Afaq Journal for Human and Applied Studies
Faculty of Arts and Sciences
ALAbyar University of Benghazi
ISSUE: 2 – August 2024
مجلة آفاق للدراسات الإنسانية والتطبيقية
كلية الآداب والعلوم الإبيار
جامعة بنغازي
العدد: الثاني – أغسطس 2024

# Forecasting Wheat Production in Libya Using ARIMA Model-ARIMA

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| DOI: https://doi.org/10.37376/ajhas.vi2.6863 | Received: 23.05.2024 | Accepted: 06.06.2024 | Published: 16.08.2024 |
|---|---|---|---|

**Abstract:**

The wheat crop is a strategic crop in Libya as a food crop and a raw material for some food industries. The study aimed to predict the amount of wheat production in context of Libya during the next six years from 2023-2028. The Auto-regressive Integrated Moving Average (ARIMA) model has been used and relied on Food and Agriculture Organization data from the period 19961 to 2022. The study findings indicated that the ARIMA (AR (1), MA (9), MA (12) model was the most appropriate model for forecasting among selected ARIMA models because it had significant coefficients, lowest volatility, highest AdjR$^2$, and lowest AIC. Furthermore, it passed all diagnostic tests, where the residuals are white noise and follow normal distribution. Also, there is no heteroscedasticity in the model and had good predictive ability. Finally, the study concluded that wheat production will witness an upward trend during the forecast period (2023-2028).upward trend during the forecast period (2023-2028).

**Keywords: Wheat Production, Forecast, ARIMA model, Libya.**

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# التنبؤ بإنتاج القمح في ليبيا باستخدام نموذج-ARIMA

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## الملخص

يعتبر محصـــول القمح من المحصـــول الاســـتراتيجي في ليبيا كمحصـــول غذائي وكمادة أولية لبعض الصـــناعات الغذائية. هدفت الدراسة إلى التنبؤ بكمية إنتاج القمح في ليبيا خلال السنوات الست القادمة من 2023-2028. تم اســـتخدام نموذج الانحدار الذاتي المتحرك المتكامل (ARIMA) والاعتماد على بيانات منظمة الأغذية والزراعة من الفترة 19961 إلى 2022. أشارت نتائج الدراسة إلى أن متوسط المتحرك المتكامل(1) (AR (ARIMA) ، (9) MA، MA ( (12)كان النموذج الأكثر ملاءمة للتنبؤ بين نماذج ARIMA المختارة لأنه يحتوي على معاملات معنوية وأقل تقلبات وأعلى AdjR2 وأقل AIC علاوة على ذلك، فقد اجتاز جميع الاختبارات التشـخيصـية، حيث كانت البقايا عبارة عن ضوضاء بيضاء وتتبع التوزيع الطبيعي أيضًا. لا يوجد أي تباين في النموذج ولديه قدرة تنبؤية جيدة. وأخيراً توصلت الدراسة إلى أن إنتاج القمح سيشهد اتجاهاً تصاعدياً خلال فترة التنبؤ (2023-2028).واتجاهاً تصاعدياً خلال فترة التنبؤ.(2023-2028) .

**الكلمات المفتاحية: إنتاج القمح، التنبؤ، نموذج أريما، ليبيا.**

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## 1. INTRODUCTION.

Agriculture.is.the.cornerstone.of.less.developed.countries.economies.(FAO,.2001).in.order.to.meet.the.people.basic.needs.and.the.production.required.by.other.sectors.(Loizou.et.al..2019)..It.also.exports.workers.to.the.industrial.and.service.sectors.as.a.result.of.increased.growth.in.demand.for.employment.(Eswaran,.2006)..Moreover,.it.is.underpinning.their.food.security,.export.earnings.to.earn.foreign.exchange.for.overhead.investment.for.industries.and.expansion.rural.development.(FAO,.2002)..Furthermore,.it.provides.the.raw.materials.for.the.agro.based.industries.(Praburaj.et.al,.2018).

Agriculture.in.Libya.was.the.main.activity.before.discovered.of.oil.and.absorbed.the.majority.of.the.population.to.work.in.this.sector.as.their.only.source.of.livelihood.(Abdelwhab,.2012)..As.for.its.importance.after.the.discovery.of.oil,.its.contribution.to.the.Libyan.GDP.is.generally.very.minor,.as.its.percentage.in.2019.was.3.69%.(Libyan.Central.Bank,.2022)..These.minor.contributions.increase.and.decrease.according.to.climatic.conditions,.the.economic.situation.of.farmers,.and.government.procedures.towards.the.agricultural.sector..

