approach by controlling a novel set of season-wise climatic and geographical variables. They found that an increase in the variance of both temperature and rainfall has adverse effects on crop yields in general. Furthermore, the impact of the difference in the average rainfall and temperature found beneficial or harmful was related to the altitudes and the kinds of crops. The findings project that adaptation strategies should be adopted in "Nepalese farming activities, owing to altitudes, growing season, and the types of crops." [47]

The empirical yield function approach has some of the same limitations as the crop simulation approach. The main weakness of the production–function model is that it focuses on a specific crop or limited set of crops. It endorses the so-called 'dumb farmer' hypothesis, and farmers are assumed to continue growing the same crop, with the same technology regardless of the change in the climate. The model excludes from the analysis of the plausible farmer strategies that replace crops that are more sensitive to others that are less so. The model does not pay due attention to the social and economic dimensions of agriculture. This model, coupled with other models, will be relevant to treat the economic dimension better.

iii. *Cross-sectional (Ricardian) Analysis*

Mendelsohn, Nordhaus, and Shaw introduced a cross-sectional approach that examines how farmland value varies across a set of exogenous variables such as economic, climatic, soils, and environmental factors. It is called the "Ricardian Method" after the 19th-century classical economist David Ricardo (1772-1823), who observed that land values would reflect land profitability within a perfectly competitive market. The approach is a hedonic model of farmland pricing that assumes the value of a tract of land equals the discounted value of the stream of future rents or profits derivable from the land. The "cross-sectional Ricardian approach is a direct method of measuring climate sensitivity across locations." The technique estimates the net productivity of farmland as a function of climate, soils, and other control variables. The method stands on the theoretical foundation that one can measure the impact of the climatic variable of interest on the value or net revenue of the land by examining the relationship between climatic variables and land value [37]. The technique that relies on a cross-sectional sample of farms that span a range of climates and agricultural systems in different climate zones are observed to see how the systems respond to being indifferent climate settings [39].

As with all empirical methods, the more accurate the measurements of the variables, the better-uncontrolled variables are accounted for, the more variation in the desired variables (climate), and more extensive the sample size, the more accurate the results. The method is based on the idea that farmland value contains the value of climate as well as all other attributes that determine land productivity. By regressing farmland value (or net farm revenue) per hectare on a set of climate variables (for example, rainfall and temperature measured either in annual or seasonal

basis) environmental characteristics (for example soil), socio-economic and other control variables, "one can determine the marginal contribution of each of these factors to farm income capitalized in land value (or net farm income)." The economic impact of climate change is captured by the difference in land values (or net revenue) across different climatic conditions. This approach estimates of farm performance across different climate conditions that can be used to infer the consequences of future climate change [40].

The model considered that farmers, given limiting factors, that they cannot control, choose a set of outputs and inputs to maximize profits. The Ricardian method implicitly captures adaptation by including decision making changes that farmers would make to tailor their operations to a changing climate. A notable example of armer adaptation strategies is crop choice, where a particular crop will become the optimal choice depending on the effects of a warmer climate. Optimal crop switching is, therefore, an essential component of measuring the agricultural impact of climate.

The "advantage of the cross-sectional approach is that it fully incorporates farmer adaptations. The underlying assumption of the model is that farmers will automatically make adjustments in their management practices and respond to changes in climate; the approach does not suffer from the ad hoc adaptation adjustments of all the other approaches". The assumption of implicit farmer adaptations frees the analyst from the burden of including adaptation while estimating the impacts of climate change.

Moreover, "it is assumed that because farmer adaptations will be reflected in land values, the costs and benefits of adaptation are embedded in those values." However, the adjustments are not explicitly modeled; the technique treats adaptation as a "black box." It does not reveal the precise adjustments made by individual farmers to suit the local conditions they face. Since the Ricardian approach implicitly captures the adaptations, it becomes possible to make a comparative assessment of climate change impact on agriculture with and without adaptation and provides valuable insight to know how adaptation measures reduce the impact of climate change [37].

According to the IPCC AR4 chapter addressing climate change impacts on food production deals almost exclusively with estimates of effects of changes in the long-run means of temperature and precipitation on crop yields and livestock productivity [6].

Extreme events may lower long-term yields by directly damaging crops at specific developmental stages, such as temperature thresholds during flowering, or by making the timing of field applications more difficult, thus reducing the efficiency of farm inputs [46].

"Several simulation studies have developed specific aspects of increased climate variability within climate change scenarios." Rosenzweig et al. computed that, under scenarios of increased heavy precipitation, production losses due to excessive soil moisture would double in the USA by 2030 to $3bn per year [44].

The reviewed work had so far established the relationship between agricultural commodities and the impact of climate on their production. More so, the majority of the work had addressed the subject matter from a qualitative point of view. Also, the world forum focus had been towards creating a framework to address climate change issues. The majority of countries had adopted policies that address climate change. Nevertheless, these changes impacted the production of an agricultural product positively?

This research work poses to quantitatively investigate the impact of climate change on the selected agricultural and non-agricultural commodities in a specific region.

d) Competitor Analysis

In this section, we took a look at three of the world top five producers of the selected commodities and compared most under the following criteria:

1. Production
2. Export
3. Domestic Consumption
4. Growth rate

Corn production (1000MT) by country shows the United States to be in the lead with 347,006, followed by China with 254,000 and Brazil with 101,00 [10]. The United States has a production growth rate of -5.26%, China, with -1.29% and Brazil with 0.00% [11]. Export for the United States is 46,992 and China with 20 and Brazil with 36,000 [12]. As for domestic consumption, the United States with 306,466 seems to consume most of what they produce, while China domestic consumption stood at 277,000 and Brazil at 66,000 [13].

Oats production (1000MT) by country, EU-27 is number one with 7,920 with Russia in second with 4,300 and the third place going to Canada with 4,000 [14]. Norway, on the other hand, leads the growth rate for Oats at 108.33%, with Russia at -8.80% and Canada with 16.41% [15]. Oats export from EU-27 is at 125 and Russia at 90, while Canada is at 1800 [16]. Domestic consumption in the EU-27 stands at 7,750 while in Russia it is 4,200 and Canada with 2,000 [17]

Soybean production (1000 MT) by country shows China as the leading producer with 66,924, followed by the United States with 44,904, while Brazil is in 3rd with 33,950. [18]. China has a growth rate of -0.59%, the United States with 1.14%, and Brazil with 1.80 % [19]. China export is at 900, and the United States has 12,111 and Brazil with 15,200 [20]. China domestic consumption is 66,074, United States is 33,249 while Brazil is 18,950 [21].

Wheat production (1000 MT) by country indicates EU-27 is number one with 153,000, followed by China at 132,000, and India being 3rd in the world has 102,190 [22]. EU-27, though, is the number one producer, but they only have a growth rate of 11.79%, while China has 0.43%, and India has 2.32% [23]. EU-27 export is at 29,000, which is 2nd in the world, China is 1,300, making them 10th in the world, and India is a distance 19th with 500 [24]. Domestic Consumption for EU-27 is 127,500, China is 128,000 and India is 98,000 [25]

Coffee production by country (1000 60 KG Bags) has Brazil on top with 59,300, followed by Viet Nam with 30,500 and then Colombia with 14,300 [26]. Interestingly, Brazil has a growth rate of -8.49% and Viet Nam 0.33% and Colombia with 0% [27]. Brazil maintains the highest export at 36, 820, with Viet Nam having 28,300 and Colombia 13,400 [28]. Brazil consumes 23,530 domestically, and Viet Nam consumes 3,400 and Colombia with 2,050 [29].

Cocoa production by country (1000MT) has Cote d'Ivoire on top with 1,449, followed by Ghana with 836 and Indonesia with 778. [51]

China is the top Gold producing nation with 399.7 tons, followed by Australia with 312.2 tons, with production up 6 percent in 2018. Russia, with a production of 281.5 tons' accounts for a massive 83 percent of European gold, which has been increasing its production every year since 2010 with output growth of 11 tons in 2018, or about 2 percent. [50]

The number one silver-producing country in the world is Mexico, with 5,600 metric tons of the metal, followed by Peru with a significant jump that took its silver production to 4,500 metric tons of silver in 2017. China, which produced 2,500 metric tons of silver, is on the 3rd. [50]

In conclusion, one can observe that the world's highest producers of a given commodity do not necessarily have the world's highest growth rate. Brazil, for example, being the world's highest producer of coffee, has a negative growth rate of -8.49%, and this might not be farfetched from climate-related events.

III. Research Methodology

a) *Introduction*

In this chapter, we introduce the method we used to carry out time series analysis in detail. We started with identifying the source for our data and the method for collection – where and how we got these data, and also, we show the background knowledge about our statistic method. Finally, we present the research criteria – validity and reliability. In other to achieve our goal as stated in chapter one the following methodology was used; Figure 3.1 below shows the methodology used in the study from gathering the data to drawing conclusions.

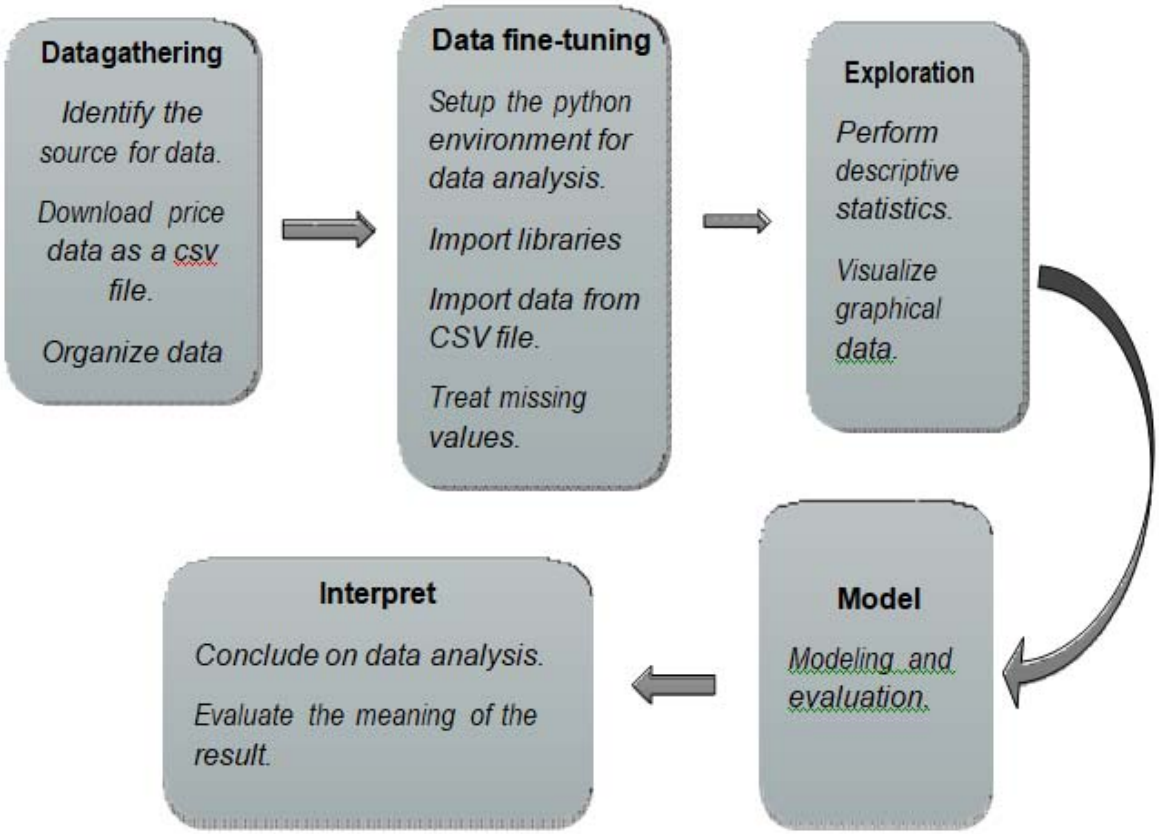


Figure 3.1: Taxonomy of the methodology

b) Data gathering

We address the research question first by identifying the data source, which is evidence to study. The approach to collect evidence depends on the research strategy and research question itself. "Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes" [5].

As illustrated by Ellen et al., their work emphasizes the importance of data collection. It is a critical part of time series analysis and about the vital part of research work. Hence, "Collect your data as if your life depends on it!". [7]

For this research work, data gathering and method form an integral part of the study. According to Adi, there are mainly two methods to collect data, which are the primary methods of data collection and secondary methods of data collection. [2]

The primary data source is direct evidence of the originator, and it is not used in the past. The data gathered by primary data collection methods are specific to the motive of the research and highly authentic and accurate. We can further break down the primary data collection method into two categories: quantitative methods and qualitative methods. [2]

Secondary data is the data that has been used in the past and can be obtained from sources such as internal; Organization's health and safety records, Mission and vision statements, Financial statements Magazines, Sales reports, CRM software executive summaries and external sources of secondary data: Government reports, Press releases, Business Journals, Libraries, Internet. [2]

For our research work, our data collection and source fit both categories of the data collection method. However, its relevance can be seen in the secondary data collection, which cascaded down to a quantitative technique where statistical methods are highly reliable as the element of subjectivity is minimum in these methods. A vital tool in this method is the time series analysis, which can accommodate smoothing techniques to eliminate a random variation from the historical data.

Sourcing the right data was a critical part of our capstone project, and care was taken to ensure our data was sources from a reliable site.

Two sets of data were sourced for the project as follows:

- Commodity data
- Weather data

Data were sourced for the following eight commodities Oats, Corn, Wheat, Soybean, Coffee, Cocoa, Gold and Silver from the following sites:

- Macrotrends - https://www.macrotrends.net/ (Oats, Corn, Wheat, Soybean, and Coffee)
- Quandl - https://www.quandl.com/ (Cocoa, Gold, and Silver)

The number of years of data collected varies from one commodity to another, and Table 3.1 below is a summary of the range of the data collected.

Table 3.1: Price data

Commodity	Start Date	End Date	Number of Years
Cocoa	1/5/1970	11/15/2019	49
Coffee	8/20/1973	11/11/2019	46
Corn	7/1/1959	11/11/2019	60
Oats	1/5/1970	11/11/2019	49
Wheat	7/1/1959	11/11/2019	60
Soybean	12/5/1968	11/11/2019	49
Gold	1/2/1968	11/14/2019	51
Silver	1/2/1968	11/14/2019	51

Data was also collected for the weather as it relates to areas/regions where the selected commodities are most produced. This weather data is to investigate the impact or non-impact of weather on the price of the commodities.

The period of weather data collected varies for each region and where taken from specific weather station within the production area from the site https://www.ncdc.noaa.gov/cdo-web/.

Table 3.2: Summary of Weather Stations used for data collection

COMMODITIES	STATION	NAME	LATITUDE	LONGITUDE	ELEVATION
Oats	CA005021695	MARQUETTE, MB CA	50.0167	-97.8	244
Corn	AR000087374	PARANA AERO, AR	-31.783	-60.483	74
Wheat	RSM00021946	CHOKURDAH, RS	70.6167	147.8831	44
Soybean	ARM00087582	AEROPARQUE JORGE NEWBERY, AR	-34.559	-58.416	5.5

Coffee	BR00E3-0520	SAO PAULO AEROPORT, BR	-23.617	-46.65	802
Cocoa	IVM00065578	ABIDJAN FELIX HOUPHOUET BOIGN, IV	5.261	-3.926	6.4
Gold	ASN00066037	SYDNEY AIRPORT AMO, AS	-33.9465	151.1731	6
Silver	MXM00076525	ZACATECAS ZAC. LA BUFA ZAC, MX	22.77492	-102.5869	2,673

c) Research Method

"Data wrangling, sometimes referred to as data munging, is the process of transforming and mapping data from one "raw" data form into another format with the intent of making it more appropriate and valuable for a variety of downstream purposes such as analytics" [3].

In essence, our research method is a quantitative study with a time series analysis. We choose historical price data and precipitation/ temperature data as our objectives to study the impact of weather on agricultural commodities. We collect a daily sequence of commodity historical price data from macrotrends website; "www.macrotrends.net" and "quandl" website; "www.quandl.com" websites. Similarly, we also downloaded daily summary of weather data (temperature and precipitation) for top producing countries of the chosen commodities from the National Centers for Environmental Information website "www.ncdc.noaa.gov/cdo-web/."

These data were analyzed thoroughly with statistic tools with an emphasis on comparative technique. Since data collected were from different periods, there was a need for us to carry out some form of data clean up to bring the data to a usable form. To archive this, we used Python 3.6 to write the code to carry out the data clean up. Steps followed in the time series analysis are listed below;

i. *Programming tool*

- We used the Python programming language (version 3.6) to carry out time- series analysis on the downloaded data. Python allows us to perform manipulation on time and date based data, visualize time series data, identify which models are suitable for a given dataset, create models for time series data. It also contains libraries that are suitable for time series analysis.

Imported libraries for our analysis include but not limited to, the following: matplotlib, numpy, pandas, sklearn, csv, scipy, stasmodels, seaborn. With the use of Jupyter notebook, required libraries were loaded using mostly the "import" statement

ii. *Price data*

- Preliminary analysis of price data: In this step, based on our objectives, we imported our data using the "CSV" library in python through jupyter notebook. Due to the anomalies that are found present in our imported dataset, we perform cleaning of our data to fit the analysis that will be performed subsequently. The data cleaning mainly encompasses using python programing language to carry out treating missing values and selecting/grouping of data according to findings in the preliminary analysis,
- Calculate Daily and Weekly Returns of grouped data: Daily and weekly returns were calculated on grouped data using the "pct_change()" function.
- Calculate spread and percentage change in the spread: Spread and percentage change in the spread were also calculated on grouped data.
- Calculate Ratio of Product Pair: Ratio was calculated among closes related product pairs.
- Plotting of product pairs: Product pairs were plotted in three categories; these include; plotting of raw data pair, plotting returns of product pairs, and plotting the spread/ratio of product pairs.
- A normality test: This test was carried out using the Q-Q test in python. This test was carried out on each of the returns of the commodity price data.
- Compute correlation matrix: This was carried out on daily and weekly returns to find out correlation among pairs.
- Skewness and Kurtosis: This test was carried out on the daily and weekly return of commodity data.
- Time Series Analysis (Serial correlation, ARIMA, ADF test): Based on the assumption that the time series are stationary for time series models, it is significant to validate it. The Augmented Dickey-Fuller test, which is a type of statistical test called a unit root test, was used to test for stationarity of our data. The Null-hypothesis for the test is that the time series is not stationary. So if the test statistic is less than the critical value, we reject the null hypothesis and say that the series is stationary. This test was carried out on the daily returns of the commodity data.

Next, after confirmation of stationarity, to select the relevant time series model, we carried out an autocorrelation plot to determine the value of q and p for SARIMAX.

iii. *Weather data*

- Loading and Cleanup of weather data using python pandas
- Interpolate to replace missing values
- Plotting raw precipitation and average temperature data for different production areas

d) Data Analysis

In this research, we mainly use comparative analysis as our statistical tools to analyze our closely related product data.

A comparative analysis is mainly used to investigate the relationships between different variables; it provides a way for an investigator to explore a specific quantitative causal effect between these variables. For a long time, comparative techniques have become a central tool for multi-factor data analysis in the economic statistics field.

In our approach for comparative, we considered:

- Loading and cleaning data
- Treat missing value
- We regress different commodities data against weather data to assess the impact

e) Model Justification

SARIMAX model stands for Seasonal Auto Regressive Integrated Moving Average. It is a general time series model, "and is used to analyze and forecast data which have an additional seasonal component. We derive values for p, d, and q in order to make the time series stationary. A stationary series has a constant mean and variance." A general explanation of a SARIMAX model is illustrated in figure3.1 below; [43]

$$\text{ARIMA}\ \underbrace{(p,d,q)}_{\substack{\uparrow\\ \text{Non-seasonal part}\\ \text{of the model}}}\ \underbrace{(P,D,Q)_m}_{\substack{\uparrow\\ \text{Seasonal part}\\ \text{of the model}}}$$

Figure 3.1: SARIMA model [43]

The model is usually of the form; *SARIMAX (p, d, q) x (P, D, Q) m,* which contains the non-seasonal and seasonal parts, as shown in figure 3.1.

The interpretation of SARIMAX (p,d,q)(P, D, Q)m is as follows:

p - auto-regressive order.
d - differencing order.
q - moving average order.
P - seasonal auto-regressive order.
D - seasonal differencing order.
Q - seasonal moving average order.
m – seasonality period (e.g., 24, 7, 52, 12)

The model accommodates an exogenous variable that is independent of the states of other variables in series. Factors outside our model determine its value. For our research, temperature and precipitation is the exogenous variable, as the occurrence of high temperature could give rise to the negative effect of agricultural commodity thereby affect demand and supply of an agricultural product. Our reliability high as the implementation of this work is dependent on different Python libraries. The majority of the algorithm to use is already implemented in the python modules. Hence usability, expressivity, and readability of the programming language structure are enhanced.

IV. Data Analysis, Results and Interpretation

a) Dataset analysis

We must analyze our data set and its form. So in this section, we will further detail our analysis of the data set and its properties. This analysis will cover the preliminary stage to the final stage.

b) Sample selection

We choose the price data for four pairs of closely related commodities and also weather database on the locations where the commodities are most produced. The data were pulled from 1953 to 2019, with the frequency being daily.

Table 4.0: Summary of data for analysis

Date	Oats	Corn	Wheat	Soybean	Coffee	Cocoa	Gold	Silver
1973-08-20	1.272	3.115	5.085	8.40	0.6735	1310.0	107.25	2.673
1973-08-21	1.212	3.015	5.285	8.14	0.6710	1265.0	103.00	2.694
1973-08-22	1.152	2.915	5.085	7.74	0.6580	1247.0	103.50	2.590
1973-08-23	1.092	2.815	5.005	7.40	0.6675	1291.0	102.50	2.556
1973-08-24	1.150	2.900	5.180	7.80	0.6660	1271.0	100.50	2.587

Date	Oats	Corn	Wheat	Soybean	Coffee	Cocoa	Gold	Silver
2019-11-05	3.0075	3.8175	5.1525	9.3425	1.0580	2508.0	1504.60	18.045
2019-11-06	3.0700	3.7875	5.1675	9.2750	1.0800	2480.0	1488.55	17.540
2019-11-07	3.0525	3.7525	5.1250	9.3650	1.0910	2458.0	1484.10	17.530
2019-11-08	3.0425	3.7725	5.1025	9.3100	1.0945	2507.0	1466.85	16.810
2019-11-11	3.1225	3.7325	5.0575	9.1700	1.0600	2524.0	1465.50	16.880

c) Statistical description

As shown in Table 4.0 above, the table represents the dataset for the selected data, which includes all the commodity data for analysis. The commodities are characterized by variation in price data. Each of the commodities was selected within and included 1973 and 2019. We already treated missing values in the data set by interpolating missing values. Interpolation is a mathematical method, adjusts a function to data and uses the function to extrapolate the missing data.

We performed descriptive statistics of the dataset to analyze the features of each commodity.

Table 4.1 below is the summary of the descriptive coefficients of the dataset, which we achieved by using the "describe ()" method on the Data Frame.

Table 4.1: Descriptive statistic of the datasets

	Oats	Corn	Wheat	Soybean	Coffee	Cocoa	Gold	Silver
count	11893.000000	11893.000000	11893.000000	11893.000000	11893.000000	11893.000000	11893.000000	11893.000000
mean	1.943889	3.129648	4.181742	7.586832	1.258932	1963.916421	591.260424	10.168358
std	0.751662	1.209386	1.456574	2.630739	0.481101	735.023371	432.911233	7.619002
min	0.945000	1.427500	2.147500	4.100000	0.425000	736.000000	89.750000	2.522000
25%	1.400000	2.325000	3.192500	5.715000	0.928000	1377.000000	319.050000	4.919000
50%	1.700000	2.742500	3.762500	6.675000	1.234500	1876.000000	389.800000	6.317500
75%	2.287500	3.610000	4.807500	8.895000	1.466000	2446.000000	842.500000	14.640000
max	4.960500	8.312500	12.825000	17.682500	3.356300	4508.000000	1896.500000	49.450000

As shown in Table 4.1 above, each of the variables has an equal number of observations, i.e., N = 11893 observations denote the sample size from 1973 to 2019. Also, in the result, the mean value for each commodity is displayed. i.e., Coffee has the lowest mean price of approximately 1.25, while cocoa has the highest mean price of approximately 1964.