Among.the.world's,.wheat.is.one.of.the.three.most.important.staple.food.crops.in.the.world.and.being.used.for.human.food.and.livestock.(Shewry,.2009)..It.is.grown.on.more.than.215.million.hectares.and.producing.over.735.million.tons.of.grain.(CrespoHerrera.et.al,.2021)...In.Libya,.wheat.is.considered.one.of.the.most.important.grain.crops..The.average.relative.importance.of.wheat.production.capacity.reached.more.than.60%.of.the.total.grain.during.the.period.(1980.2014)..In.addition,.the.amount.of.wheat.consumed.reached.515.thousand.tons.in.1980.to.about.1158.thousand.tons.in.2014(Al.Warfalli.et.al,.2016)..

## 2.THE.STUDY.PROBLEM

The.Libyan.state.has.focused.on.the.agricultural.sector.after.the.discovery.of.oil,.with.the.aim.of.diversifying.sources.of.production.and.national.income..It.believed.that.spending.on.agricultural.development.by.establishing.major.agricultural.projectors,.developing.their.infrastructure,.providing.loans.to.farmer,.and.providing.p

roduction.requirement;.it.would.ensure.achieving.self.sufficiency.and.food.security.in.wheat.crop..Despite.these.efforts,.this.goal.of.achieving.self-sufficiency.has.not.been.achieved.and.it.is.still.relying.on.imports,.which.its.quantity.in.2022.was.245465.91.tons..For.this.reason,.this.study.came.to.predict.the.value.of.wheat.production.for.the.coming.years.to.enable.decision.maker.to.put.appropriate.agricultural.policy.to.reduce.the.import.of.this.strategic.commodity.to.produce.it.locally.and.cover.the.deficit.

**3.OBJECTIVES.OF.THE.STUDY**

In.light.of.these.issues.in.forecasting.wheat.production,.this.study.seeks.to.achieve.the.following.objectives:

1.To.study.the.wheat.production.historical.trend.during.the.period.1961-2022.

2.Selecting.the.best.fit.ARIMA.mod.from.the.ARIMA.models.in.predicting.the.quantity.of.wheat.production.in.Libya..

3.Testing.and.applying.the.best.fit.ARIMA.model.selected.to.predict.the.amount.of.wheat.production.quantity.for.the.coming.years.2023-2028.

**4.SIGNIFICANCE.OF.STUDY**

The.importance.of.the.research.lies.in.the.fact.that.wheat.production.is.an.important.strategic.material.and.the.most.important.element.in.food.security,.as.it.contains.high.amounts.of.protein,.nitrogen.free.compounds.and.fats,.and.is.a.raw.material.for.many.industries..Therefore,.studying.the.reality.of.this.crop.is.very.important.for.planners,.considering.predicting.future.crop.values.by.using.the.(ARIMA).methodology.as.part.of.planning.in.light.of.agricultural.conditions.and.environment.enables.decision.makers.in.the.agricultural.sector.to.improve.their.plans,.make.them.more.realistic,.and.ensure.efficient.production.progress..The.study.also.seeks.to.enrich.experimental.studies.and.raises.many.points.for.researchers.to.research.and.study.

**5.LITERATURE.REVIEW**

The.wheat.production.forecasting.issue.has.been.the.subject.of.numerous.studies,.especially.in.developing.countries..Shrivastri.et.al..(2022).used.annual.time.series.data.from.1956.to.2020.in.five.states:.Uttar.Pradesh.(UP).Punjab.(PB).Madhya.Prades

h.(MP).Haryana.Rajasthan.(RJ).to.forecasts.for.wheat.production.in.India.from.2021.to.2030..The.findings.of.the.study.demonstrated.the.best.fit.ARIMA.model.were.determined.as.ARIMA.(1,1,0).for.UP,.ARIMA.(0,1,1).for.PB,.ETS.(M,.M,.N).for.MP,.ETS.(M,.MD,.N).for.Haryana,.ETS.(M,.N,.N).for.JR,.and.ETS.(A,.A,.N)..In.same.year,.the.study.of.Krishna.et.al.(2022).aimed.to.select.ARIMA.model.and.forecast.the.production.and.consumption.of.wheat.in.India..It.used.annual.time.series.data.from.1959.2019

The.results.of.the.study.revealed.that.the.ARIMA.(0,.1,.1).with.drift.was.the.optimal.model.for.production.of.wheat.and.expected.the.production.will.be.1,.13,909.70.thousand.MT.during.the.next.eight.years.

In.another.study.in.India.by.Prabakaran.et.al.(2013).attempted.to.forecast.area.and.wheat.production.in.India.during.the.period.of.1950-51.to.2011.12..Box.Jenkins.Auto.Regressive.Integrated.Moving.Average.(ARIMA).model.was.used.for.the.study.purpose..The.study.stated.in.its.results.that.the.forecast.wheat.production.quantity.in.2015.will.be.79.73,.with.a.maximum.of.about.107.55.thousand.tons.and.a.minimum.of.about.87.92.thousand.tons..In.the.context.of.another.study.in.India,.Patowary.et.al.(2017).aimed.to.build.a.simple.linear.regression.model.with.ARIMA.errors.in.India.for.the.period.of.1960.2016

The.finding.of.the.study.demonstrated.that.the.forecasted.wheat.productivity.revealed.an.increasing.pattern.during.upcoming.10.years.and.its.predictive.quantity.was.estimated.at.108380.66.MT.in.the.year.2027.

Sher.and.Ahmad.(2008).studied.the.future.prospects.of.wheat.production.in.Pakistan..The.study.employs.ARIMA.approach.and.annual.data.during.the.period.1979.to.2006.taken.from.the.Agricultural.Statistics.of.Pakistan.and.Area.Production.(By.Districts),.Ministry.of.Food,.Agriculture.and.Live.Stock.(MINFAL),.Government.of.Pakistan..The.results.of.the.study.showed.that.Pakistan.will.face.a.slight.wheat.shortage.in.the.future,.as.there.is.growth.of.1.6%.based.on.the.future.expectations.of.the.study..In.another.study,.Abdulla.and.Hossain.(2015),.they.targeted.to.use.the.Auto.Regressive.Integrated.Moving.Average.

(ARIMA).model.to.forecast.the.production.of.wheat.in.Kushtia.district,.in.addition.to.Bangladesh.as.a.whole.

The.study.showed.that.the.optimal.model.was.ARIMA.(1,.2,.and.1).in.Kushtia.district,.while.in.whole.Bangladesh.was.ARIMA.(0,.2,.and.1)...Moreover,.the.study.also.indicated.that.the.optimal.models.behaved.better.statistically.after.comparing.the.original.series.with.the.forecasting.series,.and.it.is.concluded.that.it.can.be.relied.on.two.optimal.models.in.the.process.of.predicting.wheat.production.

In.Arab.countries,.Atia.and.Atwa.(2009).sought.to.find.an.appropriate.ARIMA.model.for.forecasting.for.area,.average.yield.and.the.production.of.wheat.crop.in.Egypt.and.Beni-Swef.Governorate..The.study.relied.on.time.series.data.from.1982.1983.to.2006.2007..

The.study.showed.from.its.results.that.the.values.for.the.forecasts.for.the.wheat.production.for.Egypt.were.it.has.been.estimated.as.58.6243.million.ardab.in.2007/2008.and.68.3664.million.ardab.in.2012/2013..As.for.Beni.Swef.Governorate,.the.production.was.2.890.million.ardab.in.2007/2008.and.3.364.million.ardab.in.2012/2013..In.the.same.context.in.Iraq,.Madlul.and.Baker.(2020).used.the.annual.time.series.data.over.the.time.1988.to.2018.to.employ.the.ARIMA.model.for.predicting.the.crop.of.whea

The.author.points.out.through.the.results.of.the.proposed.Arima.(1.0.1).model,.Iraq's.wheat.production.will.be.increase.during.the.next.ten.years..Also,.the.growth.rate.of.wheat.production.reaching.0.94%.was.higher.than.the.annual.average.in.the.study.period.1988-2018.

Jalić,.et.al.(2021).relied.on.the.time.series.from.the.Food.and.Agriculture.Organization.database.covering.the.period.from.1998.to.2020.in.Bosnia.and.Herzegovina.to.apply.ARIMA.model.for.forecasting.wheat.production.for.a.period.of.five.years.(2021.2025)

The.results.of.the.study.showed.that.ARIMA.(1,.1,.and.10).was.relied.on.it.to.forecasting.process..It.also.showed.that.there.will.be.a.trend.of.decreasing.wheat.production.during.the.next.five.years.by.3%.each.year..The.study.justified.that.this.decline.can.be.attributed.to.the.climatic.factor

s.that.influenced.the.direction.of.expected.production..In.addition.to,.prices.in.regional.and.global.markets.that.cannot.be.predicted..Also,.to.the.government.procedures.that.took.towards.the.wheat.production..Finally,.the.study.of.Latifi.and.Shabanali.(2022).employed.Arima.and.the.Artificial.Neural.Network.(ANN).models.are.used.to.forecast.wheat.production.in.Iran..Annual.wheat.production.data.covered.the.period.between1961.1962.to.2018.2019..The.results.of.the.study.concluded.that.the.artificial.neural.network.(ANN).model.is.better.than.the.ARIMA.model.(1,.1,.and.1).in.predicting.wheat.production.by.using.its.efficient.parameter.