In this report, the standard deviation for Oats is 0.7517. With normal data, most of the observations are spread with "3" standard deviations on each side of the mean. Base on the standard deviation and the mean, wheat and soybean appears to have normal data.

The three values (25%, 50%, and 75%) indicate quartiles at different levels. The 1st quartile is at 25% (Q1), the 2nd quartile at 50% (Q2 or median), and the 3rd quartile at 75% (Q3) that divide a sample of ordered data into four parts. For oats, i.e., an ordered data, the Q1 is 1.4, which implies that 25% of the data are less than or equal to $1.4. Also, Cocoa has Q1 = 1377, which implies that 25% of cocoa price data are less than or equal to $1377

Also going by closely related pairs of commodities, the following can be deduced:

For Oats/Corn, standard Deviation for Corn is greater than the Standard Deviation of Oats. This means that Corn is more volatile than Oat. Mean for Corn is greater than the mean for Oats; this shows the return for Corn is greater than the return for Oats (for our sample date range).

For Wheat/Soybean, standard Deviation for Soybean is greater than the Standard Deviation of Wheat. This means Soybean is more volatile than Wheat. Mean for Soybean is greater than the mean for Wheat, this shows the return for Soybean is greater than the return for Wheat (for our sample date range).

For Coffee/Cocoa, standard Deviation for Cocoa is greater than the Standard Deviation of Coffee. This means that Cocoa is more volatile than Coffee. Mean for Cocoa is greater than the mean for Coffee; this shows the return for Cocoa is greater than the return for Coffee (for our sample date range).

Lastly, for Gold/Silver, Standard Deviation for Gold is greater than the Standard Deviation of Silver. This means Gold is more volatile than Silver. Mean for Gold is greater than the mean for Silver; this shows the return for Gold is greater than the return for Silver (for our sample date range).

The final descriptive analysis performed on the raw data is a histogram of the data overlaid with a normal curve to examine the normality of the price data. Figure 4.0 shows the plot for the selected raw dataset.

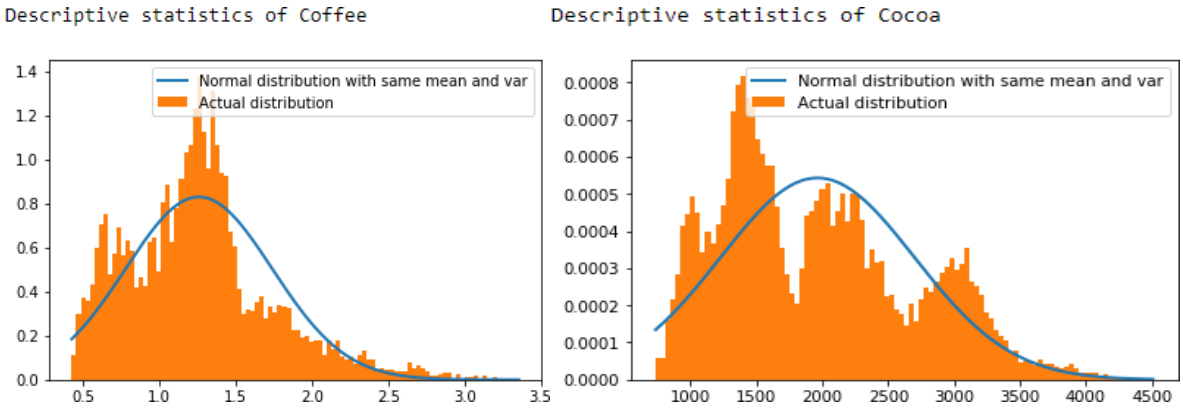


Figure 4.0: Normality test

As illustrated in the plots, the data appears to be a poor fit. A normal distribution would be a distribution that is symmetric and bell-shaped. For all the price data considered in our dataset, they appeared to be poor fit hence cannot conclude that they are normally distributed.

The next step involves calculating daily returns and weekly returns for each of the commodities. The figure below illustrates the result of descriptive statistics for the daily return.

Table 4.2a: Descriptive statistic for daily return

	Oats	Corn	Wheat	Soybean	Coffee
count	11892.000000	11892.000000	11892.000000	11892.000000	11892.000000
mean	0.000247	0.000121	0.000141	0.000112	0.000265
std	0.018542	0.014547	0.016823	0.014485	0.021356
min	-0.112518	-0.076232	-0.097874	-0.071429	-0.140410
25%	-0.010152	-0.007595	-0.009616	-0.007739	-0.010770
50%	0.000000	0.000000	0.000000	0.000390	0.000000
75%	0.010737	0.007796	0.009386	0.008175	0.010992
max	0.117417	0.094257	0.126984	0.068760	0.271298

	Cocoa	Gold	Silver
count	11892.000000	11892.000000	11892.000000
mean	0.000206	0.000297	0.000424
std	0.017357	0.012426	0.023461
min	-0.143293	-0.148100	-0.467213
25%	-0.009757	-0.005047	-0.008795
50%	0.000000	0.000000	0.000000
75%	0.009909	0.005481	0.009662
max	0.099598	0.133539	0.815650

As illustrated in Table 4.2a above, there is about 11892 sample size considered for each of the commodities. Silver, having the highest return, had a maximum value of 0.82 and a minimum value of -0.47. However, its Q1 is – 0.009, which implies that 25% of the daily return for silver is less than or equal to – 0 .09. Going by our first pairs of commodities, the standard deviation suggests that Oats is more volatile than Corn, Wheat is more volatile that Soybean, Coffee is more volatile than Cocoa, and Silver is more volatile than Gold.

Going by the weekly returns, 2412 sample size was considered for the weekly return of each commodity. As earlier noticed on daily return, Silver

maintained the highest value of 0.8915 and a minimum of -0.4352 when compared to other commodities.

Going by closely related pairs of commodities, the following can be inferred;

For Oats/Corn, the mean value for the daily returns of Oats is slighter greater than Corn's value. Also, the standard deviation for the daily returns of Oats is slightly higher than that of its closely related product, which implies that corn is less volatile when compared to its closely related product. This occurrence is also replicated in the weekly and monthly returns of Oats and Corn.

Wheat is slightly more volatile when compared to Soybeans. This is also replicated in the weekly and monthly returns for the closely related products.

In other closely related products, Coffee is moderately volatile than Cocoa; also, Gold is less volatile when compared to Silver. This description is also replicated in the weekly and monthly returns of each pair. This can be seen in Table 4.2b and 4.2c in appendix B.

Table 4.3a: Skewness and Kurtosis for daily returns

SKEWNESS and KURTOSIS RESULT ON DAILY RETURNS

Commodities	Skewness	Kurtosis
Oats	0.0626773	1.77503
Corn	0.0426126	2.58415
Wheat	0.211654	2.62211
Soybean	-0.116768	1.74379
Coffee	0.510605	8.60062
Cocoa	0.0272938	2.0969
Gold	0.357106	13.9622
Silver	3.31957	150.634

Skewness tells the amount and direction of skew. For the daily return, the skewness values are within the range of -0.5 and 0.5. This implies that the return distribution for the commodities is approximately symmetric except for silver with skewness of 3.32, which implies that its distribution is highly skewed.

We further investigated the unusually high skewness value for silver return data to understand this anomaly. From the graphs below, Figure 4.0a is the plot of the Silver data we used in our project, when compared with a similar graph of Silver data in Figure 4.0b sourced from "https://silverprice.org/silver-price-history.html" we noticed they are precisely the same which proof that our data are correct.

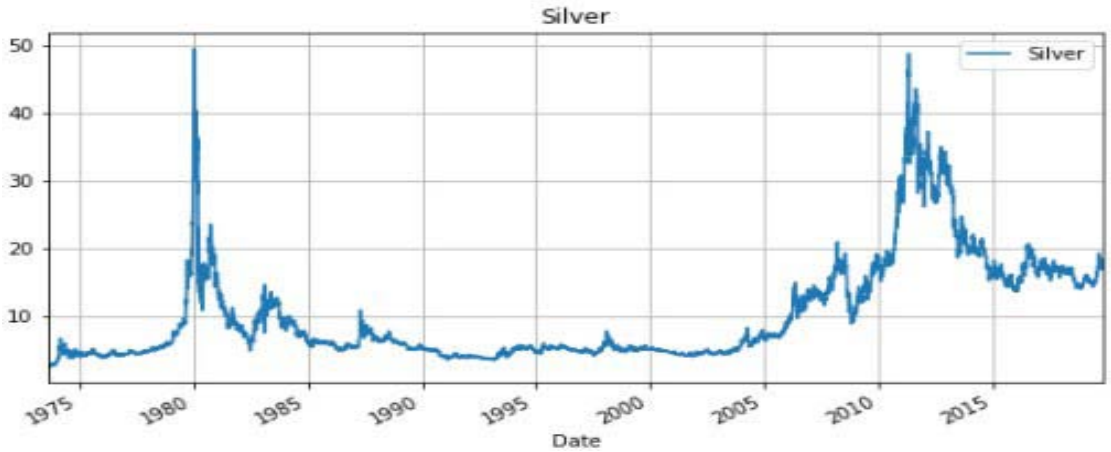


Figure 4.0a: Plot for Silver using our project data

Figure 4.0b: Plot for Silver [49]

To understand this further, we decided to break down our data into five years period and analyze each period separately. Table 4.3b below shows the skewness and Kurtosis values calculated for each five years period, and we discovered similar high skewness numbers in the period 1978 – 1983, which corresponded to the period silver price dropped to under $11 from its high of $48.70 [4].

Table 4.3b: Silver Skewness and Kurtosis for five years' period

Periods	Daily returns Skewness	Daily Returns Kurtosis
period_1 = ['1973-8-21': '1978-8-21']	0.13276071	4.760545859
period_2 = ['1978-8-22': '1983-8-22']	**3.896131243**	**84.35246364**
period_3 = ['1983-8-23': '1988-8-23']	-0.408416305	17.51717774
period_4 = ['1988-8-24': '1993-8-24']	0.320304353	4.827690375
period_5 = ['1993-8-25': '1998-8-25']	0.347668785	4.067214547
period_6 = ['1998-8-26': '2003-8-26']	0.115281399	1.835099532
period_7 = ['2003-8-27': '2008-8-27']	-1.041440941	5.62224845
period_8 = ['2008-8-28': '2013-8-28']	0.10090149	8.160369753
period_9 = ['2013-8-29':'2019-11-11']	0.071765419	2.488109109

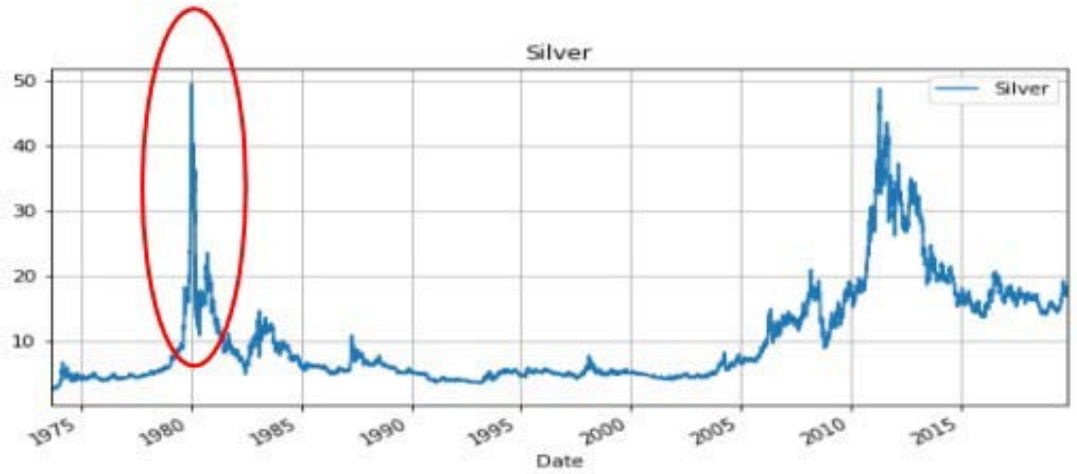


Figure 4.0c: showing the period when Silver Thursday occurred

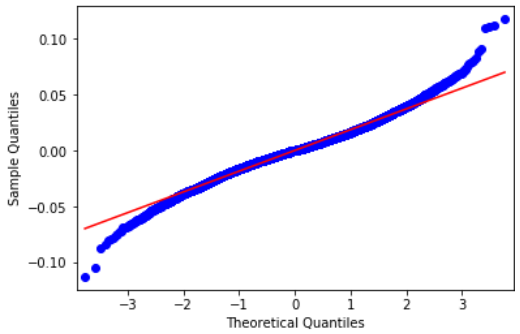
The phenomenon of 1980 is what is commonly referred to as "Silver Thursday," which was the "dramatic drop in the price of silver and the panic that ensued in the commodities market on Thursday, March 27, 1980. The sharp fall occurred because of the failed attempt of two brothers, Nelson Bunker Hunt and William Herbert Hunt, to corner the silver market." [32]

For the Kurtosis, as seen in table 4.3a, the majority of the commodity appears to be Platykurtic which, when compared to a normal distribution, its tails are shorter and thinner, and often its central peak is lower and broader. However, Coffee, Gold, and Silver appear Leptokurtic which, when compared to a normal distribution, has its tails longer and fatter, and often its central peak is higher and sharper. Excess kurtosis for Coffee, Gold, and Silver is reported for the return series and implies non-normality of distribution. This is also seen in the Kurtosis report for weekly and monthly returns of table 4.3c and 4.3d of appendix C.

d) Normality test

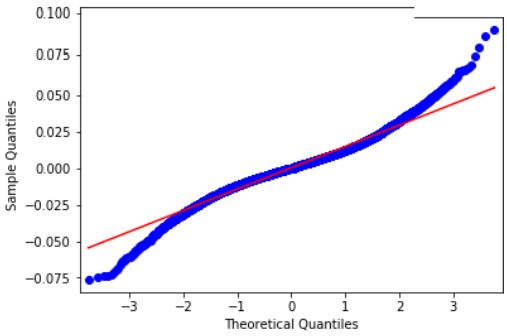
We went further to carry out a normality test to determine how well a normal distribution models our return series. A quantile-quantile (Q-Q) plot was used to show the distribution of the return series against the expected normal distribution.

```
=============
   QQ Plot
   Oats
=============
```



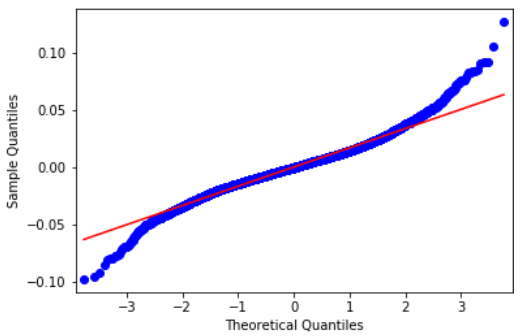

```
normality test for Oats
Statisitic: 43.757
15.000: 0.576,data looks normal(fail to reject H0)
10.000: 0.656,data looks normal(fail to reject H0)
5.000: 0.787,data looks normal(fail to reject H0)
2.500: 0.918,data looks normal(fail to reject H0)
1.000: 1.092,data looks normal(fail to reject H0)
.............................................
```

```
=============
   QQ Plot
   Corn
=============
```



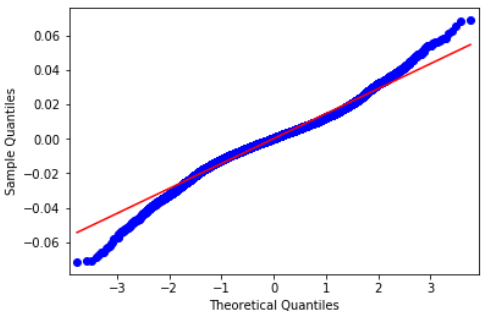

```
normality test for Corn
Statisitic: 80.317
15.000: 0.576,data looks normal(fail to reject H0)
10.000: 0.656,data looks normal(fail to reject H0)
5.000: 0.787,data looks normal(fail to reject H0)
2.500: 0.918,data looks normal(fail to reject H0)
1.000: 1.092,data looks normal(fail to reject H0)
.............................................
```

```
=============
   QQ Plot
   Wheat
=============
```




```
normality test for Wheat
Statisitic: 52.897
15.000: 0.576,data looks normal(fail to reject H0)
10.000: 0.656,data looks normal(fail to reject H0)
5.000: 0.787,data looks normal(fail to reject H0)
2.500: 0.918,data looks normal(fail to reject H0)
1.000: 1.092,data looks normal(fail to reject H0)
.............................................
```

```
=============
   QQ Plot
   Soybean
=============
```




```
normality test for Soybean
Statisitic: 64.909
15.000: 0.576,data looks normal(fail to reject H0)
10.000: 0.656,data looks normal(fail to reject H0)
5.000: 0.787,data looks normal(fail to reject H0)
2.500: 0.918,data looks normal(fail to reject H0)
1.000: 1.092,data looks normal(fail to reject H0)
.............................................
```

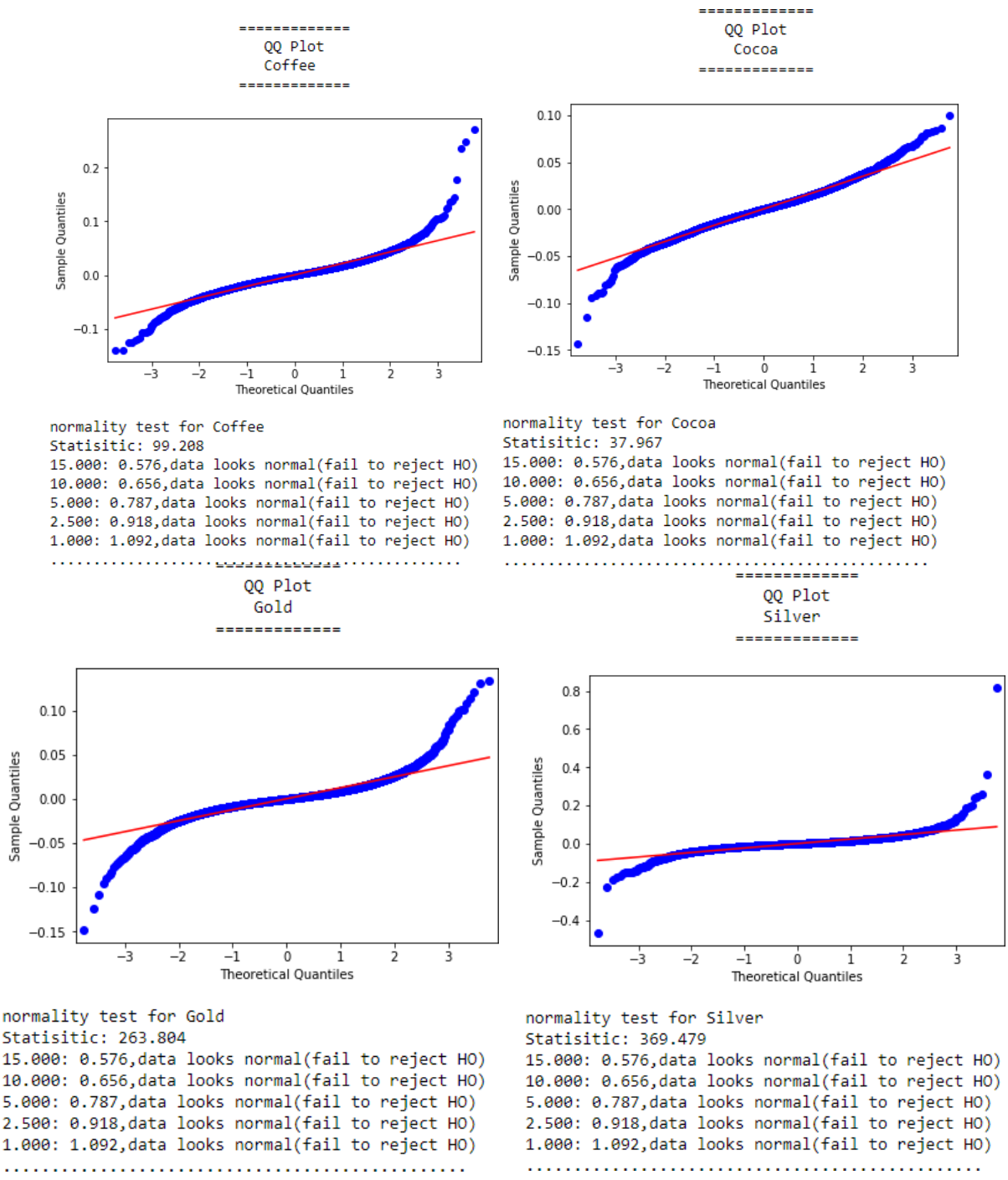


Figure 4.1: Q-Q plots for returns

As in q-q plot for various daily commodity returns, while our skewness says otherwise for some commodity returns, our distribution looks normally distributed.

We can go with the report of the q-q plot as deviations from the straight line are minimal.

e) Correlation among product pair

We conducted correlation at different frequencies among closely related pairs to show how or whether chosen pairs are related. While we confirmed that some pairs are closely correlated, performing the test lead to which pairs are the strongest in terms of correlation. Figure 4.2a below shows the matrix for the correlation coefficient among pairs.

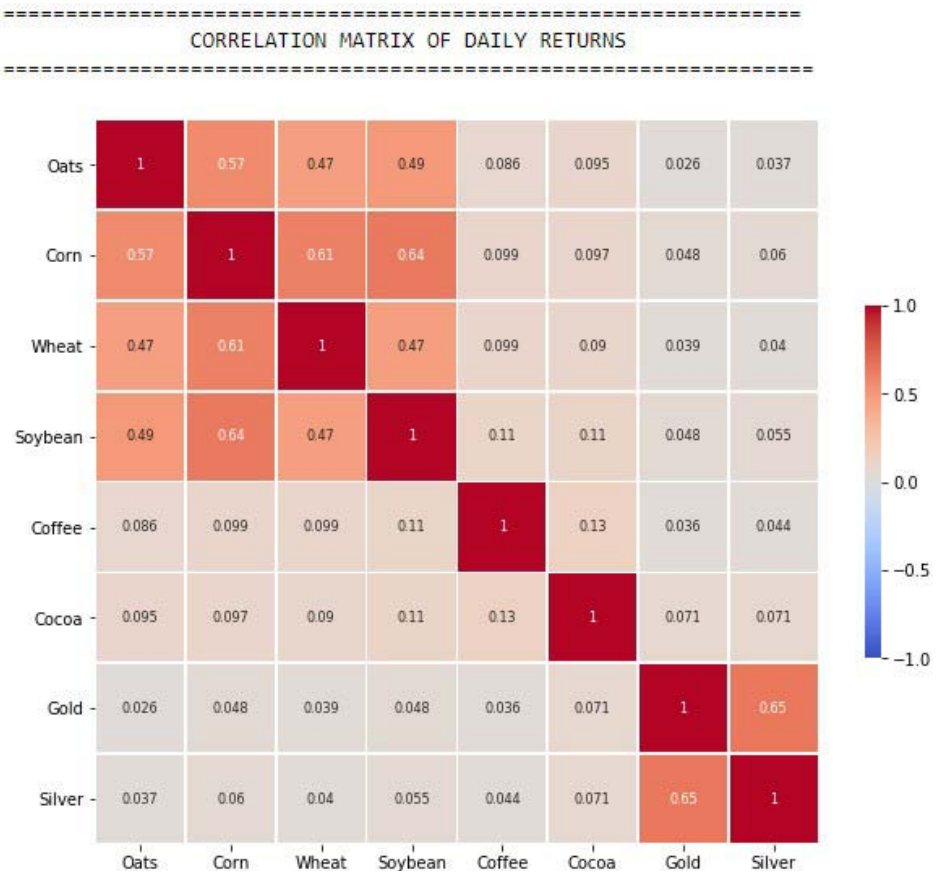


Figure 4.2a: Correlation matrix for daily returns

As shown in figure 4.2a above, Gold/Silver are strongly correlated and are the most correlated among the pairs considered. This observation is also confirmed in the weekly and monthly correlation matrix found in Figures 4.2b and 4.2c of the appendix D. Corn and Oats have a moderate rate correlation of their daily returns which is also repeated in the weekly returns matrix but they, however, have a strong correlation in their monthly returns.