**6.STUDY.METHODOLOGY**

In.this.study,.the.secondary.data.was.used.and.collected.over.the.period1961.2022.from.Food.and.Agriculture.Organization.data..The.mixed.method.(Descriptive.and.quantitative.analysis).used.to.achieve.the.research.objectives,.provides.a.better.understanding.of.a.study.problem,.and.gets.results.closer.to.reality..Descriptive.analysis.was.used.to.describe.historical.of.wheat.production.trend.during.the.period.(1961.2022)..As.for.the.quantitative.analysis,.the.ARIMA.model.was.used.to.predict.wheat.production.from.the.period.2023.to.2028..

**Specification.of.ARIMA.model.**

An.autoregressive.integrated.moving.average.is.a.statistical.analysis.model.that.uses.time.series.data.to.either.understand.predict.future.tren

The.arima.model.is.denoted.by.ARIMA.(p,.d,.q),.where.“p.“stands.for.the.order.of.the.auto.regressive.process,..“d.“.is.the.order.of.differencing.and.“.q“..is.the.order.of.the.moving.average.process..The.ARIMA.(1,.1,.and.1).model.is.formulated.as.follows.:-

yt.=.(1+ϕ).yt-1+.ϕ.yt-2.+.θ0.+.*e*t.–.θ1*e*t-1.(Amin.et.al,.2014).

Where,.ARIMA.(1,.1,.1).indicates.the.model.has:.one.lag.of.the.dependent.variable.“p.“.(1),.the.variable.being.used.is.of.first.difference.stationary.“d“.(1).and.one.lag.of.the.error.term.“.q“..It.involves.a.number.of.procedural.steps,.which.are.as.follows:.plot.the.historical.graph,.check.the.stationary.of.the.data,.plot.of.ACF.and.PACF.to.identify.potential.AR.and.MA.model,.identify.the.best.fit.ARI

MA.model,.plot.ACF.and.PACF.for.residuals.of.ARIMA.model.to.ensure.no.more.information.is.left.for.extraction,.and.forecasting.the.series.using.the.best.fit.ARIMA.model.

**7..RESULTS.AND.DISCUSSION.**

**7.1..Descriptive.analysis.of.wheat.production.series**

The.wheat.crop.is.considered.one.of.the.modern.crops.from.a.historical.perspective.in.Libya,.and.it.is.also.considered.a.food.crop.compared.to.the.chronological.age.of.barley..It.has.also.been.relied.upon.as.a.food.material.and.became.the.first.strategic.crop.as.a.result.of.the.increase.of.citizen's.income.and.uses.as.a.raw.material.in.the.food.industries.(Abdel.Razek,.2007)..

Based.on.Table.1.and.Figure.1,.it.illustrates.the.wheat.production.fluctuates.from.year.to.year..This.is.due.to.the.fact.that.wheat.production.depends.on.rain,.as.its.quantity.increased.from.29992.tons.in.1961.to.209737.tons.in.1983,.and.after.that.it.returned.and.decreased.to

Table1..Wheat.production.quantities.in.Libya.during.1961-2002.

| Year | Quantity.of.Wheat.production.(tons) | Year | Quantity.of.Wheat.product |
|---|---|---|---|
| **1961** | 29992 | 1992 | 125000 |
| **1962** | 33600 | 1993 | 126000 |
| **1963** | 34100 | 1994 | 120000 |
| **1964** | 28000 | 1995 | 117000 |
| **1965** | 56913 | 1996 | 124000 |
| **1966** | 57788 | 1997 | 156400 |
| **1967** | 62221 | 1998 | 140000 |
| **1968** | 52041 | 1999 | 130000 |
| **1969** | 78421 | 2000 | 125000 |
| **1970** | 27159 | 2001 | 125000 |
| **1971** | 17726 | 2002 | 125000 |
| **1972** | 41585 | 2003 | 125000 |
| **1973** | 67327 | 2004 | 125000 |
| **1974** | 38682 | 2005 | 125000 |
| **1975** | 75134 | 2006 | 104000 |
| **1976** | 133101 | 2007 | 104000 |