Wheat and soybeans have a moderate correlation of 0.47 in their daily return, which is also replicated in their weekly and monthly return correlation matrix.

Coffee and cocoa have a very weak correlation of 0.13 in their daily returns, which can also be seen in their weekly and monthly return correlation matrix.

f) Model Selection

In other to guide us on our model selection, we carried out a statistical test called a unit root test on the daily returns of each commodity. The Augmented Dickey- Fuller (ADF test) was used to carry out stationarity of the return series.

Augmented Dickey-Fuller Test on "Oats"

Null Hypothesis: Data has a unit root. Non-Stationary.
Significance Level = 0.05
Test Statistic = -48.7205
No. Lags Chosen = 4
Critical value 1% = -3.431
Critical value 5% = -2.862
Critical value 10% = -2.567
=> P-Value = 0.0. Rejecting Null Hypothesis.
=> Series is Stationary.

Augmented Dickey-Fuller Test on "Corn"

Null Hypothesis: Data has a unit root. Non-Stationary.
Significance Level = 0.05
Test Statistic = -19.6698
No. Lags Chosen = 28
Critical value 1% = -3.431
Critical value 5% = -2.862
Critical value 10% = -2.567
=> P-Value = 0.0. Rejecting Null Hypothesis.
=> Series is Stationary.

Figure 4.3: ADF test for Oats and Corn return series

The result of the report in figure 4.3 indicated that Oats and Corn are stationary. This is also shown in the report of the ADF test for the other pairs, which is available in figure 4.3a of appendix E.

Going by the test carried out so far, it is imminent that SARIMAX will be a better choice to fit our model. The model incorporates endogenous and exogenous variables. Our commodity data formed the endogenous variables, while precipitation and temperature make up the exogenous variables.

Before analyzing the model fit, we have first analyzed precipitation/temperature data for each commodity in specific regions.

g) Weather impact

Weather data (precipitation/temperature) was downloaded for regions where each of the commodities has high production. The weather data is saved in the "CSV" format, and the necessary data were loaded on python notebook using the "pandas" module. The weather data was considered from 1973 to 2019 to match the date covered for each commodity price data. The precipitation value and the average temperature value were used to carry out the analysis. The next step was followed by treating missing values using the interpolate method, which resulted in plotting weather data against commodity prices.

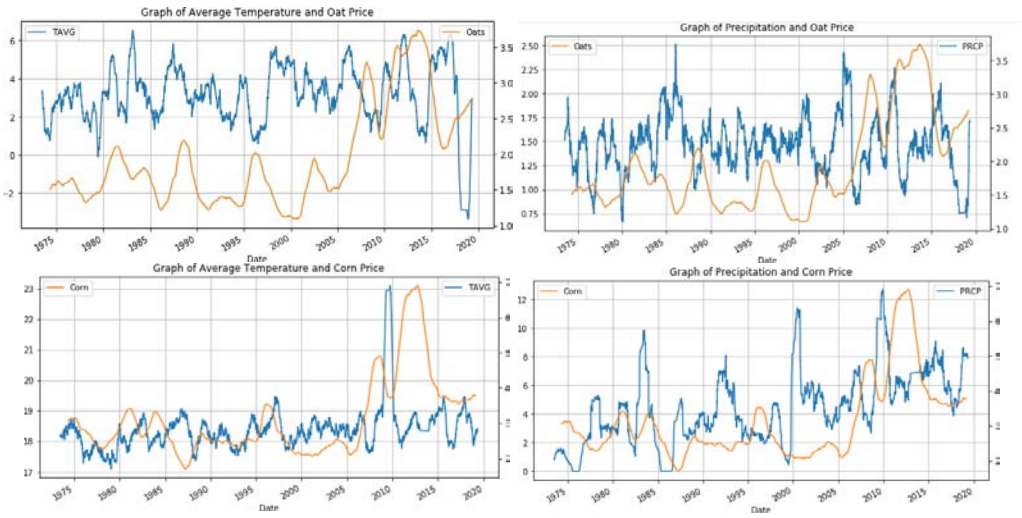


Figure 4.4a: Plot illustrating weather data and Oats/Corn prices

Weather data characterize oats and corn prices. As illustrated in Figure 4.4a, there are moments when a spike in temperature resulted in price reduction for the pair. This is also evident in the precipitation plot where a spike in its value resulted in a deep in commodity price. While 2010 – 2015 is characterized by a period of the most price for oat and corn, a sharp fall in the price of oats and corn is evident in 2016 – 2017, which is evident to be a period of high temperature in history. Also, the pair which exhibited most volatility in the last decade of the year under review (figure 4.4 in appendix F) recorded their highest price thou with occasions of spikes in temperature leading to a reduced price.

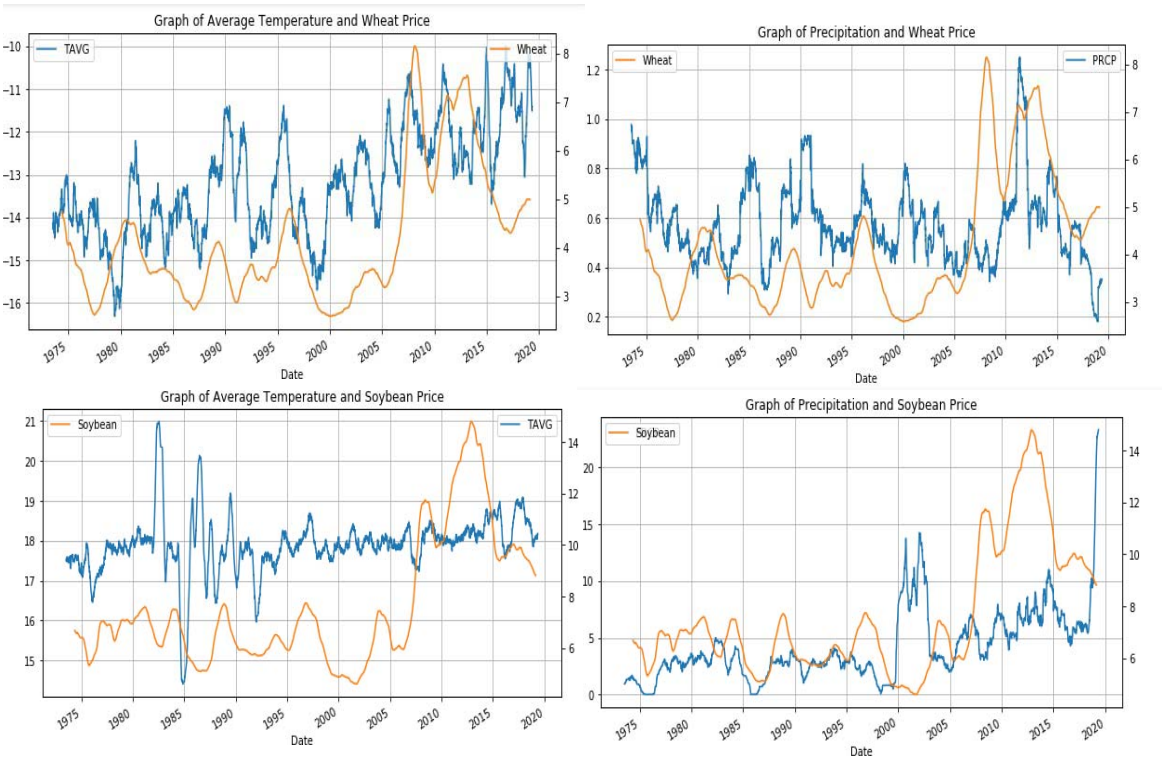


Figure 4.4b: Plot illustrating weather data and Wheat/Soybean prices

Weather data also characterize wheat and Soybean. For most of the features of the plot, Wheat and Soybean had maintained a low price where average temperature and precipitation had a spike in their value. A 2017/2018 study for wheat shows a deep in the price characterized by high temperature and precipitation.

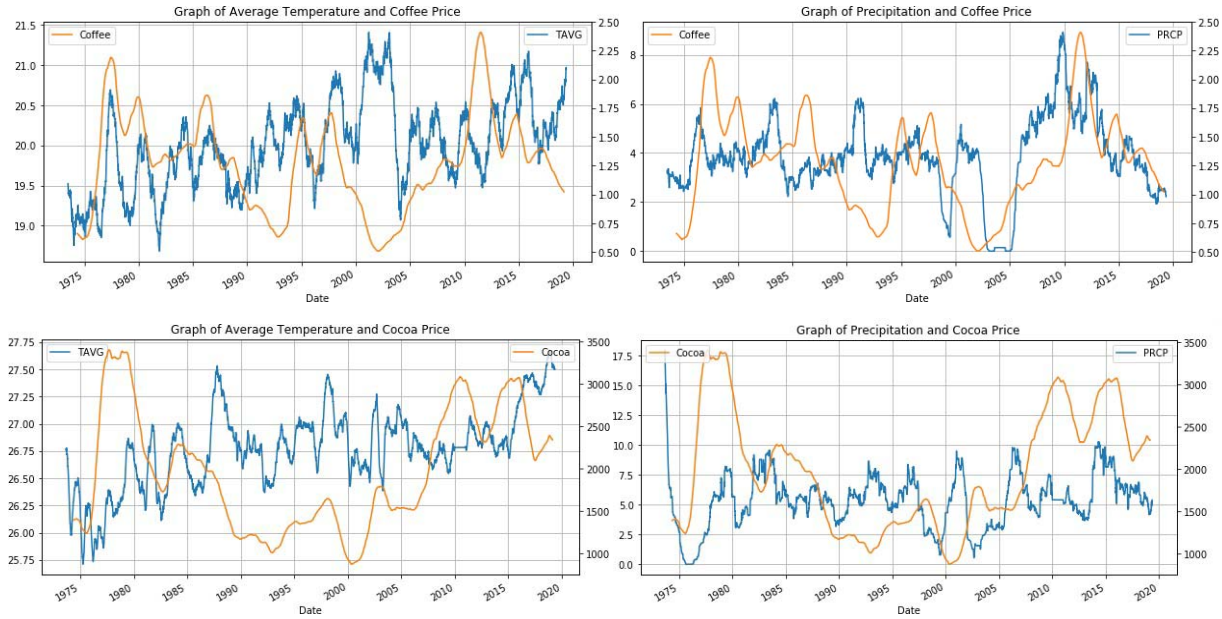


Figure 4.4c: Plot illustrating weather data and Coffee/Cocoa prices

Coffee and Cocoa weather chart has an interesting characteristic. The price data exhibit an inverse relationship with the average temperature, mostly during the last decade of the years under review. Cocoa, when compared to coffee, has a seasonal trend. The price data for the two commodities also exhibit an inverse relationship with the precipitation value. The closely related pairs had experience declined volatility (Figure 4.4 in appendix F), as shown in the latter part of the year under review.

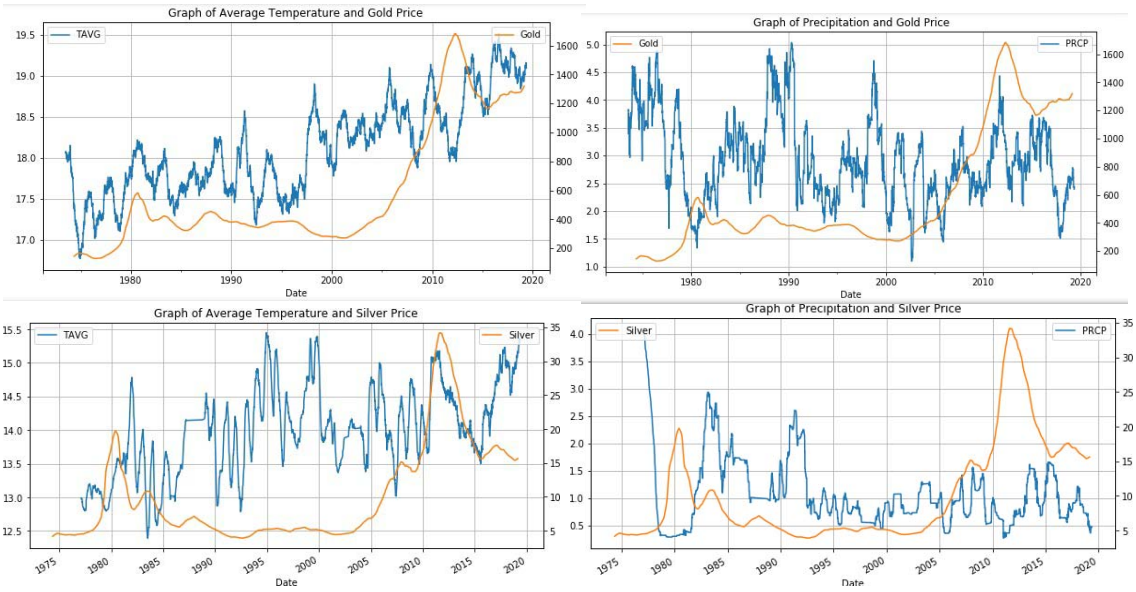


Figure 4.4d: Plot illustrating weather data and Gold/Silver prices

Gold and Silver constitute the only closely related non-agricultural commodity. Going by the plot of average temperature and precipitation for each commodity, the two pairs seem to exhibit no relationship with weather data. We can infer from these findings that weather data does not correlate with the price of the closely related product.

h) Model analysis

SARIMAX was selected to perform a regression analysis of commodity data and weather data. This model allows for a situation that requires a dependent variable (commodity price data) to be regressed with an exogenous variable (weather data). SARIMAX model was carried out on commodity data with their respective exogenous variable. Optimal parameters for our models was carried out by selecting optimal parameter values systematically using the grid search (hyperparameter optimization) method. It iteratively explores different combinations of the parameters, and for each discovery of parameters, we fitted a new seasonal ARIMA model with the SARIMAX() function and assessed its best value. The values for (p, d, q) (P, D, Q) in the SARIMAX model were selected to choose a combination with the lowest AIC (a more parsimonious model) while "m," seasonality period of 12 was used. The first part of the model (p, d, q) accommodates auto-regressive order, differencing order, and moving average order. While the second part of the model included a seasonal effect (P, D, Q), which is essential.

i. *Oats/corn and weather data*

As shown in figure 4.6a and 4.6b below, from the standardized residual plot of both commodities, the residual errors seem to fluctuate around a mean of zero and have a uniform variance. The residuals over time do not display any apparent seasonality and appear to be white noise.

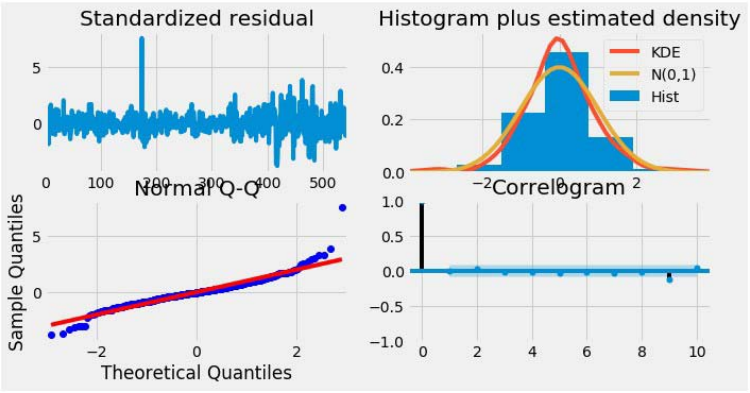


Figure 4.6a: Arima diagnostic plot for oats and temperature data

The density plot suggests normal distribution with a mean of zero. KDE line follows closely with the N (0,1) line. Where N (0,1) is the standard notation for a normal distribution with mean 0 and a standard deviation of 1. This implies that the residuals are normally distributed.

On the Q-Q plot, almost all the dots fell perfectly in line with the red line suggesting a normal distribution.

The Correlogram shows the residual errors are not autocorrelated for both corn and oats since there was no visible pattern, and the residuals have low correlation with lagged versions of itself.

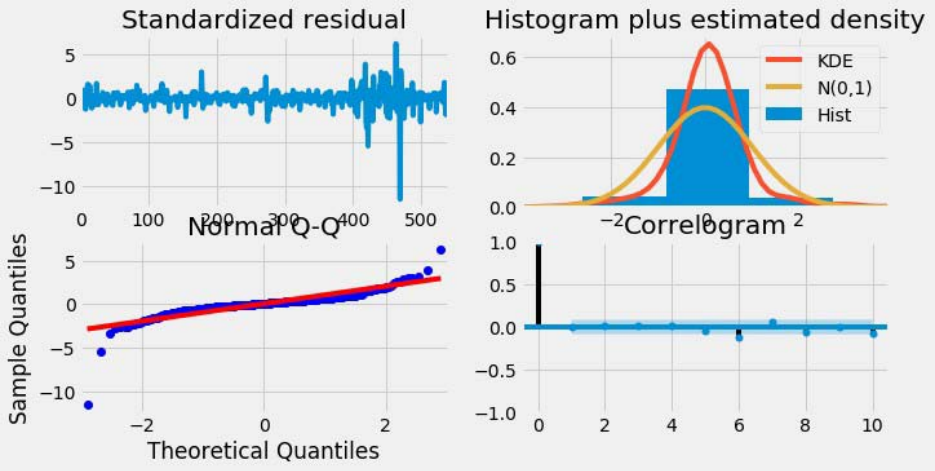


Figure 4.6b: Arima diagnostic plot for corn and temperature data

The log-likelihood of corn is -15.789 (result in appendix H), which is much lower in absolute value than that of oat, which had a log-likelihood of 250.425. That means that the regression of corn is a better fit for the data as compared to oats. The model has estimated that the AIC and the P values (<< 0.05) of the coefficients look significant. In summary, it seems to be a good fit. Also, oats and corn exhibit a negative coefficient in the temperature and precipitation coefficient, suggesting that as the independent variable increases, the dependent variable tends to decrease.

ii. *Wheat/Soybean and weather data*

As illustrated in figure 4.6c and 4.6d, the residual errors seem to fluctuate around a mean of zero and have a uniform variance. The density plot suggests normal distribution with a mean of zero.

On the Q-Q plot, almost all the dots fell perfectly in line with the red line suggesting a normal distribution.

The diagnostic tests report for wheat suggests that our residuals do not appear to be white noise - as such, we can reject at the 5% level the null hypotheses of serial independence (Ljung-Box test), Hetero-skedasticity test, and normality test.

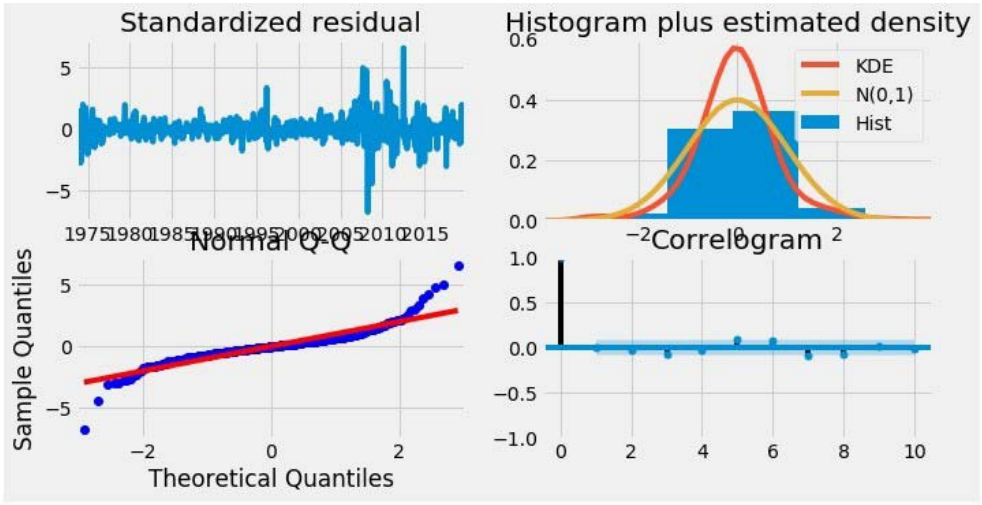


Figure 4.6c: Arima diagnostic plot for wheat and temperature data

The Correlogram shows the residual errors are not auto correlated for both wheat and soybean since there was no visible pattern.

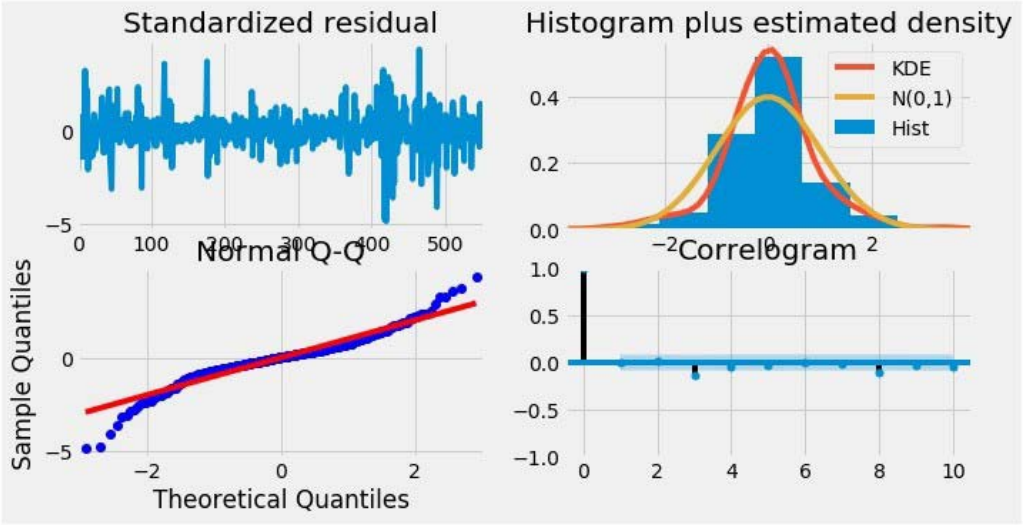


Figure 4.6d: Arima diagnostic plot for Soybean and temperature data

The log-likelihood of wheat is -146.335, which is much lower in absolute value than that of soybean, which had a log-likelihood of -375.201. That means that the regression of wheat is a better fit for the data as compared to the two commodities. The model has estimated that P values (<< 0.05) of the coefficients of wheat look more significant as compared to soybean. In summary, Wheat seems to be a better fit when compared to soybean.

iii. *Coffee/Cocoa and weather data*

For Coffee/Cocoa and weather data, the "coef" column of the model result (Appendix H) indicates the importance of each feature and how they contribute to the dataset. The P>|z| column informs us of the significance of each feature weight. As shown, coffee has some of the features with a p-value close to 0, while the exogenous data are not. With this, we may not satisfactorily conclude that the features should make up our model.

A model diagnostic was illustrated to make an informed assumption about the model further. The residual errors indicate that there may trend information not included by the model.

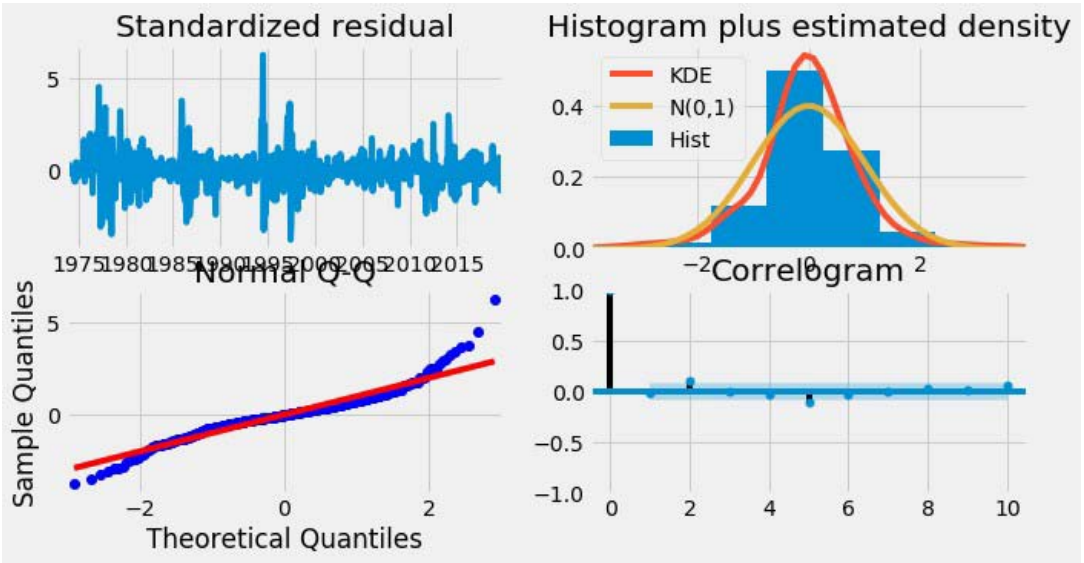


Figure 4.6e: Arima diagnostic plot for Coffee and temperature data

The QQ plot has most of its dot falling on the red line without any indication of a break. This is an indication that the residuals are normally distributed. The correlogram plot for the commodities shows that the residuals have a low correlation with lagged versions of itself. This implies that our model produces a satisfactory fit that could help us understand our dataset.

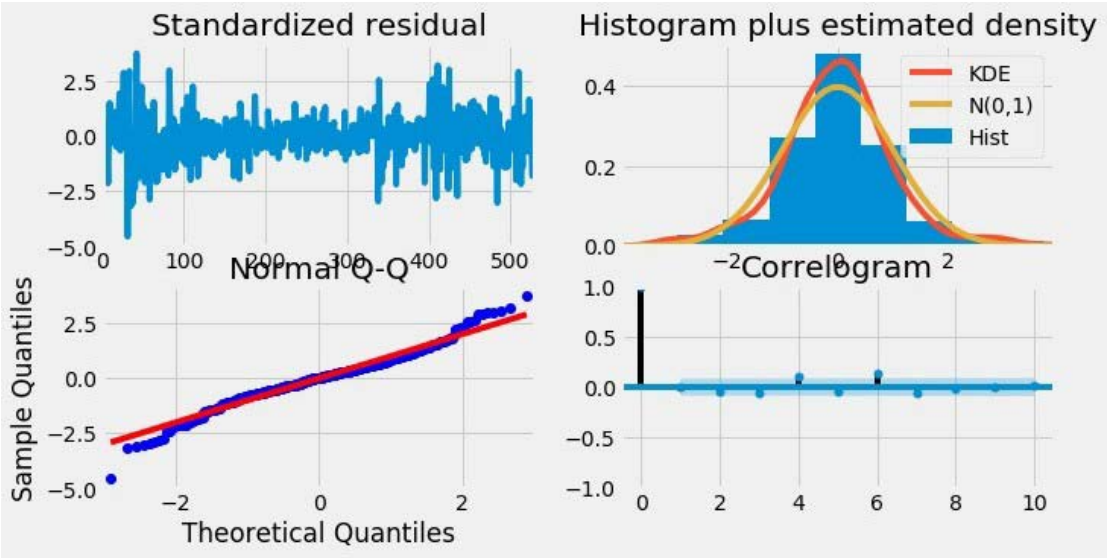


Figure 4.6f: Arima diagnostic plot for Cocoa and temperature data

Coffee has log-likelihood of the regression as 410.29, while Cocoa has it is to be - 3329.24. This is an indication that the regression of Coffee is a better fit for the data as compared to Cocoa.

iv. *Gold/Silver and weather data*

As shown in figure 4.6g and 4.6h below, the standardized residual plot for gold is characterized by spike at the beginning and end of the year, however, most of the time, the residual errors fluctuate around a mean of zero and have a uniform variance. For silver, residual error of the standard plot is characterized by a spike at the time of "silver Thursday" but maintained residual errors fluctuating around mean of zero and having a uniform variance.

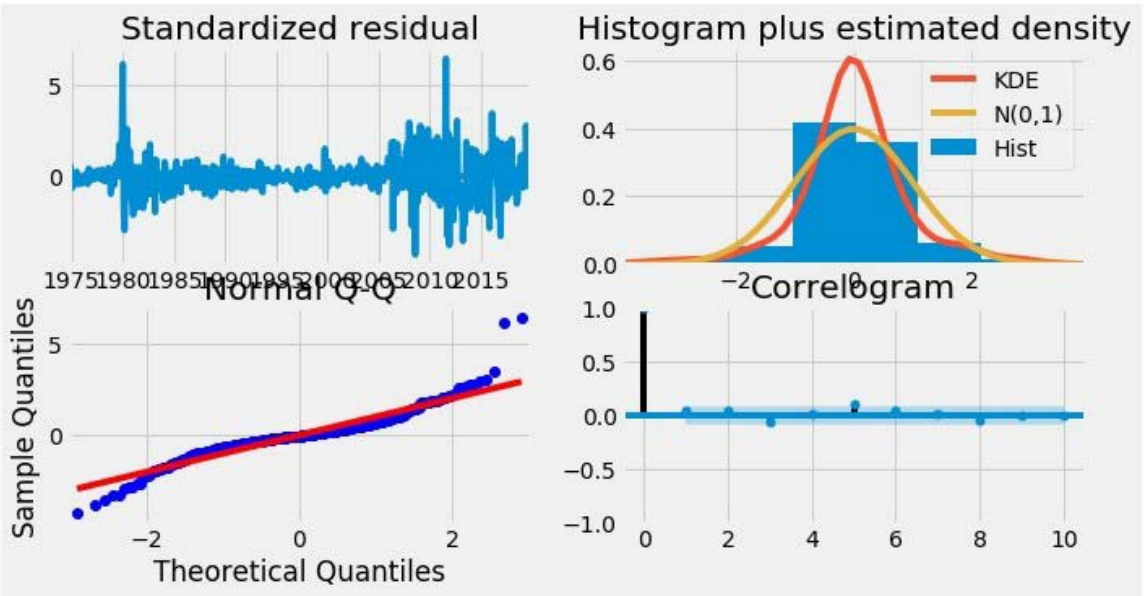


Figure 4.6g: Arima diagnostic plot for Gold and temperature data

For Gold/Silver, the density plot does not ultimately suggest a normal distribution as sample sizes of residuals are generally small (<50), so the histogram may not be the best choice for judging the distribution of the residuals.

A more sensitive graph is the Q-Q plot. Both plots are characterized by few departures from the red line, which is a normal probability plot are common. There are no visible breaks near the middle of this plot, and all dots seem to fall on the red line; hence, suggest normality in their residual distribution.

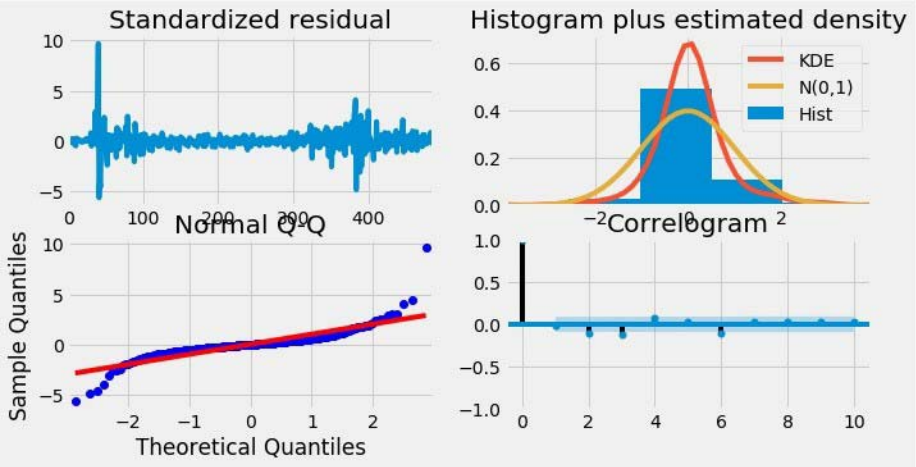


Figure 4.6h: Arima diagnostic plot for Silver and temperature data

In the Correlogram plot for both commodities, the correlations are very low (the y- axis goes from +1.0 to -1.0) and do not seem to have a pattern.

The log-likelihood of the regression for Gold is -2617.25, which is much higher in absolute value than that of Silver, which had a log-likelihood of -862.753. This means that the regression of Silver is a better fit for the data as compared to Gold.

V. Conclusion and Recommendation

This Capstone project was an Exploratory Data Analysis (EDA) that looked at daily historical price data of selected commodities and closely related products to understand their price relationships and the impact of weather on price variation, if any.

Time series data values are obtained at a sequential time interval. In other words, the values are characterized with or without increasing or decreasing trend and seasonality. A comparative analysis is a required time series analysis method to describe and extract information from time-descriptive data, and an informed decision could be made about the datasets.

A quantitative analysis using a time series model was used to check for the effect of weather on commodity dataset. We first came up with a plot of our time series dataset for the commodities to have an idea of the visual trend and seasonality of the series. We then use a descriptive statistic to check the raw data and its returns for the type of distribution.

The correlation test at different frequencies among commodity pairs was carried out on the returns to show how or whether chosen pairs are related. While we confirmed that some pairs are closely correlated, performing the test lead to which pairs are the strongest in terms of correlation. This justifies our selected closely related pairs for comparison.

Before regressing the price dataset with weather data, an essential technique of finding the value of SARIMAX (p, d, q) (P, D, Q) m was carried out to implement the model that best optimize our metric of interest. Optimal parameters for our model were carried out by selecting optimal parameter values systematically using the grid search (hyperparameter optimization) method.

While our model appreciably showed the relationship between the regression of commodity price data and temperature/precipitation. This is evident as the coefficients for the selected agricultural commodity price data tends to zero. However, the result provided for the non-agricultural commodity indicated that the temperature and precipitation data for these commodities (Gold and Silver) are highly insignificant, which can be seen in their respective p-values for the coefficients.

It is essential to point out at this junction that the project was never intended to forecast future commodities prices or weather patterns, but there is always room for future study in these areas

Furthermore, though there was some form of correlation between the temperature values and the agricultural commodities, the study is not sufficient to conclude whether or not the weather has a direct impact on the prices of these commodities. This is an area that is open to further study in the future by taking into consideration other commodity variables like yield and growth rate to investigate any indirect relationship to prices.

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Appendix A

Descriptive statistic of raw data

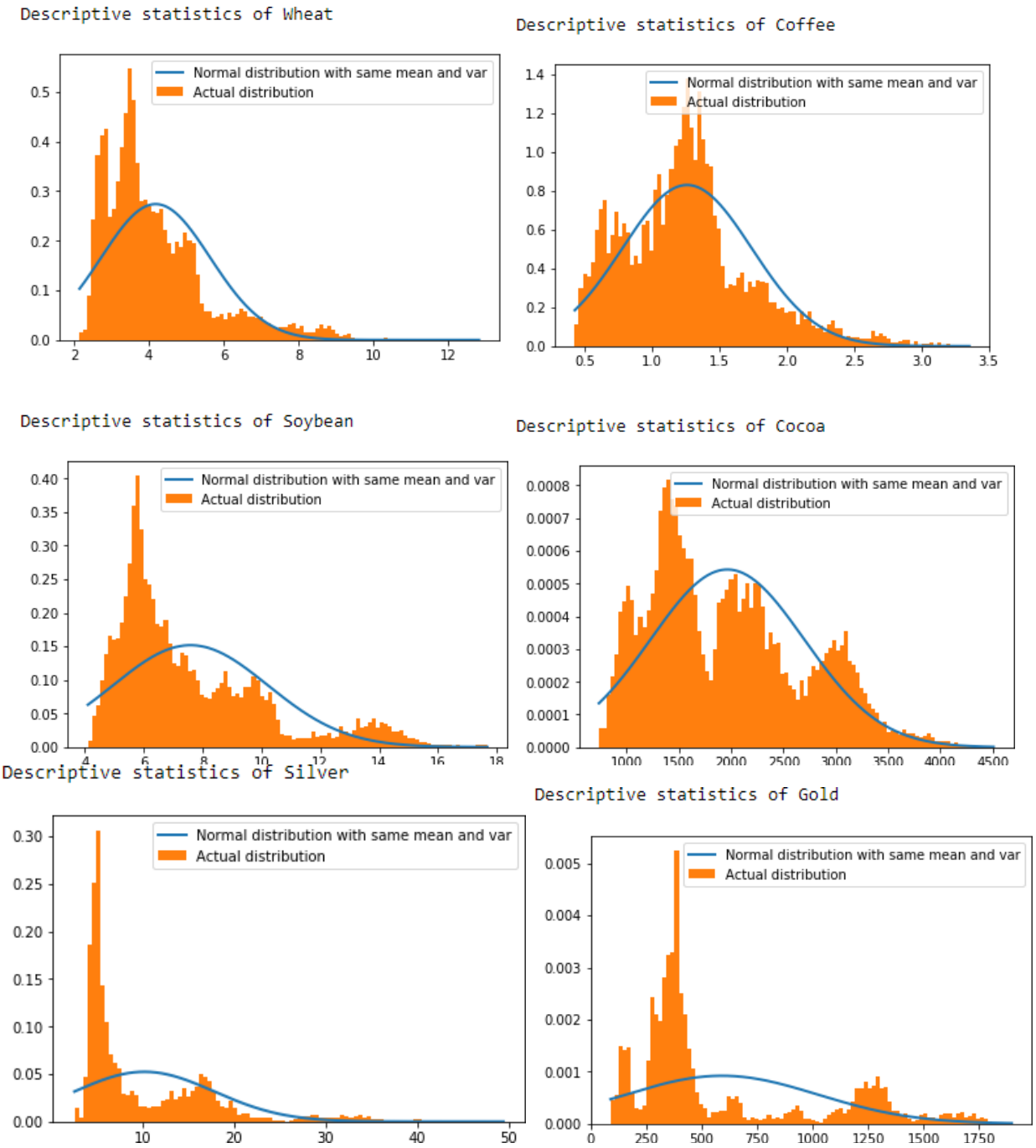


Figure 4.0: Normal distribution test for commodity price data

Appendix B

Descriptive statistic of return

Table 4.2b: Descriptive statistics of weekly return

	Oats_W	Corn_W	Wheat_W	Soybean_W	Coffee_W
count	2412.000000	2412.000000	2412.000000	2412.000000	2412.000000
mean	0.001370	0.000707	0.000678	0.000653	0.001336
std	0.043824	0.034695	0.037228	0.034132	0.048383
min	-0.186851	-0.163904	-0.171213	-0.162380	-0.178421
25%	-0.022706	-0.017162	-0.022785	-0.017109	-0.025575
50%	0.000000	0.001026	-0.001024	0.001568	0.000367
75%	0.025742	0.018060	0.020859	0.019969	0.026161
max	0.323155	0.207761	0.197068	0.164715	0.549424

	Cocoa_W	Gold_W	Silver_W
count	2412.000000	2412.000000	2412.000000
mean	0.001034	0.001460	0.001902
std	0.038731	0.026592	0.048207
min	-0.204117	-0.165214	-0.435206
25%	-0.021614	-0.011838	-0.019098
50%	-0.000450	0.001151	0.000235
75%	0.022711	0.013608	0.021359
max	0.196182	0.353279	0.891512

Table 4.2c: Descriptive statistics of weekly return

	Oats_M	Corn_M	Wheat_M	Soybean_M	Coffee_M	Cocoa_M
count	555.000000	555.000000	555.000000	555.000000	555.000000	555.000000
mean	0.005802	0.003445	0.002984	0.003387	0.006115	0.004689
std	0.093528	0.074636	0.077403	0.076944	0.105188	0.082740
min	-0.281658	-0.225996	-0.248192	-0.279766	-0.361795	-0.318365
25%	-0.046174	-0.035670	-0.048558	-0.035782	-0.059641	-0.051973
50%	-0.000771	-0.000357	0.001394	0.001362	-0.004656	-0.000929
75%	0.050303	0.046855	0.046292	0.042049	0.053132	0.053326
max	0.943014	0.496544	0.386356	0.570313	0.533759	0.334545

	Gold_M	Silver_M
count	555.000000	555.000000
mean	0.006338	0.007836
std	0.056593	0.094331
min	-0.213672	-0.620101
25%	-0.025116	-0.042227
50%	0.000260	-0.002205
75%	0.034325	0.050445
max	0.274809	0.694737

Appendix C

Skewness and kurtosis of returns

Table 4.3c: Skewness and Kurtosis for weekly returns

SKEWNESS and KURTOSIS RESULT ON WEEKLY RETURNS

Commodities	Skewness	Kurtosis
Oats	0.269816	2.7101
Corn	0.0771866	2.77241
Wheat	0.397143	2.04088
Soybean	-0.176502	2.31248
Coffee	1.0185	9.4295
Cocoa	0.109242	1.45824
Gold	0.983068	16.5317
Silver	2.41927	55.997

Table 4.3d: Skewness and Kurtosis for monthly returns

```
============================================================
      SKEWNESS and KURTOSIS RESULT ON MONTHLY RETURNS
============================================================
Commodities      Skewness    Kurtosis
-------------  ----------  ----------
Oats             2.04217     18.3864
Corn             0.632904     3.96188
Wheat            0.390539     1.47566
Soybean          0.616611     5.98835
Coffee           1.15048      3.82862
Cocoa            0.459498     1.16766
Gold             0.738831     4.12935
Silver           0.850449    11.2526
```

Appendix D

Correlation matrix of return

```
============================================================
          CORRELATION MATRIX OF WEEKLY RETURNS
============================================================
```

Figure 4.2b: Correlation matrix for daily returns

```
============================================================
          CORRELATION MATRIX OF MONTHLY RETURNS
============================================================
```

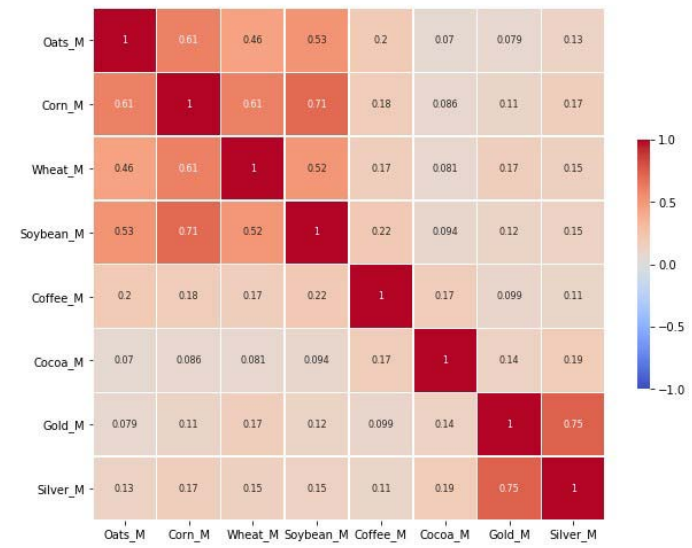


Figure 4.2b: Correlation matrix for daily returns

Appendix E

Augmented Dickey-Fuller test

```
    Augmented Dickey-Fuller Test o
n "Wheat"
    ------------------------------
-----------------
 Null Hypothesis: Data has unit ro
ot. Non-Stationary.
 Significance Level    = 0.05
 Test Statistic        = -78.4073
 No. Lags Chosen       = 1
 Critical value 1%     = -3.431
 Critical value 5%     = -2.862
 Critical value 10%    = -2.567
 => P-Value = 0.0. Rejecting Null
Hypothesis.
 => Series is Stationary.
```

```
    Augmented Dickey-Fuller Test o
n "Cocoa"
    ------------------------------
-----------------
 Null Hypothesis: Data has unit ro
ot. Non-Stationary.
 Significance Level    = 0.05
 Test Statistic        = -45.1571
 No. Lags Chosen       = 5
 Critical value 1%     = -3.431
 Critical value 5%     = -2.862
 Critical value 10%    = -2.567
 => P-Value = 0.0. Rejecting Null
Hypothesis.
 => Series is Stationary.
```

```
 Augmented Dickey-Fuller Test on "
Soybean"
    ------------------------------
-----------------
 Null Hypothesis: Data has unit ro
ot. Non-Stationary.
 Significance Level    = 0.05
 Test Statistic        = -19.8719
 No. Lags Chosen       = 28
 Critical value 1%     = -3.431
 Critical value 5%     = -2.862
 Critical value 10%    = -2.567
 => P-Value = 0.0. Rejecting Null
Hypothesis.
 => Series is Stationary.
```

```
 Augmented Dickey-Fuller Test on "
Gold"
    ------------------------------
-----------------
 Null Hypothesis: Data has unit ro
ot. Non-Stationary.
 Significance Level    = 0.05
 Test Statistic        = -16.6773
 No. Lags Chosen       = 40
 Critical value 1%     = -3.431
 Critical value 5%     = -2.862
 Critical value 10%    = -2.567
 => P-Value = 0.0. Rejecting Null
Hypothesis.
 => Series is Stationary.
```

```
    Augmented Dickey-Fuller Test o
n "Coffee"
    ------------------------------
-----------------
 Null Hypothesis: Data has unit ro
ot. Non-Stationary.
 Significance Level    = 0.05
 Test Statistic        = -24.7959
 No. Lags Chosen       = 22
 Critical value 1%     = -3.431
 Critical value 5%     = -2.862
 Critical value 10%    = -2.567
 => P-Value = 0.0. Rejecting Null
Hypothesis.
 => Series is Stationary.
```

```
 Augmented Dickey-Fuller Test on "
Silver"
    ------------------------------
-----------------
 Null Hypothesis: Data has unit ro
ot. Non-Stationary.
 Significance Level    = 0.05
 Test Statistic        = -16.6123
 No. Lags Chosen       = 38
 Critical value 1%     = -3.431
 Critical value 5%     = -2.862
 Critical value 10%    = -2.567
 => P-Value = 0.0. Rejecting Null
Hypothesis.
 => Series is Stationary.
```