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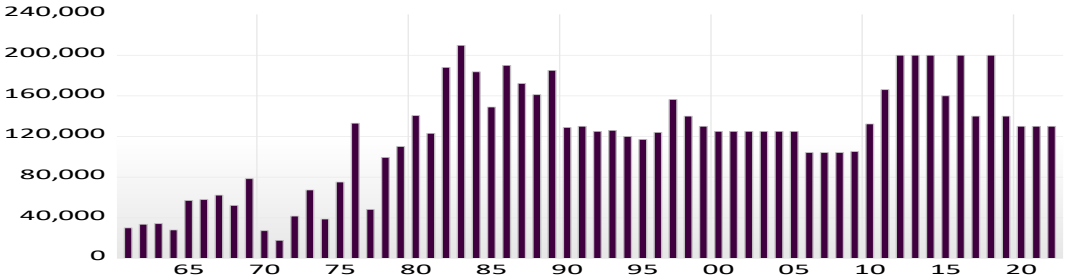
| Year | Quantity.of.Wheat.production.(tons) | Year | Quantity.of.Wheat.product |
|---|---|---|---|
| **1977** | 48117 | 2008 | 104000 |
| **1978** | 99295 | 2009 | 105000 |
| **1979** | 110000 | 2010 | 132239 |
| **1980** | 140500 | 2011 | 166000 |
| **1981** | 123110 | 2012 | 200000 |
| **1982** | 188000 | 2013 | 200000 |
| **1983** | 209737 | 2014 | 200000 |
| **1984** | 183634 | 2015 | 160000 |
| **1985** | 149000 | 2016 | 200000 |
| **1986** | 190000 | 2017 | 140000 |
| **1987** | 172000 | 2018 | 200000 |
| **1988** | 161011 | 2019 | 140000 |
| **1989** | 185000 | 2020 | 130000 |
| **1990** | 128760 | 2021 | 130000 |
| **1991** | 130000 | 2022 | 130000 |

Source:.Faostat.Production.Data..Food.and.Agriculture.Organization,.United.Nation.http://www.fao.org/en/#data/QCL




.Figure1..Wheat.Production.Quantities.(Tons).during.the.period.1961.2022

.130000.tons.in.2022,.with.an.annual.average.production.1191122.5.tons.during.the.last.62.years.from.1961.to.2022..In.this.duration.the.maximum.value.of.wheat.production.was.in.1983;.the.lowest.value.of.wheat.was.in.1971.

On.the.other.hand,.the.standard.deviation.was.51708.14;.it.is.lower.than.the.mean.119122.5..This.means.that,.the.data.are.more.reliable.or.clustered.closely.around.the.mean,.while.the.probability.of.jarque.bera.was.0.38.which.is.greater.than.0.05..This.

means.that.the.null.hypothesis.is.cannot.be.rejected,.and.there.is.no.evidence.to.suggest.that.the.data.doesn't.follow.a.normal.distribution..In.another.word,.the.data.of.wheat.production.under.the.study.investigation.follow.a.normal.distribution.

**7.2..Model.identification.**

The.first.step.in.identification.of.the.model.is.to.identify.the.initial.characteristics.of.the.wheat.production.time.series.by.showing.the.plot.of.this.series..The.curve.of.wheat.production.shows.a.general.trend..As.the.amount.of.wheat.production,.the.plot.shows.that.there.was.a.stable.trend.from.1961.1964,.a.sharp.increase.in.1965.and.a.drop.around.1971.and.again.a.sharp.increase.in.wheat.production.in.the.year.1983.as.shown.in.figure2.