Figure 4.3a: ADF test report

Appendix F

Graph of product pair

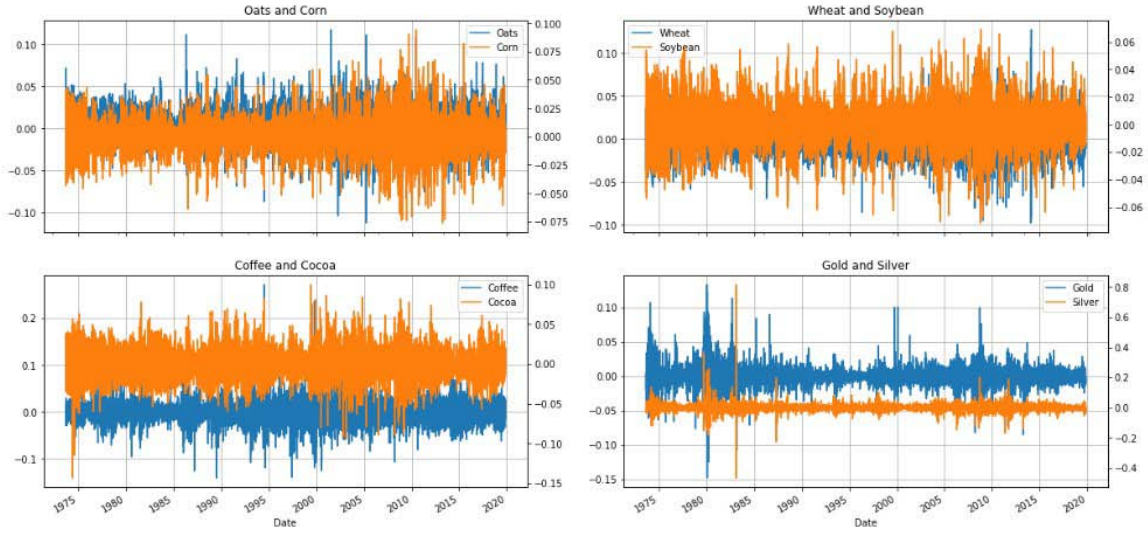


Figure 4.4: Plot of product pair returns

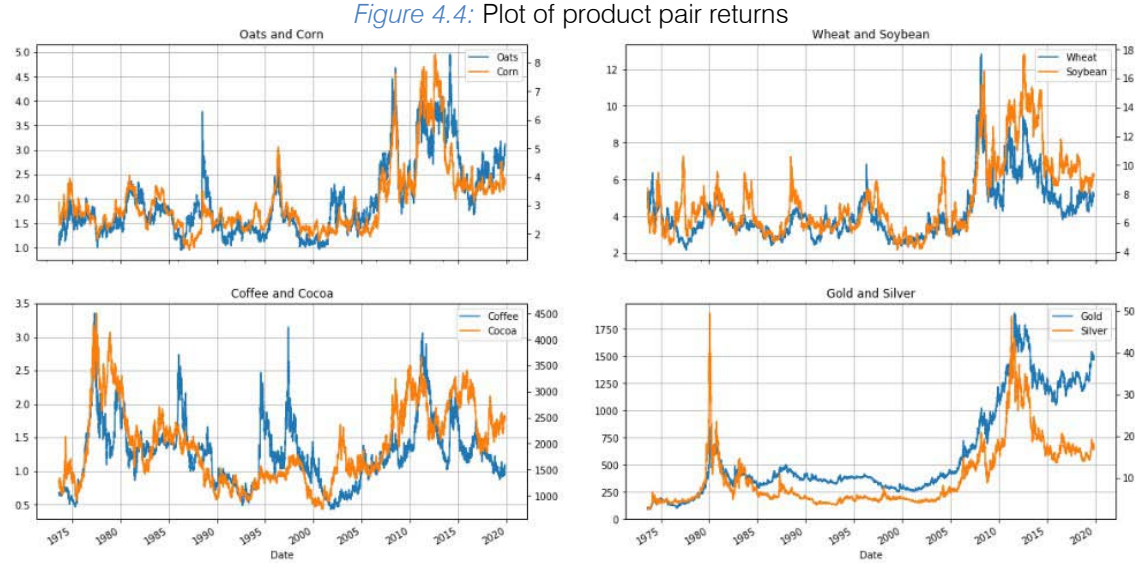


Figure 4.4e: Pair plot for a closely related commodity (price data)

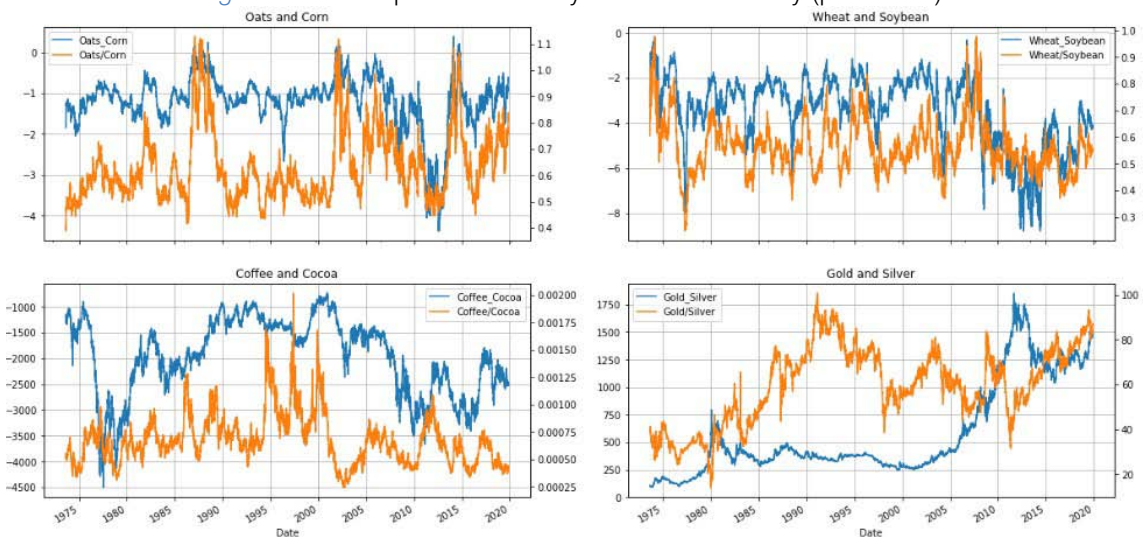
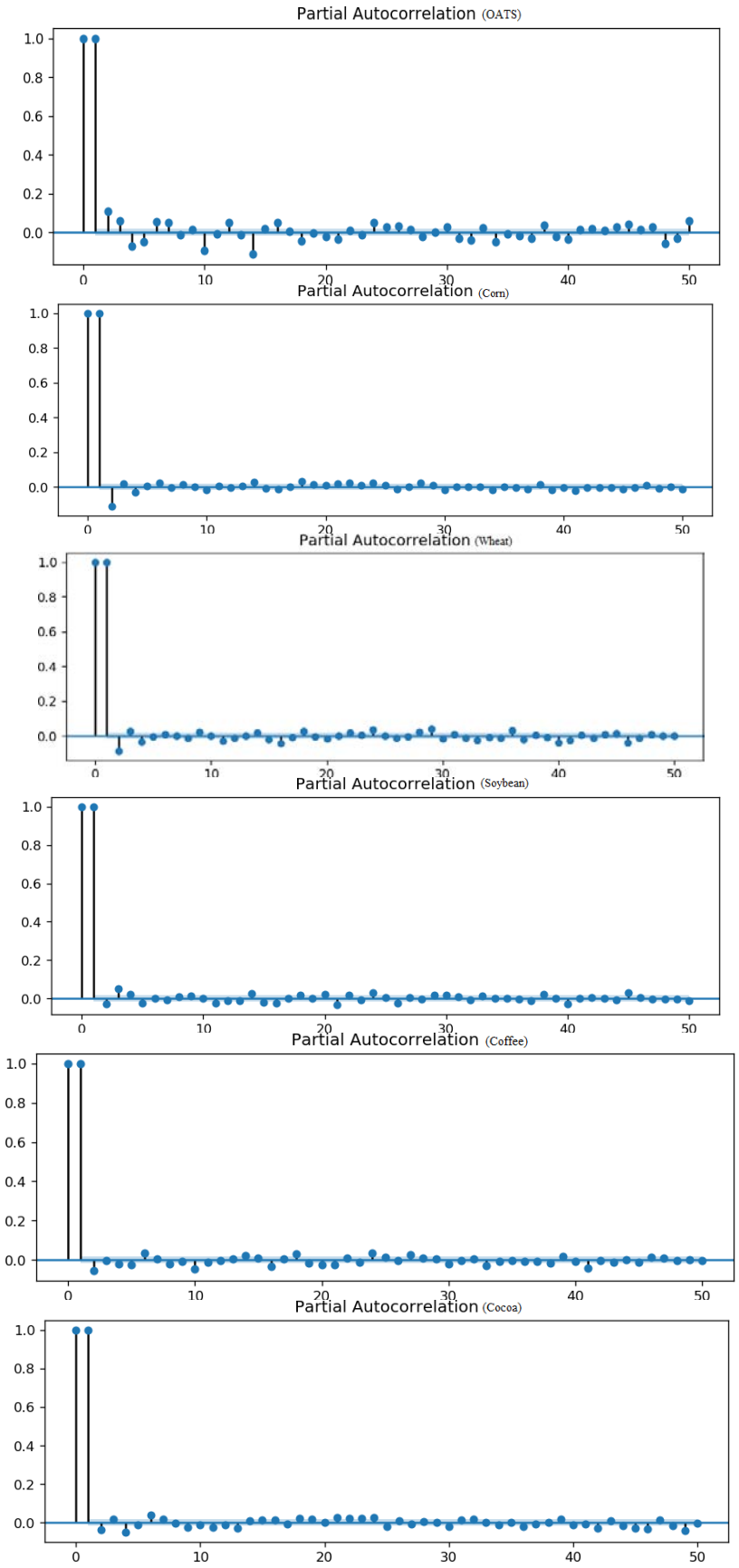


Figure 4.4f: Plot of Spread and closely related product ratio

Appendix G

PAC plot



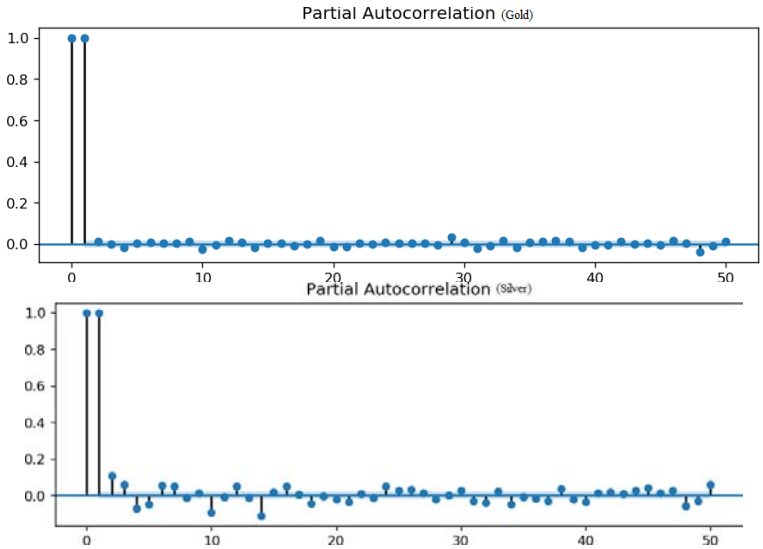


Figure 4.5f: Partial autocorrelation plot for commodity price data

Appendix H

Model report using SARIMAX

Dep. Variable:	Oats	**No. Observations:**	547
Model:	SARIMAX(1, 1, 0)	**Log Likelihood**	250.425
Date:	Sun, 05 Jan 2020	**AIC**	-492.850
Time:	23:41:12	**BIC**	-475.639
Sample:	0	**HQIC**	-486.122
	- 547		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
TAVG	-0.0009	0.001	-0.798	0.425	-0.003	0.001
PRCP	-0.0059	0.005	-1.299	0.194	-0.015	0.003
ar.L1	0.1350	0.035	3.900	0.000	0.067	0.203
sigma2	0.0234	0.001	33.277	0.000	0.022	0.025

Ljung-Box (Q):	48.63	**Jarque-Bera (JB):**	1219.95
Prob(Q):	0.16	**Prob(JB):**	0.00
Heteroskedasticity (H):	2.07	**Skew:**	0.78
Prob(H) (two-sided):	0.00	**Kurtosis:**	10.15

Warnings:

[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Figure 4.7a: Arima model for oat and weather data

Dep. Variable:	Corn	**No. Observations:**	540
Model:	SARIMAX(1, 1, 0)	**Log Likelihood**	-15.785
Date:	Sun, 05 Jan 2020	**AIC**	39.571
Time:	22:50:25	**BIC**	56.730
Sample:	0	**HQIC**	46.282
	- 540		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
TAVG	-0.0022	0.005	-0.461	0.645	-0.011	0.007
PRCP	0.0001	0.002	0.054	0.957	-0.004	0.005
ar.L1	0.1970	0.023	8.428	0.000	0.151	0.243
sigma2	0.0621	0.001	53.206	0.000	0.060	0.064

Ljung-Box (Q):	54.45	**Jarque-Bera (JB):**	32837.67
Prob(Q):	0.06	**Prob(JB):**	0.00
Heteroskedasticity (H):	6.20	**Skew:**	-2.70
Prob(H) (two-sided):	0.00	**Kurtosis:**	40.85

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Figure 4.7b: Arima model for corn and weather data

Dep. Variable:	Wheat	**No. Observations:**	556
Model:	SARIMAX(1, 1, 1)x(1, 0, 1, 12)	**Log Likelihood**	-146.335
Date:	Sun, 05 Jan 2020	**AIC**	306.669
Time:	22:57:02	**BIC**	336.902
Sample:	08-01-1973	**HQIC**	318.479
	- 11-01-2019		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
TAVG	-0.0016	0.002	-0.916	0.360	-0.005	0.002
PRCP	-0.0265	0.029	-0.923	0.356	-0.083	0.030
ar.L1	-0.3010	0.099	-3.028	0.002	-0.496	-0.106
ma.L1	0.5204	0.082	6.383	0.000	0.361	0.680
ar.S.L12	0.2041	0.528	0.387	0.699	-0.831	1.239
ma.S.L12	-0.2748	0.517	-0.531	0.595	-1.289	0.739
sigma2	0.0992	0.003	33.796	0.000	0.093	0.105

Ljung-Box (Q):	68.26	**Jarque-Bera (JB):**	2465.06
Prob(Q):	0.00	**Prob(JB):**	0.00
Heteroskedasticity (H):	4.25	**Skew:**	0.43
Prob(H) (two-sided):	0.00	**Kurtosis:**	13.29

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Figure 4.7c: Arima model for wheat and weather data

Dep. Variable:	Soybean	**No. Observations:**	555
Model:	SARIMAX(1, 1, 1)x(0, 0, 1, 12)	**Log Likelihood**	-375.201
Date:	Sun, 05 Jan 2020	**AIC**	762.402
Time:	22:59:59	**BIC**	788.305
Sample:	0	**HQIC**	772.521
	- 555		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
TAVG	-0.0039	0.009	-0.435	0.663	-0.021	0.014
PRCP	-0.0024	0.003	-0.785	0.433	-0.008	0.004
ar.L1	0.2415	0.078	3.086	0.002	0.088	0.395
ma.L1	0.1032	0.081	1.277	0.202	-0.055	0.262
ma.S.L12	0.0113	0.036	0.312	0.755	-0.060	0.082
sigma2	0.2268	0.008	27.864	0.000	0.211	0.243

Ljung-Box (Q):	45.34	**Jarque-Bera (JB):**	368.75
Prob(Q):	0.26	**Prob(JB):**	0.00
Heteroskedasticity (H):	1.73	**Skew:**	-0.31
Prob(H) (two-sided):	0.00	**Kurtosis:**	6.95

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Figure 4.7d: Arima model for Soybean and weather data

Dep. Variable:	Coffee	**No. Observations:**	556
Model:	SARIMAX(1, 1, 0)	**Log Likelihood**	410.294
Date:	Sun, 05 Jan 2020	**AIC**	-812.588
Time:	23:48:46	**BIC**	-795.312
Sample:	08-01-1973	**HQIC**	-805.839
	- 11-01-2019		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
TAVG	0.0016	0.003	0.539	0.590	-0.004	0.007
PRCP	-0.0017	0.001	-1.543	0.123	-0.004	0.000
ar.L1	0.2118	0.024	8.951	0.000	0.165	0.258
sigma2	0.0133	0.000	31.030	0.000	0.013	0.014

Ljung-Box (Q):	64.24	**Jarque-Bera (JB):**	634.37
Prob(Q):	0.01	**Prob(JB):**	0.00
Heteroskedasticity (H):	0.50	**Skew:**	0.58
Prob(H) (two-sided):	0.00	**Kurtosis:**	8.11

Warnings:

[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Figure 4.7e: Arima model for Coffee and weather data

Dep. Variable:	Cocoa	**No. Observations:**	544
Model:	SARIMAX(0, 1, 1)x(1, 1, 1, 12)	**Log Likelihood**	-3329.215
Date:	Sun, 05 Jan 2020	**AIC**	6670.430
Time:	23:15:45	**BIC**	6696.078
Sample:	0	**HQIC**	6680.468
	- 544		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
TAVG	3.2803	7.101	0.462	0.644	-10.637	17.198
PRCP	1.1317	0.814	1.390	0.165	-0.464	2.728
ma.L1	0.2544	0.035	7.227	0.000	0.185	0.323
ar.S.L12	-0.0718	0.042	-1.713	0.087	-0.154	0.010
ma.S.L12	-1.0000	22.805	-0.044	0.965	-45.698	43.698
sigma2	1.496e+04	3.41e+05	0.044	0.965	-6.54e+05	6.84e+05

Ljung-Box (Q):	49.56	**Jarque-Bera (JB):**	80.73
Prob(Q):	0.14	**Prob(JB):**	0.00
Heteroskedasticity (H):	0.79	**Skew:**	-0.10
Prob(H) (two-sided):	0.11	**Kurtosis:**	4.90

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Figure 4.7f: Arima model for Cocoa and weather data

Dep. Variable:	Gold	**No. Observations:**	556
Model:	SARIMAX(1, 1, 1)x(0, 1, 1, 12)	**Log Likelihood**	-2617.251
Date:	Sun, 05 Jan 2020	**AIC**	5246.501
Time:	23:19:52	**BIC**	5272.284
Sample:	08-01-1973	**HQIC**	5256.582
	- 11-01-2019		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
TAVG	1.8066	1.137	1.589	0.112	-0.422	4.035
PRCP	-0.0452	0.344	-0.132	0.895	-0.719	0.628
ar.L1	-0.5906	0.067	-8.811	0.000	-0.722	-0.459
ma.L1	0.7974	0.051	15.773	0.000	0.698	0.897
ma.S.L12	-1.0282	0.031	-33.629	0.000	-1.088	-0.968
sigma2	798.7640	41.556	19.222	0.000	717.316	880.212

Ljung-Box (Q):	51.90	**Jarque-Bera (JB):**	1125.66
Prob(Q):	0.10	**Prob(JB):**	0.00
Heteroskedasticity (H):	2.88	**Skew:**	0.70
Prob(H) (two-sided):	0.00	**Kurtosis:**	9.91

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Figure 4.7g: Arima model for Gold and weather data

Dep. Variable:	Silver	**No. Observations:**	499
Model:	SARIMAX(1, 0, 1)x(0, 1, 1, 12)	**Log Likelihood**	-862.753
Date:	Sun, 05 Jan 2020	**AIC**	1737.507
Time:	23:23:04	**BIC**	1762.636
Sample:	0	**HQIC**	1747.378
	- 499		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
TAVG	-0.0735	0.030	-2.457	0.014	-0.132	-0.015
PRCP	-0.0153	0.033	-0.461	0.644	-0.080	0.050
ar.L1	0.9677	0.006	165.937	0.000	0.956	0.979
ma.L1	0.4313	0.016	27.289	0.000	0.400	0.462
ma.S.L12	-0.9516	0.030	-31.738	0.000	-1.010	-0.893
sigma2	1.9045	0.058	32.853	0.000	1.791	2.018

Ljung-Box (Q):	43.15	**Jarque-Bera (JB):**	10833.71
Prob(Q):	0.34	**Prob(JB):**	0.00
Heteroskedasticity (H):	0.77	**Skew:**	1.34
Prob(H) (two-sided):	0.10	**Kurtosis:**	25.95

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Figure 4.7h: Arima model for Silver and weather data

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Global Journal of Computer Science and Technology: C
Software & Data Engineering
Volume 21 Issue 1 Version 1.0 Year 2021
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Optimized Drug Distribution for Pharmacies of the National Order of Pharmacists in DR Congo using a Multi-Agent Engineering Approach

By Blaise Fyama & Ruphin Nyami Nyate
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Abstract- This paper focuses on a Multi-Agent Oriented Engineering for the problem of registration of pharmacists in the National Order of Pharmacists (NOP) and the regulation of the sale of pharmaceutical products in a distributed environment. The behavior of a pharmacist in the practice of pharmacy is characterized by interactions with the Provincial Council of the Order of Pharmacists (PCOP) of his jurisdiction, where he obtains an authorization to practice pharmacy. This authorization is accompanied by the ethical rules to be observed in order to expose medicines on the market. The activities of each pharmacist are continuously subject to quality control and pharmaceutical vigilance to protect the health of the population. In this paper, we focus on the design of a Multi-Agent System (MAS) in order to help the PCOP to control the pharmaceutical activity on the one hand, and the pharmacists to sell their drugs safely on the other hand.

Keywords: *JADE, multi-agent systems, agent modeling, O-MaSE, pharmacist.*

GJCST-C Classification: *D.3.4*

Strictly as per the compliance and regulations of:

Optimized Drug Distribution for Pharmacies of the National Order of Pharmacists in DR Congo using a Multi-Agent Engineering Approach

Blaise Fyama [α] & Ruphin Nyami Nyate [σ]

Abstract- This paper focuses on a Multi-Agent Oriented Engineering for the problem of registration of pharmacists in the National Order of Pharmacists (NOP) and the regulation of the sale of pharmaceutical products in a distributed environment. The behavior of a pharmacist in the practice of pharmacy is characterized by interactions with the Provincial Council of the Order of Pharmacists (PCOP) of his jurisdiction, where he obtains an authorization to practice pharmacy. This authorization is accompanied by the ethical rules to be observed in order to expose medicines on the market. The activities of each pharmacist are continuously subject to quality control and pharmaceutical vigilance to protect the health of the population. In this paper, we focus on the design of a Multi-Agent System (MAS) in order to help the PCOP to control the pharmaceutical activity on the one hand, and the pharmacists to sell their drugs safely on the other hand. Our MAS is designed based on the O-MaSE (Organization based Multi- agents System Engineering) method, and our methodology took into account the following steps: The analysis phase we identified the goals from the user's needs and we structured them in a goal hierarchy diagram; followed by the application of use cases and associated sequence diagram to have the initial set of roles and communication channels; for each role, we assigned the goals to be achieved as well as the capabilities required to achieve its goals. In the design phase we assigned the roles to specific classes of agents, and identified the conversations. The execution plans are also presented in the form of a protocol diagram, where we had to ensure that each action appearing in a conversation is implemented as a method within the agent architecture. We have also given the architecture and deployment model of our MAS. The JADE Framework has been used for the implementation of our MAS.

Keywords: JADE, multi-agent systems, agent modeling, O-MaSE, pharmacist.

I. Introduction

Nowadays, the field of Distributed Artificial Intelligence provides Software Agents with cognitive capabilities comparable to those of human beings (reasoning, thinking, learning, and deciding). The conquest of the power of this science and the evolution of technology is forcing the standalone or pre-programmed software development process to emancipate itself from the silo for distributed systems where each application is endowed with the ability to learn and use the distributed intelligence across the network. Each software agent distributed in the network is specialized in a given domain and interacts with other agents to solve complex problems in an environment. The DRC's pharmacy domain is no exception as the skills of each pharmacist must be put together to produce knowledge bases. This field is experiencing a proliferation of pharmaceutical dispensaries commonly called "death boxes", coupled with the increase in the counterfeiting of pharmaceutical products which endangers the health of the populations. The consumer of Congolese pharmaceutical products is faced with a total opacity to distinguish a licensed pharmacy from a "death box", notwithstanding the rules enacted by the PCOP. Our study wants to bring an answer to this problem by developing a Multi-Agent System made up of intelligent agents able to identify each pharmacist, his pharmaceutical activities in order to make it public to consumers. Each pharmacist registered with the PCOP will obtain exclusive authorization to practice pharmacy, which will undoubtedly limit the proliferation of unlicensed pharmacies. The consumer can now search for a drug in the MAS and the intelligent agent will contact qualified vendors (pharmacists) to obtain the drug safely. The pharmacy domain being complex in its broad spectrum, the agents, their interactions and sociability are also complex as confirmed by the theory of AMAS (Adaptive Multi-agent Systems) which proposes to solve complex problems by self-organization for which no algorithmic solution is known [1], [2]. Moreover, the autonomous agents of our MAS will be subject to ethical rules and pharmacists' deontology to make decisions which are perceived as locks, or design problems according to an agent-centered perspective. This implies the use of formal rules to collective ethical issues in multi-agent systems proposed in [3], [4], for the achievement of the primary goal of protecting the health of the population. Several methodologies, allowing the development of this kind of system have been proposed. Our choice is oriented towards the O-MaSE approach to develop our MAS. This methodology is selected for its conceptual richness and simplicity.

Our study is structured around the following three points excluding the introduction:

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– The related works: this part will allow us to present the related works;
– The design of the MAS for the adherence and regulation of the sale of pharmaceutical procedures in the market;
– ADM implementation and simulation. We implement under the JADE platform (Java Agent Development Framework) a sales negotiation capability between intelligent agents.

II. Related Works

Membership of the national order of pharmacists and pharmaceutical vigilance have been the subject of previous studies. The result produced in [5] proves that the period of hospitalization or discharge of the patient, constitutes a critical stage for the drug risk and the notion of drug quality must be a priority because only a limited number of patients know how to access the accredited pharmacies. This result confirms that access to medications requires an intelligent system to guide the acquisition of medications. In addition, the current technological evolution pushes the profession of pharmacy mutation including all professionals and pharmacy students who must grasp the advances [6]. The research conducted by Benhajji [7] have led to a satisfactory result of using a patient-centered and agent-based approach that minimizes waiting times, length of stay, and therefore costs of care, while ensuring quality care for all patients. With regard to drug safety and the proliferation of unlicensed pharmacies, research has been carried out to dissuade offenders B. Allenet and his team [8], [9]. According to G. Rousset [10], the distribution of medicines online has indirect and negative consequences for patients and public health and generates major risks related to the difficulty for pharmacists to fulfil their obligations and ethics. Other studies deal with the management of patients in hospitals. This is notably the case of the work of Chuan-Jun and his teammate [11] and others in 2018 [12]. Other studies have focused their research on the ethical and deontological compliance of agents with respect to a domain [3], [4]. The problem with all the works is that the emphasis has been on reminding the agents of the rules established at the domain level even if this is not enforced. The literature review previously cited shows the interest given to pharmaceutical activities whose consequences are incalculable in human health. On the other hand, we did not find any papers that addressed the issue of pharmacists' membership, pharmaceutical vigilance and the practice of pharmacy using the Multi-Agent approach. Multi-agent systems (MAS) require interactions between agents [13], [14], [15]. These interactions drive learning to achieve the common goal [16]. Scott and Wooldridge have used agent-oriented methodologies such as MaSE [17] ASEME [12] and other appropriate modeling techniques. It has been found that some projects use multi-agent systems to develop their approach in the field of such as industry, tourism, decentralized control policies, decision making and coordination. The methodology "MaSE" is a seven-step process in two phases [18]. In the analysis phase, the identification of goals, the application of use cases through sequence diagrams and the definition of roles with their required competencies. As for the design phase, it defines the agent diagram, the protocol diagram (sequences) or conversation diagram between classes and deployment diagram [18], [19]. In 2012, M. Fethi with his research team [20] applied the "O-MaSE" (Organization based Multi-agents System Engineering) methodology to solve the vehicle touring problem. O-MaSE is an extension to the MaSE methodology and completes it with the organization dimension. It considers a multi-agent system as a social organization. Each agent is a member of this organization and plays a specific role according to its capacity. In 2019, Hanane E. Adil Haddi and H. Allali [13] used the "MaSE" methodology to design a system to support metacognitive skills to learners. Other research works have focused on the MaSE methodology as in [21], [12]. This literature on MaSE methodology is matched with three main families that exist when designing MAS [20]: functional, object and agent. The functional approach is generally applied to the domain of enterprise information systems by treating both the data and processing point of view and the aspects going from design to implementation. In the object approach, modeling a system consists of breaking it down into independent units, each unit having its own characteristics (attributes) and operations that it can perform (methods). Unlike an agent, an object only reacts to a method call and all the situations it will face must be taken into account by the designer [22]. Moreover, objects cannot have goals nor seek satisfaction and the mechanism of sending messages is summarized in a simple call of the methods of the class. There is no communication language as such between the objects in an application. The interaction mechanisms are the responsibility of the programmer. In turn, the agents have goals that give them autonomy of decision with respect to the messages received. In [23], it is clearly stated that the MAS reorganizes itself continuously according to different scales thanks to the movements in the life cycle of the agents. The global behavior of the MAS depends on the links between its different agents. The behavior will sometimes be regular, sometimes chaotic, in all cases non-linear. The behavioral model must therefore take into account the possibility of non-regularity of the system.

This distinguishes the agent-based approach from those used with functional and object models. In conclusion, the functional and object models are not sufficient to design the systems of membership to the National Order of Pharmacists and the regulation of the

sale of medicines. Because they do not take into account the characteristics of autonomy, learning and sociability of each component of this system as well as their characteristics of complexity and evolution. To design our ADM, in the following section 3 we will use the O-MaSE methodology [24], [23].

III. Design of Our MAS

The process of joining the national order of pharmacists and the process of selling pharmaceutical products discussed in this article is very similar to the technology of distributed intelligent agents, whose centrifugal points are as follows The Provincial Council of the Order of Pharmacists is the only body empowered to assign a unique national order number to a pharmacist to practice pharmacy. Once registered, a pharmacist can manufacture molecules and submit them to the Congolese Control Office (O.C.C). for quality control and conformity. Once certified, the molecule is exposed on the market to sellers for consumption. Sometimes some drugs are recalled for ineffectiveness or for complications that they cause in patients. It is up to the competent authority to decide on the withdrawal of these. Whenever a buyer wants to purchase any pharmaceutical product, he/she is usually faced with a plethora of sellers offering the same product at different prices and with different characteristics. Since this system is made up of several actors at different levels of responsibility, we reaffirm that it fits well with the distributed paradigm. In the following we will model the process of procurement, quality control and compliance, and the sale of pharmaceutical products, in this case drugs, in a distributed environment. The methodologies for modeling computer systems can be classified into three main families: functional, object and agent [20]. The functional approach is generally applied to the field of enterprise information systems by treating both the data and processing point of view and the aspects ranging from design to implementation [20] [25]. In the object approach, modeling a system consists in decomposing it into independent units, each unit having its own characteristics (attributes) and operations that it can perform (methods). Unlike an agent, an object only reacts to a method call and all the situations it will face must be taken into account by the designer. Moreover, objects cannot have goals nor seek satisfaction and the mechanism of sending messages is summarized in a simple call of the methods of the class. There is no communication language as such between the objects in an application. The interaction mechanisms are the responsibility of the programmer. In turn, the agents have goals that give them autonomy of decision with respect to the messages received [21]. In [20], it is clearly stated that the MAS reorganizes itself continuously according to different scales thanks to the movements in the life cycle of the agents. The overall behavior of the MAS depends on the links between its different agents. The behavior will sometimes be regular, sometimes chaotic, in all cases non-linear. The behavioral model must therefore take into account the possibility of non-regularity of the system. This distinguishes the agent-based approach from those used with functional and object models. In conclusion, the functional and object models are not sufficient to model the systems of membership to the National Order of Pharmacists and the regulation of the sale of medicines. This is because they do not take into account the autonomy, learning and sociability characteristics of each component of this system as well as their complexity and evolution characteristics. To model our ADM, we used the O-MaSE methodology [24], [23]. O-MaSE (Organization based Muti-agents System Engineering) is an extension to the MASE methodology that completes it by the organization dimension. O-MaSE considers a multi-agent system as a social organization. Our methodology has thus pursued the following approach: each agent is a member of this organization and plays a specific role according to its capacity. It is mainly composed of models (Goal, Organization, Roles, Ontology, Agent, Protocol and Agent State). In the following paragraphs we present the main diagrams, namely the goal diagram, the role diagram, the agent diagram, the plan diagrams and the protocol diagrams.

a) Development of the Congolese Pharmaceutical Universe Goal Map

The goal diagram of the MaSE methodology is an acyclic directed graph where the nodes represent the goals and the arcs define a sub-goal relationship [26]. Following the problematic of the present article exposed previously, the main goal is to protect the health of the population by regulating the registration to the PCOP for each candidate wishing to practice pharmacy, the quality control of medicines intended for sale. This primary objective constitutes the overall goal, noted Goal 0. Goal 0 is dependent on the achievement of four sub-goals which are:

- Managing the enrollment of new pharmacy graduates in PCOP (Goal 1),
- Management of the supply of medicines in stock (Goal2),
- Consumption of drug products (Goal3),
- And the application of pharmaceutical vigilance to decide whether or not to use the drug (Goal 4).

Goal1 is dependent on meeting the objectives of several sub goals. Indeed, to enroll a new graduate in PCOP, one must first adjudicate the application to examine whether the conditions for membership are met (Goal1.1). Then, the applicant is identified for enrollment in the PCOP (Goal1.2). Goal1.1 depends on the achievement of two sub goals, the first of which is to select the application for enrollment noted (Goal1.1.1).

And the second goal is the automatic rejection of the application by the PCOP noted (Goal1.1.2). Goal 1.2, which concerns «identification of a new pharmacist", is dependent on the child goal (Goal 1.2.1) of "accessing professional data", the academic curriculum. Goal 1.1.1 is only achieved if all the elements of the file are accepted, i.e. verified, validated by the PCOP noted (Goal 1.1.1.1) and also if the notification of the interested party of his national order number has taken place noted (Goal 1.1.1.2). In addition, Goal 2, "To make medicines available on the market», depends on several sub goals. In general, the marketing of a drug requires prior authorization from the health authorities noted (Goal 2.1). This is followed by the distribution of medicines through pharmacies (Goal 2.2) and the submission of a complete file to the PCOP to obtain a license to practice pharmacy (Goal 2.3). The (Goal2.1) which consists in "authorizing the marketing of a drug" entails de facto quality controls of this drug noted (Goal2.1.1). And also to consult t h e conformity information on the noted drugs (Goal 2.1.2). Goal 2.1.1 related to "Quality control of medicines" is only achieved when the compliance of health specificities is proven noted (Goal2.1.1.2) and also when the analysis result "prepare notice" has been published, noted (Goal2.1.1.1). Goal 2.1.2 "to consult data on medicinal products" depends on two sub goals: To consult data (technical details) on the medicinal product, this entails the extraction of data noted (Goal2.1.2.1) as well as the prior identification of the medicinal product concerned before it is placed on the market (Goal2.1.2.2). Goal 2.2 on "Distribution of medicinal products" is achieved if its several sub goals are met. The marketing of a batch of medicines requires the dissemination of information (publish package leaflets and labels) about the medicine noted (Goal2.2.1). Then apply the sales policy noted (Goal2.2.2). Goal 2.2.2 "Process medicine sales" is achieved if quotations have been issued to applicants, noted (Goal2.2.2.1) and then if issuing the invoice to conclude a sale has taken place, scored (Bu2.2.2.2). The Goal3 representing "Consumption of medicines" is decomposed into two sub-goals. Indeed, the purchase of a drug requires the consultation of the list of pharmacists (sellers) available at the PCOP, noted (Goal3.1). Then one must be able to carry out the drug purchase operation, noted (Goal3.2). Goal3.2 "buy product" depends in turn on two child goals. Indeed, the purchase of a drug requires the choice of a better offer among many others, noted (Goal3.2.1) and, the request for quotation from the sellers affiliated to the PCOP noted (Goal3.2.2). The goal4 related to "pharmaceutical vigilance" depends on several sub-goals. Specifically, it starts with the patient experiencing adverse events (complications) related to medication and reporting the information to the health care professional for appropriate action, noted (Goal4.1). Next comes the recording of information to decide whether the is harmful or not (Goal4.2). Goal 4.2 is achieved if the decision to withdraw or not to withdraw the problem drug from the market is issued, noted (Goal 4.2.1). And also if recommendations have been issued to pharmacists, decision makers, consumers, noted (Goal4.2.2). To illustrate this textual description, the goal diagram thus constructed is presented in Fig. 1.

b) Application of the use cases of our SMA

The use case application step of the MaSE methodology is crucial to translate the goals (objectives) into associated roles and tasks [18], [12].

To build the use cases of our MAS, we will refer to the requirements described above. The use cases are full of exchanges that will become the communication elements of our MAS; they must then be converted into sequence diagrams to describe sequences of events between roles and to define the communications between the agents that will play these roles (Fig.2).

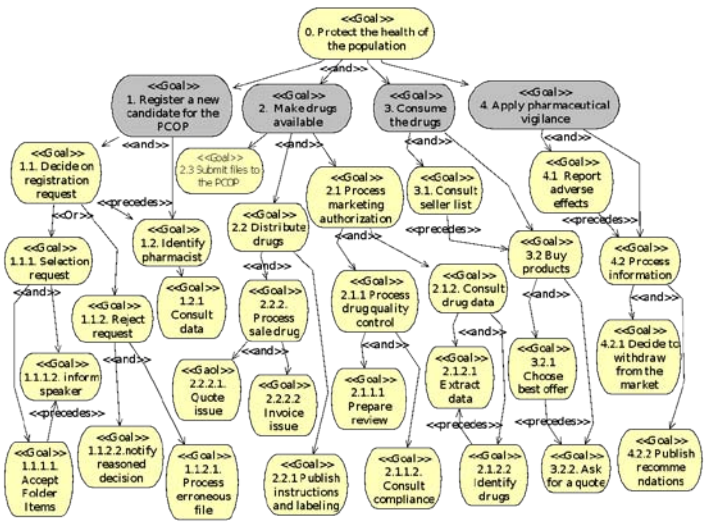

Fig. 1: Goal diagram of our (MAS)

The roles thus identified in this step form the initial set of roles used to completely define the system roles in the next step [18]. In this sequence diagram the boxes at the top of the diagram represent the system roles and the arrows between the lines represent the events that occur between the roles. Time is assumed to flow from the top of the diagram to the bottom.

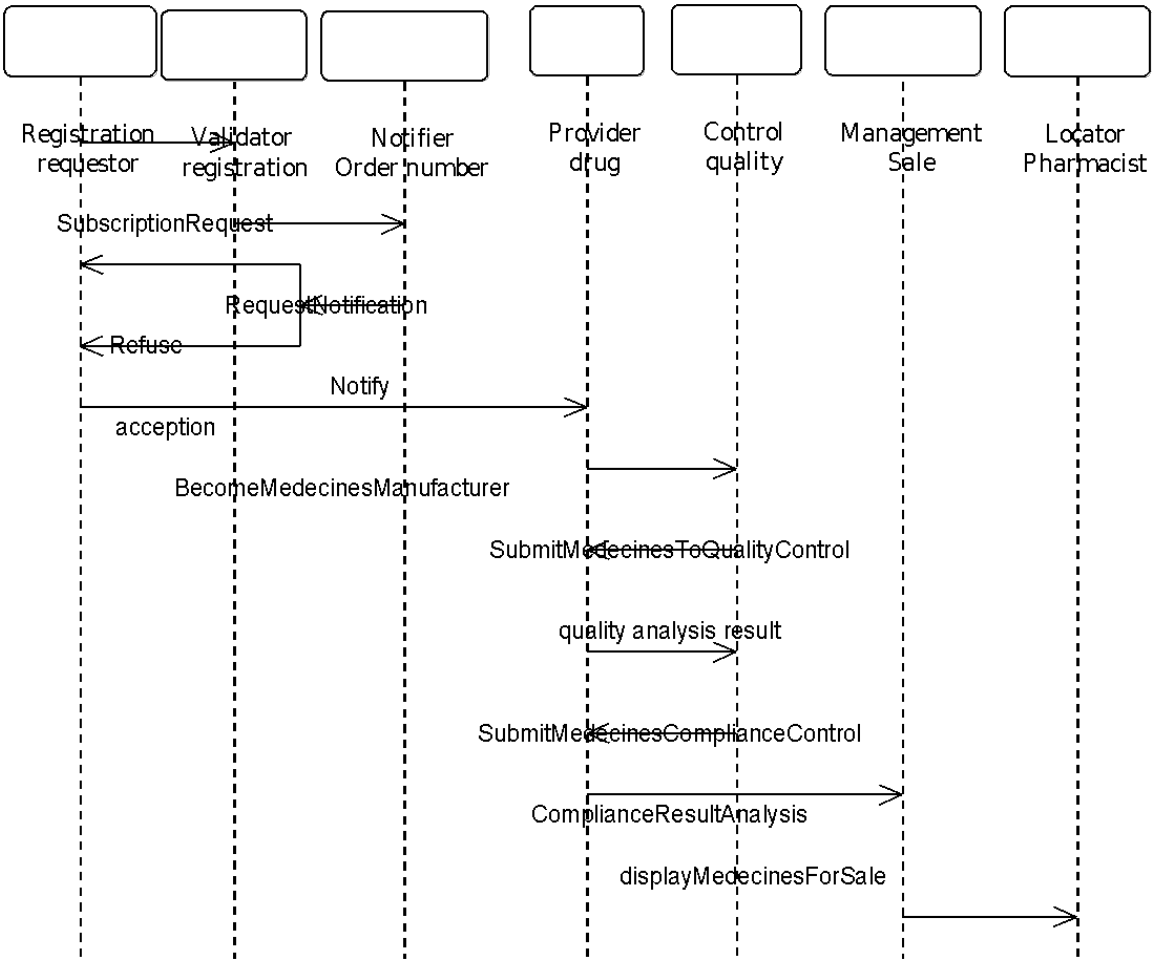

Fig. 2: Pharmacist Enrollment Process Sequence Diagram

b) Role diagram

The transformation of goals into roles generally follows a sequential logic. However, there are situations where it is useful to have one role to be responsible for several goals. For each goal/sub-goal identified earlier, we will have to create a role to realize it. A role can in this case achieve two goals at the same time. In order to achieve a goal, a role must have at its disposal one (or more) "Capabilities". To identify the roles of our AMASDM, we based ourselves on the application of use cases and diagrams of the previous section (3.2). Thus eleven roles have been identified with goal mapping as follows: Health Reporter completes goal4.2; Drug Consumer completes goal 4.1; Order Number Notified completes goals (1.1.2, 1.1.2.2, 1.1.2.1 and 1.1.1.2); Registration Validator completes goals (1.1, 1.2, 1.1.1, 1.1.1.1); Enrollment Applicant completes goal 2,3; Drug Utilization Decision Maker completes goals (4.2.1, 4.2.2); Drug Provider completes goals (2.2, 2.2.1); Quality Control completes goals (2.1, 2.1.1, 2.1.2, 2.1.2.1, 2.1.2.2, 2.1.1.1, 2.1.1.2); Pharmacist Locator completes goal1.2.1; Purchase Negotiator completes goals (3.1, 3.2, 3.2.1, 3.2.2) finally Sales Management completes the goals (2.2.2, 2.2.2.1, 2.2.2.2). We have mapped goals to individual roles with two exceptions. Goals, 1, 2, 3 and 4 were not mapped to roles because they were partitioned. The role diagram is given in *Fig. 3*.

d) Role capacity

In the following Table 1, the objective is to specify the knowledge and skills "Capabilities" or "competencies" required for each role. A capability or skill is a know-how, a mastery of business rules that an agent must have before playing a given role; generally this "know-how" is translated into execution plans that will be translated into (state- transition) diagrams (section 3.5) describing the way an agent must behave. The following Table 1 describes each role and its capabilities required to achieve the goals assigned to it:

Table I: Role Table

Goals	Roles	Capabilities
Process health information	Health reporter	He/she must be able to "communicate cases": identify medications, enter health reports, and transmit complicated cases to the decision maker.
Reporting adverse events	Consumer of medicines	The consumer must be able to "report adverse events": enter the adverse events, enter the medication taken, the date, the time taken, the source of the medication.
Notify reasoned decision	Order Number Notifier	He is responsible for "informing the decision of file processing" more precisely: enter the answer (negative or positive), enter the date, place, and motivation of the decision taken by the PCOP.
Reject Registration request		
Identify pharmacist	PCOP Registration Validator	He must be able to "update the membership roster": enter administrative, academic, Galen's oath, type of pharmacy to practice.
Ruling on application Purpose(1.1)		
Submit file to PCOP	Applicant for registration	Responsible for collecting the following data: entering the time of application, recording the elements of the file, detecting the absence of an element of the file.
Goal(4.2.2) Publish recommendations	Deciding on the use of medication	It is responsible for the "publication of recommendations": enter the name of the product, form, manufacturer, complications caused and issue the "List of unauthorized and authorized drugs".
To decide on the withdrawal of a drug from the market Goal (4.2.1)		
Stop2.2) Dispense medication	Drug supplier	He is responsible for the "supply of medicines": enter the product name, form, manufacturer, unit price, wholesale price, date of manufacture, leaflet, update the product catalog.
Goal (2.2.1): To publish notices and labels		
Goal (2.1.1): To address product quality	Quality control	It must determine the "quality and conformity of the product": to seize name, form, series, date manufacture and the date of expiry, genealogical form, innocuities. He must detect if the drug is clean or unfit for consumption. He must know the list of drugs to be withdrawn from the market (expired).
Goal (2.1.1.1): to prepare analysis result		
Goal(2.1.1.2): to verify compliance and Goal(2.1.2.2)		
Goal (1.2.1): Consult with pharmacists	Pharmacist Locator	Responsible for collecting the following data: enter the address of the pharmacy, List of products, customer comments on this pharmacy, detect the status of the pharmacist (active, passive).
Goal (2.2.1.1): To issue a quote Goal (2.2.2.2): To issue an invoice	Sales management	"Master the steps of the sale: enter number, date, and quantity, total. It must detect the profit of an outstanding sale or the loss.
Goal (2.2.2.2): To issue an invoice		
Goal(3.1): Consult vendor list	Purchasing Negotiator	Responsible for the following operations: inputting drugs to be ordered, requesting quotes, negotiating the purchase, accepting or rejecting a Proposal.
Goal (3.2.1): request for quotation		
Goal (3.2.2): choose best offer		

e) Agent class diagram

In this diagram (Fig.5) we want to mod el classes of agents capable of possessing all the necessary capabilities to play each role. Each class represents a model for a type of agent that can be instantiated several times according to the needs of the system. Indeed, these agent classes describe the global organization of the MAS composed of agent classes and the conversations between them. An agent class is a model for a type of agent in the system and is defined in terms of the roles they will play and the conversations in which they can participate. If roles are the basis of MAS design, agent classes are the building blocks used to implement this MAS [4].

For the functioning of our system, we have retained seven classes of agents that work simultaneously: a first agent named "PCOP" having the capacities and know-how to play the roles: Validator of registration request, Notifier of answers and national order numbers of pharmacists and the role of Locator of pharmacists. The second class of agent selected is the "OCC" agent, having as roles: quality control of pharmaceutical products. This agent must have all the necessary capabilities to play these roles. The third agent used is the "Pharmacist", whose role is to file with the PCOP and to dispense drugs. He/she must have the necessary skills to play these roles. The fourth agent needed is the "Salesperson" whose roles are: Sales Management. The sales agent must have all the required capabilities to perform these roles. The fifth agent used is the "Buyer" agent having the roles: Buying Negotiator. He must also have the necessary capabilities to perform this role. The sixth agent used is the "Patient" agent whose only role is to report fake drugs. Finally, the "Health Professional" agent whose role is to decide on the withdrawal of medication and to process health alerts. This agent must have the capabilities to perform this role. Agent classes are similar to object- oriented class diagrams with two main differences. First, agent classes are defined by the roles they play, not by attributes and methods. Second, all relationships between agents classes are captured as conversations. The agent class diagram of our ADM is also shown in *Fig. 5*. The rectangles of indicate the agent classes and contain the class name and the set of roles that each agent plays. The lines with arrows identify the conversations and point from the conversation initiator to the responder.