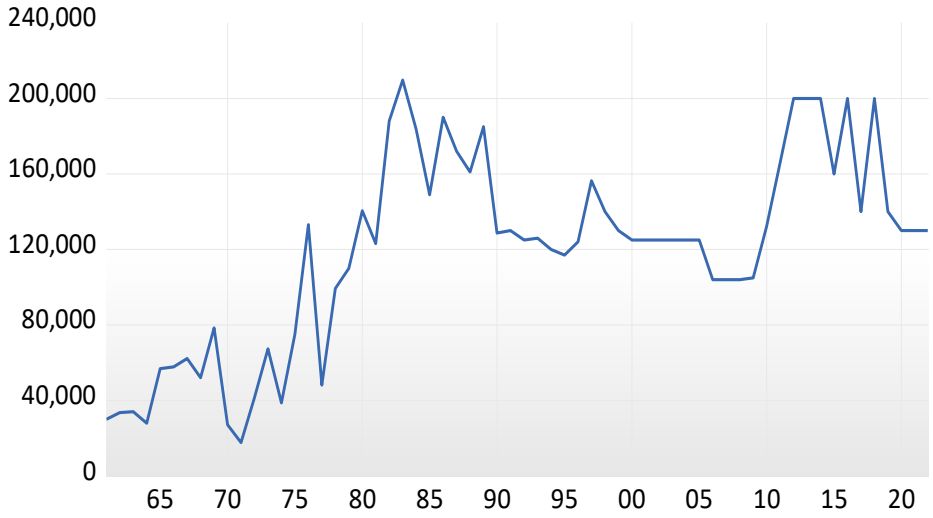



Figure2..Line.graph.of.Wheat.Production

Also,.Augmented.Dickey-Fuller.(ADF).and.Phillips.Perron.(PP).tests.are.employed.to.analyse.the.stationarity.of.wheat.production.series..The.ADF.and.PP.results.in.Tables.2.and.3.showed.that.wheat.production.series.not.stationary.because.the.probability.was.greater.than.5%..It.is.meaning.that.it.is.not.stationary.than.it.should.be.accept.the.null.hypothesis,.which.states.the.existence.of.a.unit.root.

Table2..Results.of.Unit.Root.Test.for.ADF.Test

| | At.Level | | At.First.Difference | | The.Decision |
|---|---|---|---|---|---|
| Constant | t-Stat | Prob | t-Stat | Prob | I(1) |
| | -2.084 | 0.25 | -11.59 | 0.00 | |
| Constant.And.Trend | -2.03 | 0.58 | -11.60 | 0.00 | I(1) |
| Non | -0.190 | 0.61 | -11.63 | 0.00 | I(1) |

Source:.Prepared.by.the.researcher.based.on.the.outputs.of.Eviews.12.

After.that,.the.tests.were.repeated.at.the.first.difference,.it.was.found.that.the.series.was.stationary.and.the.probability.was.less.than.5%..Therefore,.the.null.hypothesis.was.rejected.and.the.alternative.hypothesis.was.accepted,.which.states.that.there.is.no.unit.root.and.the.series.stationary.at.the.first.difference.as.it.is.clear.in.Table3.

Table3..Results.of.Unit.Root.Test.for.PP.Test

| | At.Level | | At.First.Difference | | The.Decision |
|---|---|---|---|---|---|
| Constant | t-Stat | Prob | t-Stat | Prob | I(1) |
| | -2.44 | 0.13 | -11.80 | 0.00 | |
| Constant.And.Trend | -2.937 | 0.15 | -11.69 | 0.00 | I(1) |
| Non | -0.319 | 0.56 | -11.81 | 0.00 | I(1) |

Source:.Prepared.by.the.researcher.based.on.the.outputs.of.Eview12.

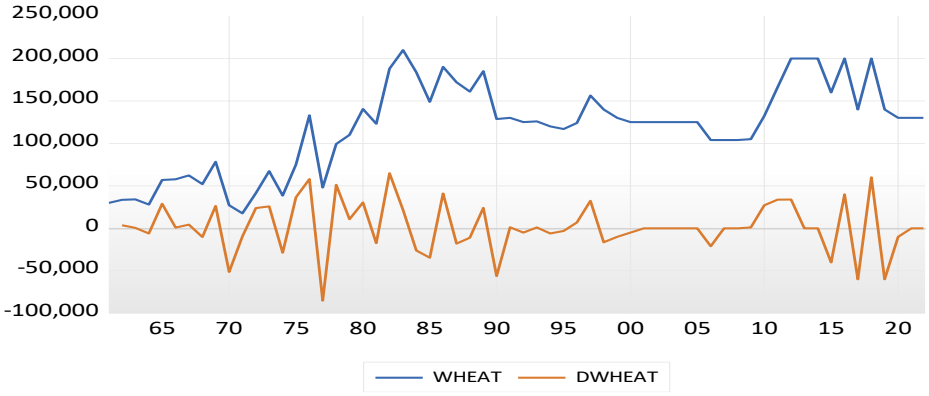



Figure3.Line.graph.of.Wheat.Production.at.level.and.the.first.difference

Afaq Journal for Human and Applied Studies
Faculty of Arts and Sciences
ALAbyar University of Benghazi
ISSUE: 2 – August 2024
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In.addition,.the.results.of.correlograms.at.level.showed.same.result.as.shown.in.figure.4,.it.can.see.that.from.the.Box.Liwung.statistic.at.leve,.which.has.a.value.of.Q.=.200.28.at.the.lagged.24,.which.is.a.big.value.and.this.evidence.that.the.wheat.production.series.is.not.stationary.in.the.level.and.stationary.in.the.first.difference..