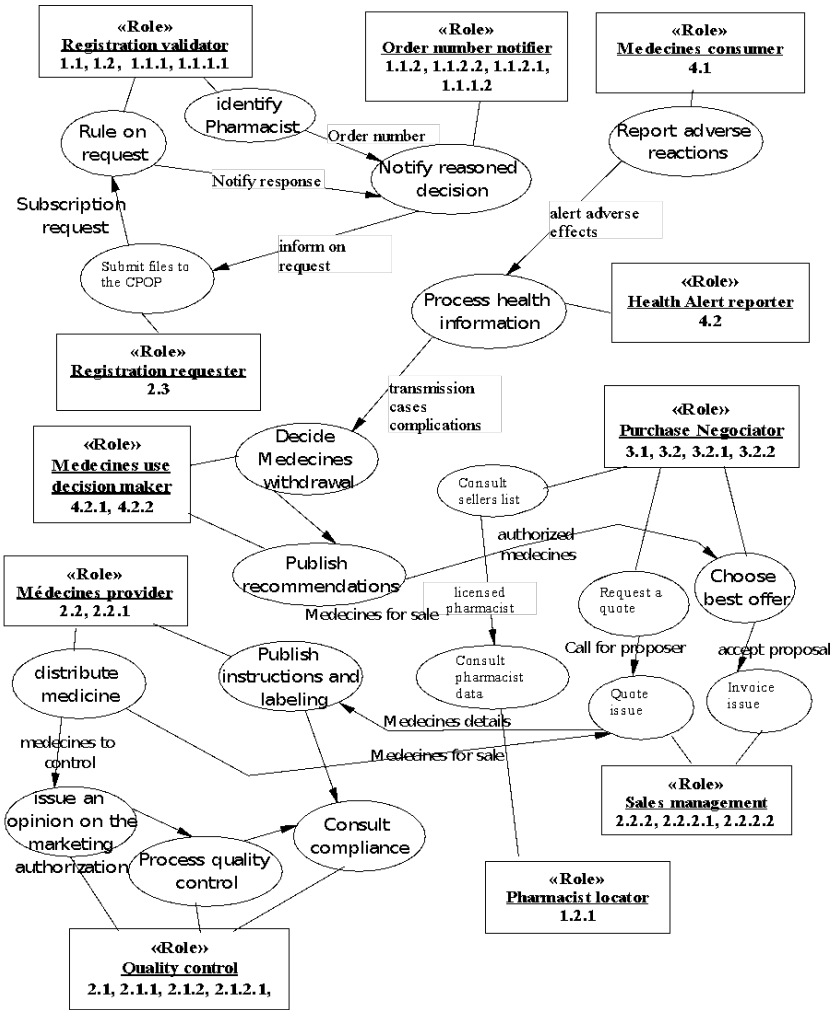

Fig. 3: Role diagram

To consolidate the textual description in Table I, the diagram in the following Fig.4 illustrates the roles and capabilities of our MAS.

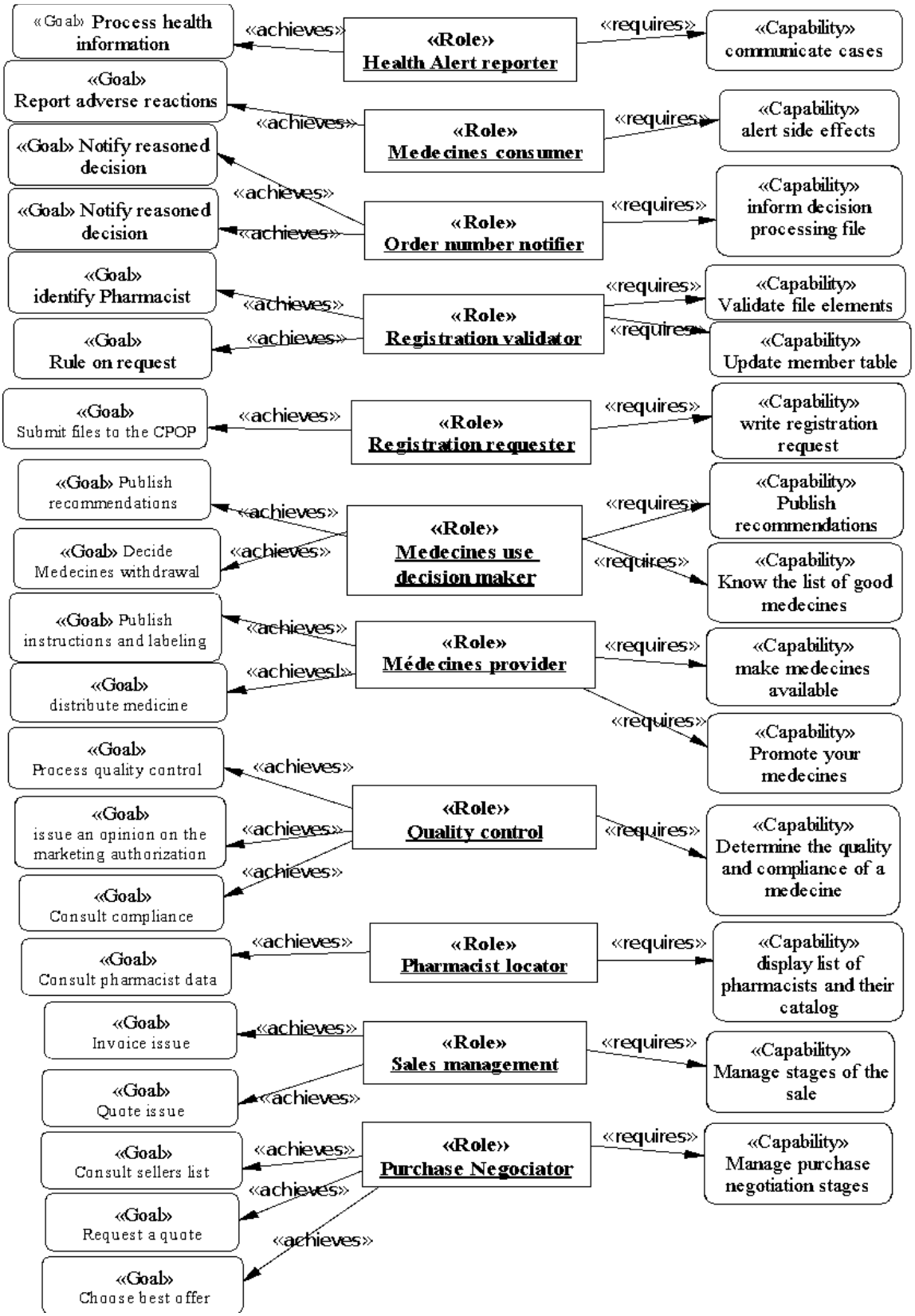

Fig. 4: Detailed role-capability diagram

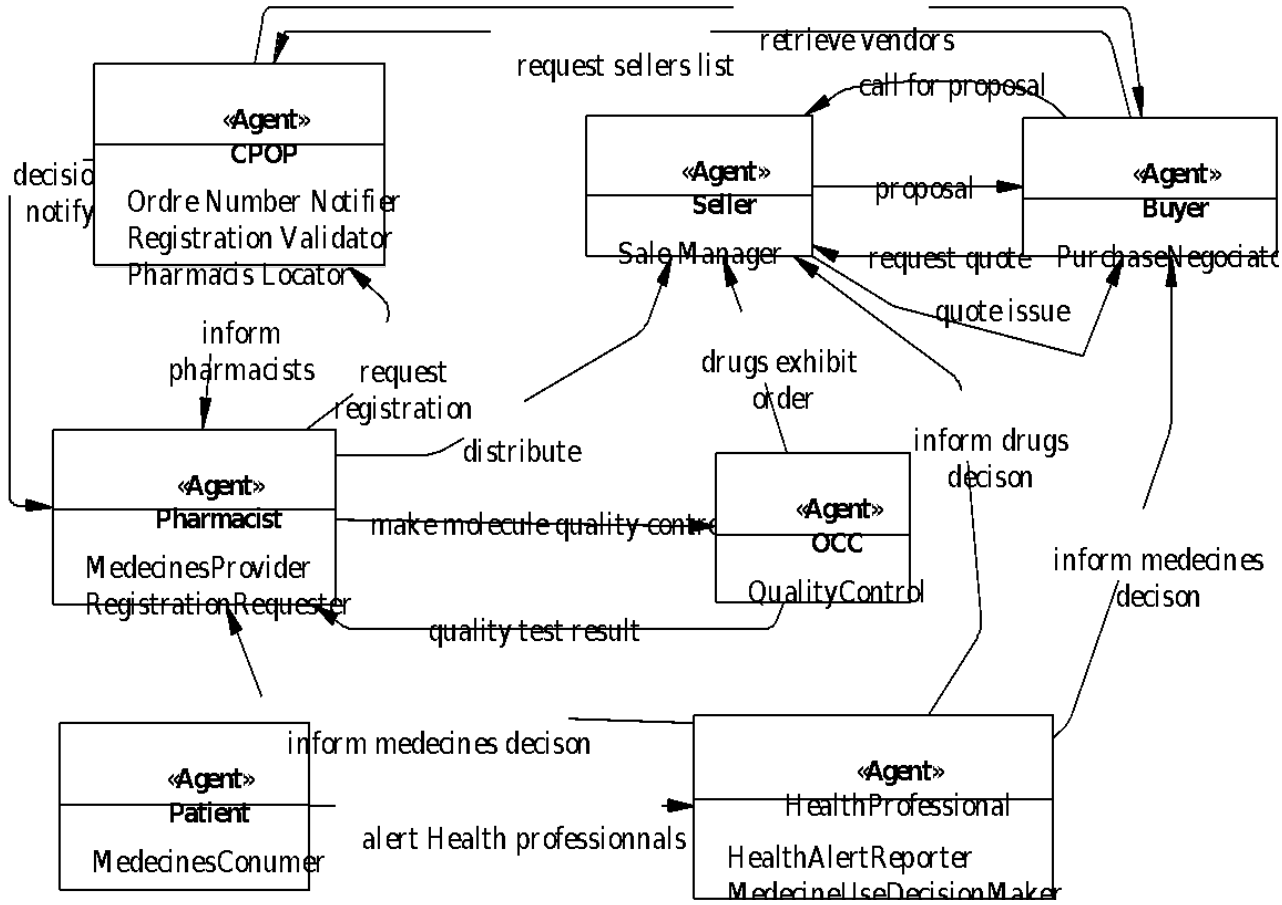

Fig. 5: Agent Class Diagram

f) Diagram of plans

The creation of roles followed by the identification of tasks previously performed requires us to specify the behavior of the role by defining the algorithmic details of the individual tasks. A role can be composed of several tasks that, taken together, define the required behavior of that role. Each task runs in its own control thread, but can communicate with each other. Concurrent tasks are defined in the plan diagrams in the following paragraphs and are specified as finite state automata, which consist of states and transitions. The states encompass the processing that takes place internally to the agent while the transitions allow communication between agents or between tasks. In this section, we detail the capability plan diagrams identified earlier, including: PCOP application validation, pharmacist location plan, sales management, drug control and certification plan, drug purchase negotiation plan finally the drug withdrawal plan on the market.

i. *Application Validation» flowchart*

Following the reception of a PCOP membership application containing elements to be validated one by one of the type receive(validate(elts, condit)) where elts represents the elements of the file each of which describes the identity of the applicant (candidate) and other administrative information, condit designates the conditions required for the validation of the application the PCOP agent must verify the presence of each element, verify the conditions required to satisfy this application among other things (nationality, Galien's certificate of oath dating back to two months, diplomas,.) in order to register the pharmacist in the membership table by assigning him a number. Upon satisfaction of the request, a report from the PCOP is sent to the CNOP (Fig. 6)

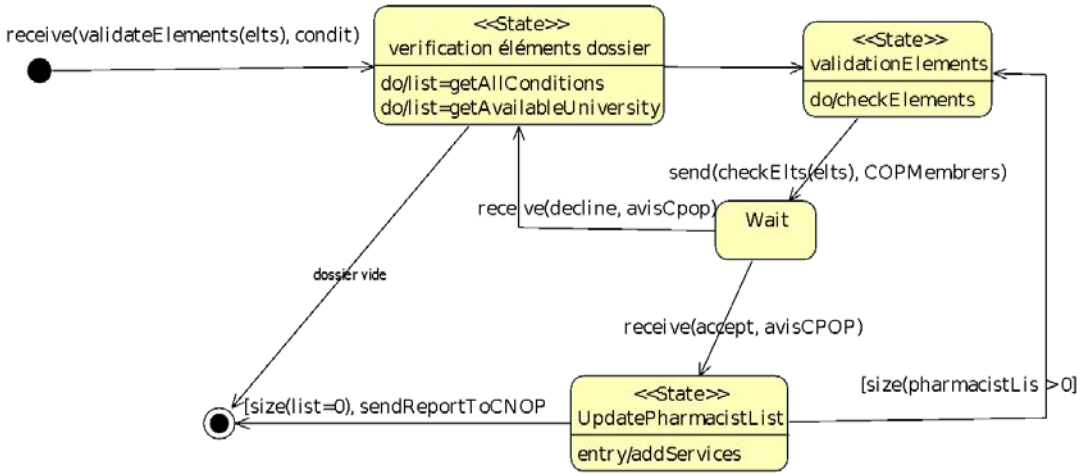

Fig. 6: "Validation of registration request" plan diagram

ii. *Pharmacist Location Map*

Following the reception of a "receive (select Pharmacis())" message requesting the selection of the pharmacist, the agent sets itself to the initialization state, then retrieves the input search parameter by executing the relevant thread. At the end of the execution, the agent sends the list of results found according to the criterion, otherwise a null result will be sent to indicate the absence of the pharmacist. To consolidate this description we give below the corresponding plan diagram (Fig.7)

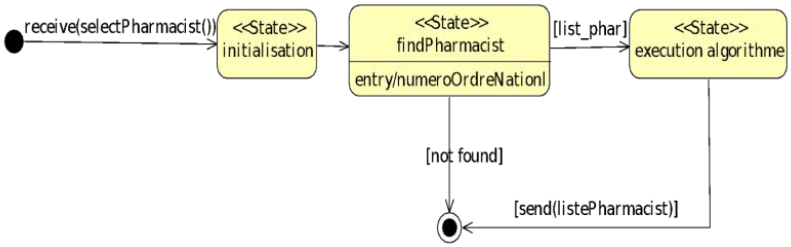

Fig. 7: 'Pharmacist location' plan diagram

iii. *Drug sales management plan*

When a receive(CFP, AID) message is received, where CFP represents the call for proposal of the drugs, AID represents the identifier of the buying agent in order to facilitate the communication between the two agents. The agent goes to the state "In this report, the agent goes to "Wait" for the approval or not of the quote by the requester and checks the buyer's answer which can be a refusal "REFUSE" or an approval "CONFIRM". In the case of acceptance, the agent sends the invoice back to the buyer for payment. The following diagram (Fig.8) illustrates the sales management plan.

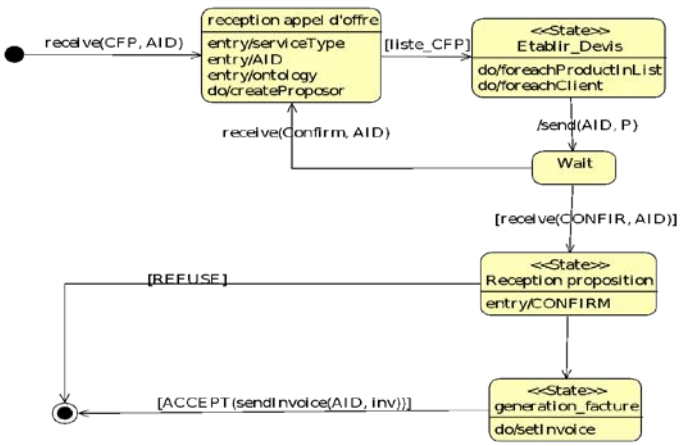

Fig. 8: "Drug Sales Management" Plan Diagram

iv. *Drug compliance and quality control plan*

The compliance and quality control process starts when the agent receives a receive (analyze (medi, AID)) message where *medi* represents the drug sample data to be analyzed and AID represents the requesting agent who can be a pharmacist who submits a molecule to the control or a seller who wants to expose on the market the medicines ordered outside the country. Everything starts with the analysis of the quality of the drug if it requires all the qualities, it passes to the state of verification of compliance, if it is also compliant, the drug is added to the list already on the market otherwise the product is quarantined for destruction. This algorithm will run as long as there are drugs or molecules to be controlled (Fig. 9).

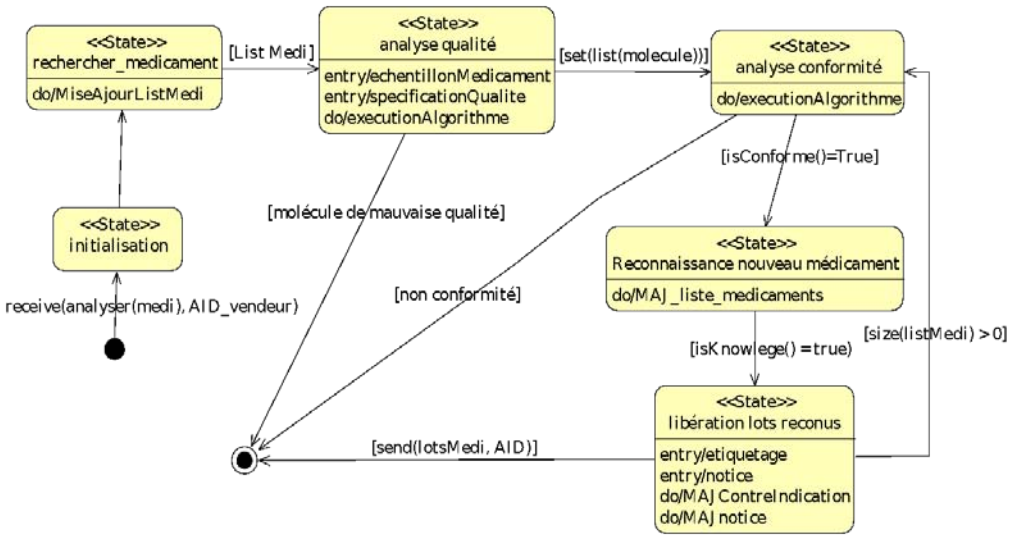

Fig. 9: Medicines Quality and Compliance Control Plan Diagram

v. *Drug Purchase Negotiation Plan*

When the Buyer agent container is launched, it passes through the initialization state where it communicates certain technical parameters such as the type of service sought, the name of the service, the ontology of the service sought and listens to events. When it receives a message containing the drug services, it switches to the "create call for proposal" state while looking for the list of potential sellers of these drugs to submit the request. The agent switches to the "waiting" state until it receives a sales proposal that will be submitted for selection before confirming the purchase (Fig.10).

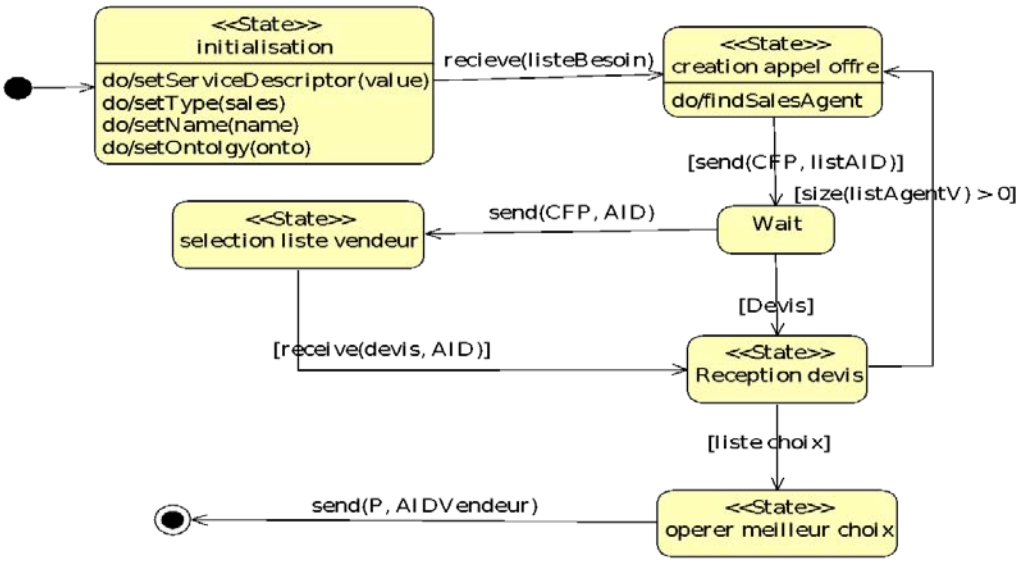

Fig. 10: Drug Purchase Negotiation Plan Diagram

vi. *Drug withdrawal plan*

At the launch of the Health Professional agent container, this service starts to contact the Patient agents to get feedback on the drugs administered to him, a series of questions is sent to the existing or created patient agents. Upon receipt of a response and after the selection of the patient agents involved, the Health Professional agent decides whether to withdraw a given drug from the market and creates recommendations to be made public. The objective is to identify ineffective drugs or drugs that create adverse effects on the health of the population (Fig.11).

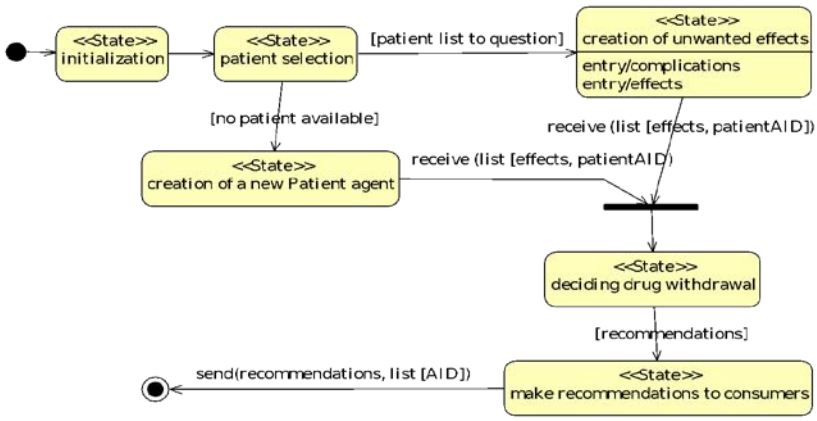

Fig. 11: "Drug on the market" plan diagram

g) Protocol diagram

In this section the objective is to define the details of conversations according to the internal details of concurrent tasks. A conversation defines a coordination protocol between two agents and is documented using two communication sequence diagrams where we find the initiator a n d the responder [27]. Cooperation is necessary when an agent cannot achieve its goals without the help of other agents. This situation is common even in primitive species. The goals requiring cooperation can be coordination, negotiation, communication between agents. These conversations are defined according to rules called "cooperation protocols" or "Conversation protocols", which indicate the allowed sequences of messages. A wide variety of protocols exist. Examples are the "Contract Net Protocol" for bidding and the generic protocols proposed by FIPA [28], such as "Dutch auction protocol" and "Iterated Contract Net Protocol". In our approach we use the “Contract Net Protocol" for inter-agent negotiation [28] with the FIPA 2002 extension consisting of successive rounds of proposal confirmations and refusals [27]. The "Contract Net Protocol" is a negotiation mechanism between two types of agents: contractor and manager. It allows a manager, after some exchanges with a group of agents, to retain the services of an agent called contractor for the execution of a contract task. This protocol is qualified as a "mutual selection" type since to sign a contract, the chosen agent must commit to the manager for the execution of the task and the manager selects only the agent having provided the most advantageous proposal. The original version of the protocol has three main steps: the call for bids, the submission of proposals and the award of the contract. A protocol linking two agents is described by a sequence diagram that represents the different interactions between the entities by indicating the order of messages exchanged. In our case, we have five types of communication between the different agents. The first concerns the processing of a new PCOP registration request. The second deals with the identification of pharmacists, the third deals with the control of drugs, the fourth deals with the negotiation of purchases and finally the fifth deals with pharmacovigilance.

i. "*PCOP Application Processing*" *Protocol Diagram*

After receiving a new application for registration D, CG, ID, AID, where D represents the university degrees obtained, CG means the certificate of Galen, ID means the identity document of the applicant and AID represents the unique identifier of the agent and its location, the PCOP agent sends a response to the applicant which can be a refusal in case the conditions are not met otherwise an acceptance of the application for registration. At the same time, a report is sent to the CNOP for a possible attribution of a national order number in case of an acceptance, otherwise a simple information report of the rejection. Acceptance of the application results in the assignment of a national order number to the pharmacist: transmit national number (NN), the PCOP agent notifies the pharmacist concerned of his registration with the national order of pharmacists confirm registration (NN) (Figure 12).

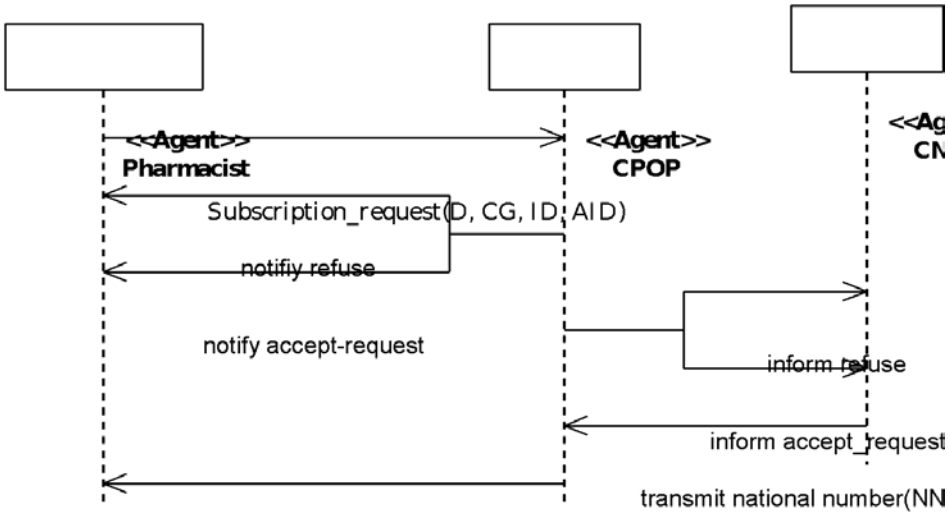

Fig. 12: Protocol diagram "Processing of the PCOP registration request

ii. *Protocol Diagram "Identification of Pharmacist Services*

After the PCOP agent approves the requests, the PCOP agent updates the table of skills, services, and locations of each registered pharmacist's pharmacy (Fig. 13). The request for publication of services promotes their services (S, AID) where S designates the services offered (drugs) by this pharmacist and AID indicates the location, address of the requesting agent.

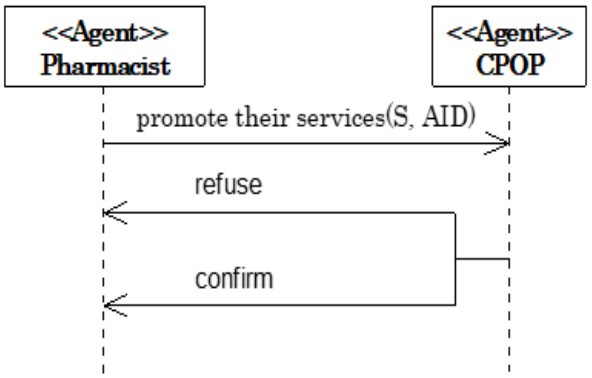

Fig. 13: Protocol diagram "identification of pharmacist services"

iii. *Quality control protocol diagram*

Following the reception of a drug sample to be analyzed (*E, Q, AID*) where *E* represents the sample to be analyzed, *Q* designates the drug and *AID* represents the address and identifier of the pharmacist agent. The *OCC* agent authorizes or does not authorize the market exposure of the drug according to the analysis result (*Fig.14*)

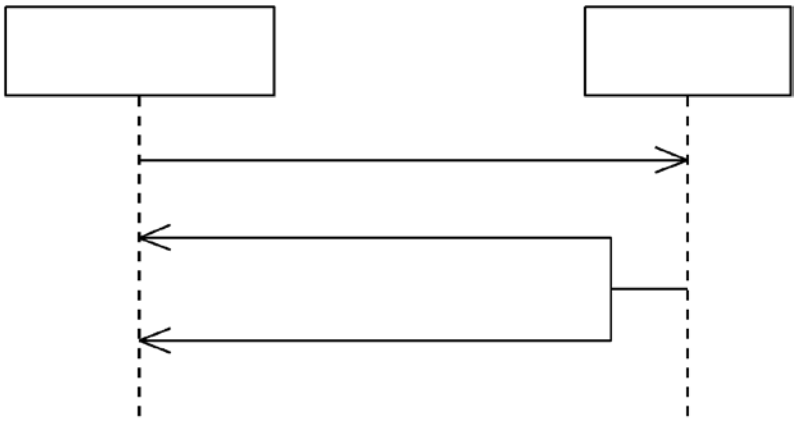

Fig. 14: Quality control protocol diagram"

iv. *Drug purchase negotiation" protocol diagram*

Following the reception of an alert of a medical prescription (*M, Q*) where *M* indicates the drugs to be bought and *Q*, the prescribed quantity of a Consumer agent who informs the Buyer agent by this prescription. The Buyer agent has to look for a potential pharmacist (seller) to buy these drugs safely. Upon this, the Buyer agent issues a query to the PCOP to find sellers who have these drugs (*S, AID*) where S denotes the type of service that will be used as a pharmacist selection criterion and AID denotes the location and ID of the Buyer agent. The PCOP agent provides the latter with a list of potential sellers found. The Buyer Agent now issues a call for proposal (request for quote) to the sellers received for a possible proposal or refusal. In case of a proposal, the buyer must choose one of the best offers (accept proposal) or reject the proposal (Fig.15)

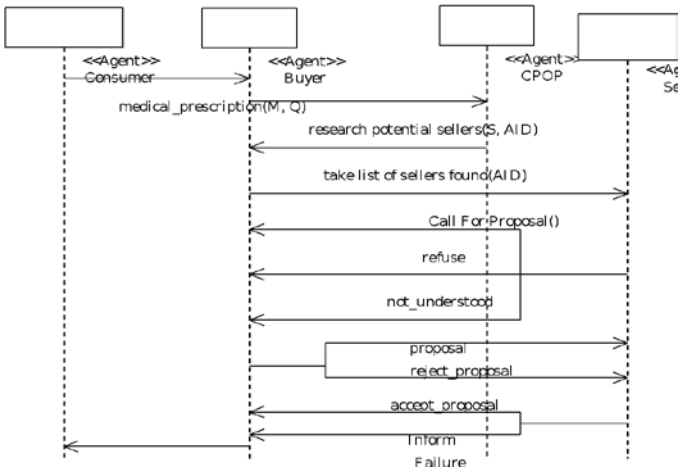

Fig. 15: "Drug purchase negotiation" protocol diagram

v. *Pharmaceutical vigilance management" protocol diagram*

Following the receipt of an alert or complication due to the use of a drug or ineffectiveness or adverse reactions from a patient agent, the health professional agent must inform the agents: Vendor, Pharmacist and Consumer of the withdrawal of a problem drug from circulation (Fig. 16).

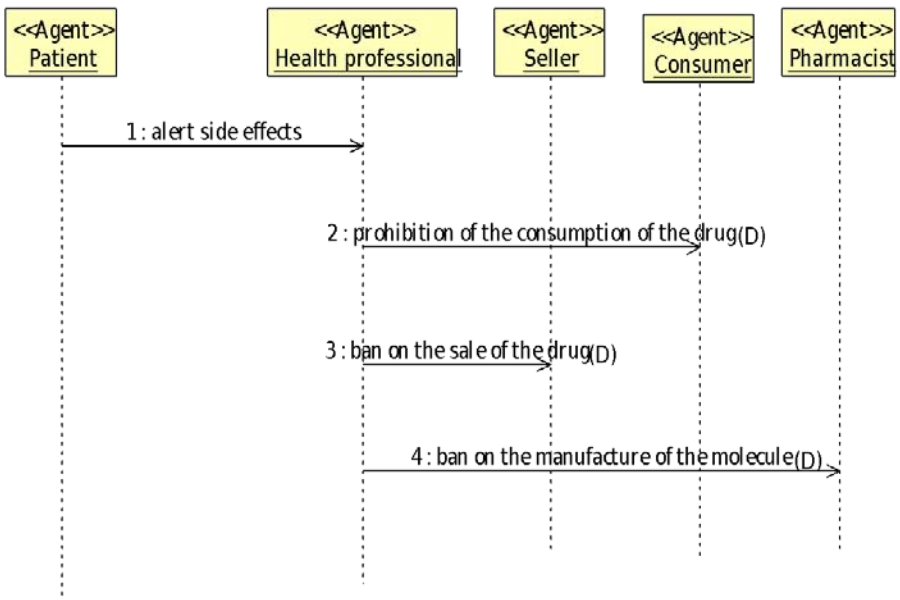

Fig. 16: Pharmaceutical vigilance Management protocol diagram

h) Agent architecture of our MAS

Starting from the agent class diagram described above, we will present the agent architecture of our SMA. It is worth recalling that our ADM allows us to identify the pharmacist before practicing his profession, to control his products to ensure that they comply with the standards, to negotiate the sale between the buyer and the seller. This results in a

permanent "pharmaceutical vigilance" control of the effects of drugs on the market. The proposed solution also makes it possible to manage unforeseen events that may occur, such as the arrival of a new pharmacy graduate or the appearance of a complication due to the use of a drug. The architecture defined (Fig. 17) provides for the use of seven agents: PCOP agent, Pharmacist agent, OCC agent, Sales agent, Buyer agent, Patient agent, and Healthcare Professional agent.

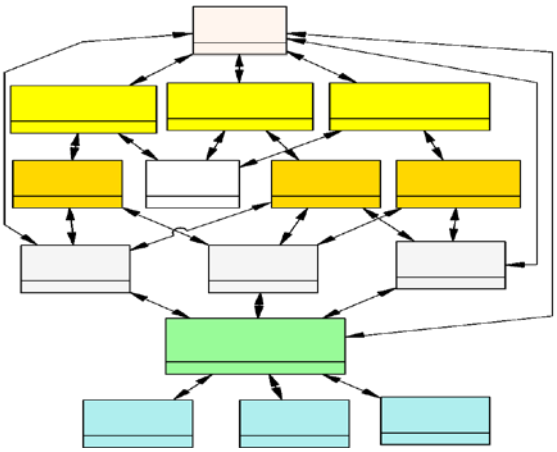

Fig. 17: Architecture diagram of our MAS

h) Deployment architecture of our MAS

This paragraph defines the deployment of our ADM before its implementation because agents usually need information on the deployment diagram, such as a host name or an address, for communications that usually incur a cost in the network. *Fig. 18* shows a deployment diagram for the National Order of Pharmacists membership and drug sales system. The cube nodes represent the agents while the connection lines represent the actual conversations between agents. Agents are identified by their class name in the form name-instance: class. The dotted boxes define the processing platforms. To reduce the communication load, we preferred to deploy the Buyer agents as well as the consumer on the same machine and the Seller, Pharmacist agents on the same machine. The rest of the agents are each deployed in a machine connected to the network in order to guarantee the advantages of the distribution obtained by using the multi-agent paradigm.

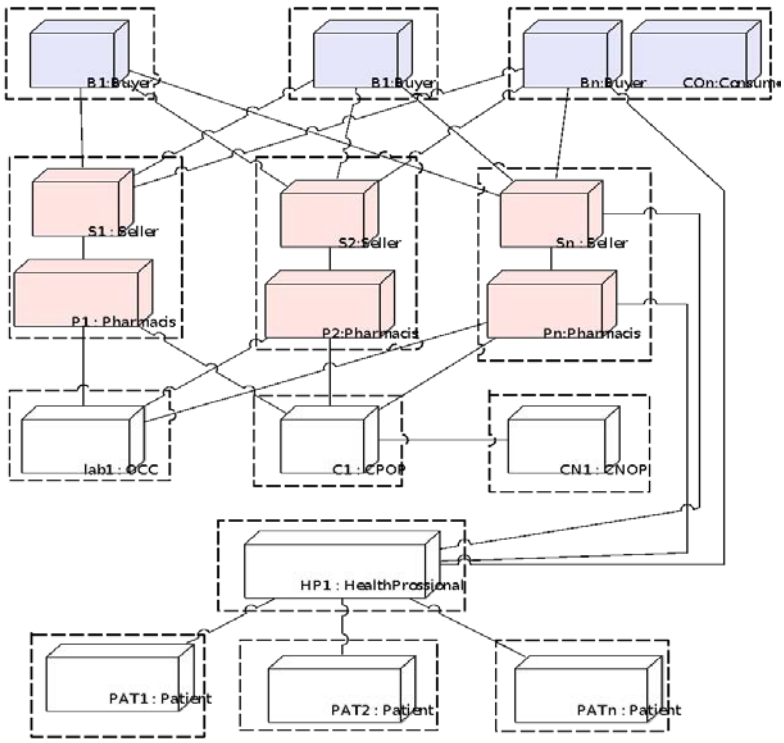

Fig. 18: Deployment architecture of our MAS

IV. Implementation of the Proposed Solution under Jade

Given this multitude of multi-agent development tools, we chose the JADE Framework. JADE (Java Agent Development Framework) is a multi-agent platform developed in Java by CSELT (Gruppo Telecom Research Group, Italy) a n d which aims at facilitating the development of multi-agent applications in compliance with FIPA specifications [29], [27]. The JADE agent platform includes all mandatory components that control an ADM. These components are: the Agent Communication Channel (ACC) which provides the route for basic interactions between agents inside and outside the platform, the Agent Management System (AMS) which is the agent management system, and the Directory Facilitator (DF) which provides a yellow page service to the multi-agent platform. All communication between agents is performed by FIPA-ACL messages [27]. The agent platform can be distributed over several servers. A single Java application, and thus a single Java Virtual Machine (JVM), is executed on each server. Each JVM is an agent container that provides a complete environment for agent execution and allows multiple agents to run in parallel on the same server. The communication architecture provides flexible and efficient message passing. JADE creates and controls a queue of incoming messages for each agent. It should also be noted that each platform launched and all the agents that make it up are controlled by the RMA (Remote Management Agent). The choice of JADE is justified by the fact that the agents can communicate dynamically with each other, which is consistent with the multi-agent orthodoxy. For the sake of simplicity, we will limit ourselves in this paper to the implementation of the "Negotiation of the purchase of drugs" capability in our MAS.

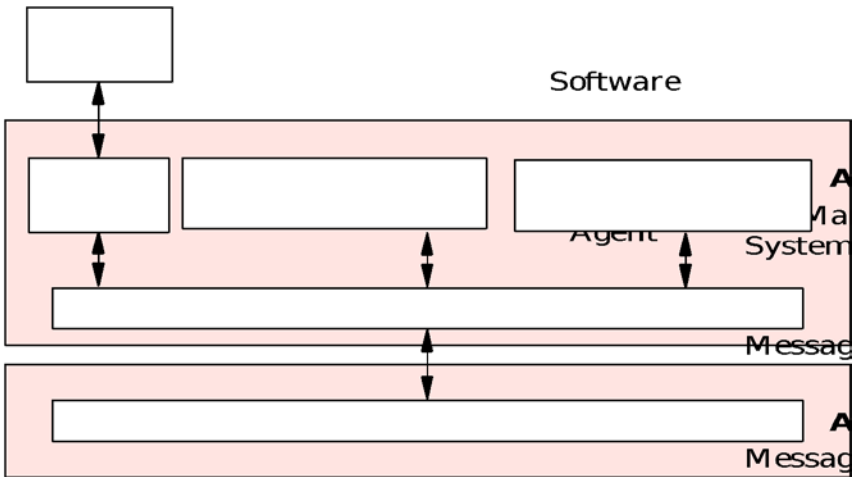

Fig. 19: JADE platform software architecture [27]

a) The "Negotiate Drug Purchases" Capacity

Additional programming platforms were used JADE [11], NetBeans [30], a jade.jar API [31]. The purchase of drugs in our MAS involves interaction requires a negotiation capability between the buyer and sellers. The buying agent is placed in a different container than the seller or the consumer. Note that there can be as many agents on the same container depending on the needs. In the detailed protocol diagram (Figure 20) where each agent is located in a single container with the possibility of migrating from one container to another without losing its capabilities. The main container "MainContainer" contains the main modules AMS and DF respectively the identifier of the agents and the facilitator in the search for services; we also find two containers: Container 0 which contains the first salesman (pharmacist1) and Container 1 for the second pharmacist. Containers 2 and 3 are reserved for the buyer and the seller respectively. Each selling agent publishes his services to the DF and listens for buyer events; the buying agent simply contacts the DF to find potential sellers for his needs.

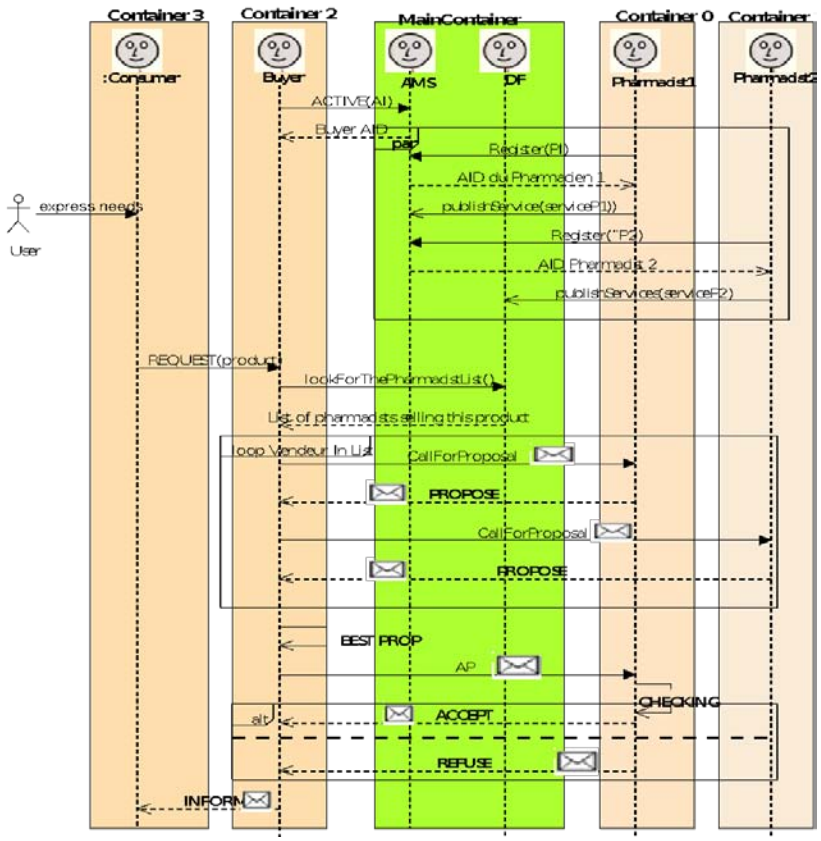

Fig. 20: Detailed protocol diagram of the "Drug Purchase Negotiation" capability

In the following Fig.21, it is clearly demonstrated the discrete communication between the agents involved in this drug purchase negotiation scheme in our AMS. Using the Sniffer agent we decided to spy on a group of agents (Consumer, Buyer, a first pharmacist named DE SIFA and another named DEMBO, an AMS agent and DF). Each message leaving or going to this group is captured and displayed on the sniffer interface. We can see the message leaving from the consumer to the buyer, from the buyer agent to DF and vice versa. Note also that a click on the link of a message gives the details on the content of the message.

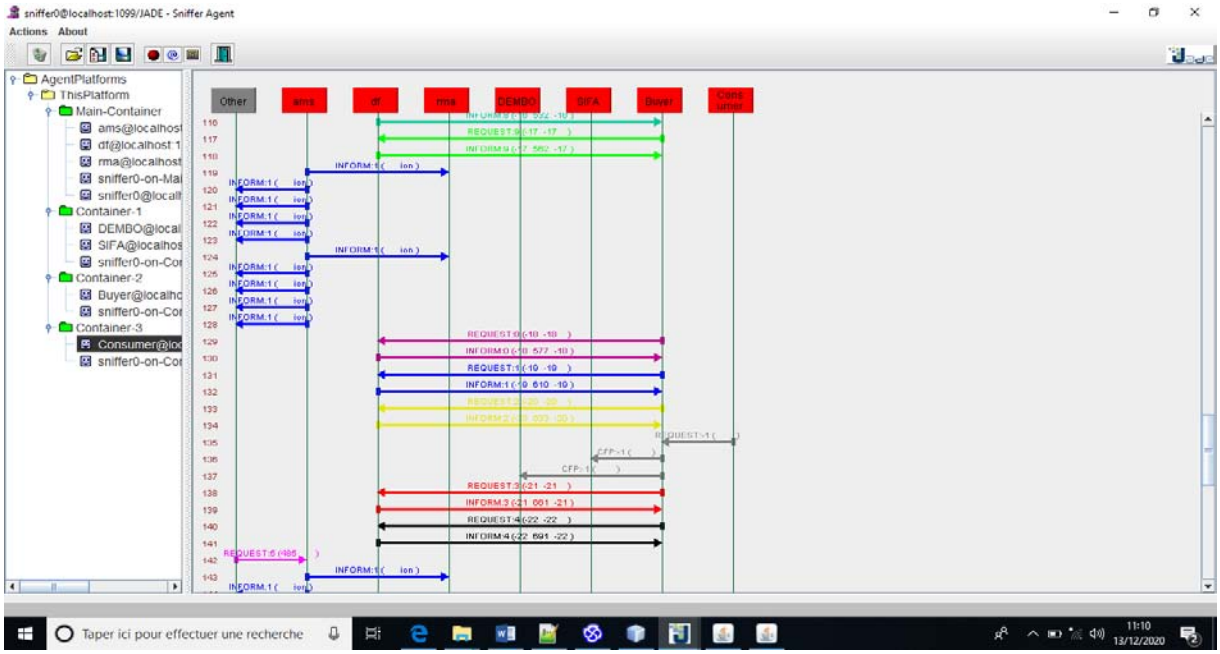

Fig. 21: Interface de l'agent Sniffer de notre MAS

V. Conclusion

This paper aimed at designing a Multi-Agent System for the regulation of drug sales in order to secure the health of the population. Indeed, the designed MAS allows the registration of pharmacists in the Provincial Council of Pharmacists, the control of the quality and conformity of drugs before their exposure on the market, the negotiation of sales between agents and the follow-up of pharmaceutical vigilance. Our MAS is composed of seven classes of agents: Pharmacist, Vendor, Buyer, OCC, PCOP, Healthcare Professional and Patient who communicate with each other using the "Contract Net Protocol" with the FIPA 2002 extension. The modeling of the system was done according to the O-MaSe methodology. The implementation of the agents as well as the interactions between them were carried out under the JADE platform. In the near future, it would be imperative to address issues of quality control and drug design, certification of pharmacy degrees to ensure the health of the population.

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We accept the manuscript submissions in any standard (generic) format.

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Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

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3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
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Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

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Tips for writing a good quality Computer Science Research Paper

Techniques for writing a good quality computer science research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10.Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

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Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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ISSN 9754350