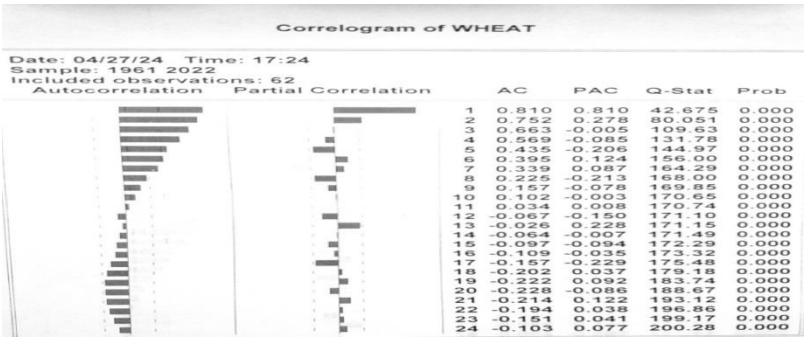


Figure4..The.auto.correlation.(ACF).and.partial.auto.correlation.(PACF).at.level

**7.3..Model.Estimation**

After.ensuring.the.stationary.of.the.wheat.production.series,.the.estimation.and.selecting.the.appropriate.model.for.AIRMA.model.step.comes,.where.the.main.goal.of.this.stage.is.to.identified.model.ARIMA.(p,.d,.q).The.auto.correlation.function.(ACF).refers.to.the.autoregressive.components.'q'.of.the.model,.while.partial.auto.correlation.function.(PACF).function.gave.an.indication.for.the.parameter.p.and.they.are.considered.among.of.the.model.specification..

In.order.to.determine.the.order.of.the.autoregressive.component.("p").and.the.order.of.the.moving.average.component.("q").at.the.first.difference,.as.shown.in.Figure.5..The.component.of.P.is.(1),.and.MA.components.are.MA.(5).and.MA.(12)..Accordingly,.three.potential.candidate.models.for.ARIMA.models.have.been.identified.namely.(1.1.1),.(1.1.5),.and.(1.1.12)..

E-ISSN 3007-4495
ISSN-L 3007-4495
Legal Deposit Number 313/2023
DOI https://doi.org/10.37376/ajhas.vi2
Frequency: Two Issues per year
Publication Fees are Free
Publisher: University of Benghazi, Benghazi, Libya
Editor-in-Chief Prof. Mohamed Lama
https://journals.uob.edu.ly/AJHAS
ajhas.journal@uob.edu.ly
+218924809776

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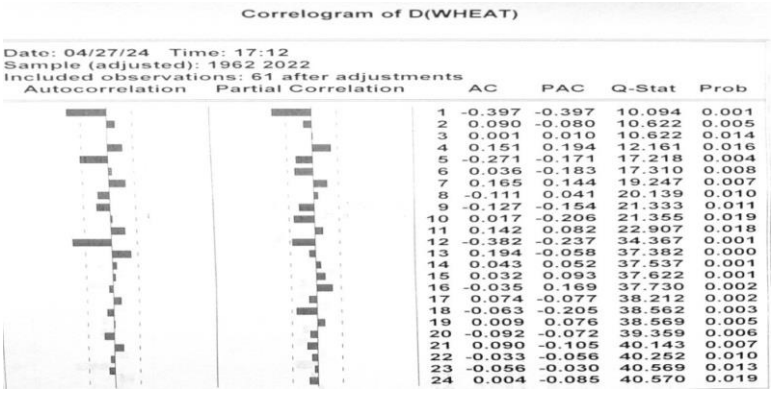


| | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|
| 1 | -0.397 | -0.397 | 10.094 | 0.001 |
| 2 | 0.090 | -0.080 | 10.622 | 0.005 |
| 3 | 0.001 | 0.010 | 10.622 | 0.014 |
| 4 | 0.151 | 0.194 | 12.161 | 0.016 |
| 5 | -0.271 | -0.171 | 17.218 | 0.004 |
| 6 | 0.036 | -0.183 | 17.310 | 0.008 |
| 7 | 0.165 | 0.144 | 19.247 | 0.007 |
| 8 | -0.111 | 0.041 | 20.139 | 0.010 |
| 9 | -0.127 | -0.154 | 21.333 | 0.011 |
| 10 | 0.017 | -0.206 | 21.355 | 0.019 |
| 11 | 0.142 | 0.082 | 22.907 | 0.018 |
| 12 | -0.382 | -0.237 | 34.367 | 0.001 |
| 13 | 0.194 | -0.058 | 37.382 | 0.000 |
| 14 | 0.043 | 0.052 | 37.537 | 0.001 |
| 15 | 0.032 | 0.093 | 37.622 | 0.001 |
| 16 | -0.035 | 0.169 | 37.730 | 0.002 |
| 17 | 0.074 | -0.077 | 38.212 | 0.002 |
| 18 | -0.063 | -0.205 | 38.562 | 0.003 |
| 19 | 0.009 | 0.076 | 38.569 | 0.005 |
| 20 | -0.092 | -0.072 | 39.359 | 0.006 |
| 21 | 0.090 | -0.105 | 40.143 | 0.007 |
| 22 | -0.033 | -0.056 | 40.252 | 0.010 |
| 23 | -0.056 | -0.030 | 40.569 | 0.013 |
| 24 | 0.004 | -0.085 | 40.570 | 0.019 |

Figure5..The.auto.correlation.(ACF).and.partial.auto.correlation.(PACF).at.the.first.difference

The.estimation.process.then.comes.to.select.the.most.appropriate.model.from.among.them.and.comparison.between.each.other..The.study.is.found.(1,.1,.12).the.best.of.them,.but.its.correlogram.of.the.residuals.is.not.flat.which.indicate.that.lag.9.has.some.information.that.must.be.captured.and.reestimation.was.conducted.again.by.adding.MA.(9).which.made.the.correlogram.of.the.residuals.is.flat..Thus,.the.AIRMA.model.(AR.(1).MA.(9).MA.(12)).the.most.appropriate.model.among.them.because.it.had.significant.coefficients,.lowest.volatility,.highest.AdjR2,.and.lowest.AIC.as.seen.in.the.above.Table.

Table.4..Selected.the.appropriate.arima.model.

| ARIMA | (1.1.1) | (1.1.5) | (1.1.12) | AR(1).MA(9.).MA(12) |
|---|---|---|---|---|
| Significant.Coefficients | 0 | 2 | 2 | 2 |
| SIGMA2.(volatility) | 7.39E+08 | 6.73E+08 | 5.63E+08 | 5.24.E+08 |
| AIC | 23.3920 | 23.307 | 23.1870 | 23.1751 |
| Adj.R2 | %11.79 | %23.62 | %32.79 | %36.35 |

From.the.estimated.results.in.Table.5,.the.ARIMA.model.has.taken.as.following.formula..Also,.t-statistic.of.coefficient.was.written.under.each.its.corresponding.estimate.value.

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ΔWheatt.=.1786.655.0.42468
4.Wheatt.1.0.263094εt.8.0.549230ε.t
12.(1.72).(4.51).(1.092).(-2.27)

Table5..Estimation.results.of.the.ARIMA.model.for.Wheat.Production

| | | | | |
|---|---|---|---|---|
| Dependent.Variable:.D(WHEAT) | | | | |
| Method:..ARMA.Maximum.Likelihood.(OPG.-.BHHH) | | | | |
| Date:.04/29/24...Time:.21:02 | | | | |
| Sample:.1962.2022 | | | | |
| Included.observations:.61 | | | | |
| Convergence.achieved.after.26.iterations | | | | |
| Coefficient.covariance.computed.using.outer.product.of.gradients | | | | |
| .....Variable | Coefficient | Std.Error | t-Statistic | Prob. |
| C | 1786.655 | 1035.080 | 1.726104 | 0.0898 |
| AR(1) | -0.424684 | 0.094082 | -4.513963 | 0.0000 |
| MA(9) | -0.263094 | 0.240797 | -1.092599 | 0.2792 |
| .....MA(12) | -0.549230 | 0.241737 | -2.272013 | 0.0269 |
| ....SIGMASQ | 5.24E+08 | 1.27E+08 | 4.133260 | 0.0001 |
| R-squared | 0.406013 | Mean.dependent.var | | 1639.475 |
| Adjusted.R-squared | 0.363586 | S.D..dependent.var | | 29933.98 |
| S.E..of.regression | 23880.00 | Akaike.info.criterion | | 23.17519 |
| Sum.squared.resid | 3.19E+10 | Schwarz.criterion | | 23.34821 |
| Log.likelihood | -701.8433 | Hannan-Quinn.criterion | | 23.24300 |
| F-statistic | 9.569550 | Durbin-Watson.stat | | 2.044859 |
| Prob(F-statistic) | 0.000006 | | | |

Source:.Prepared.by.the.researcher.based.on.the.outputs.of.Eview12.

**7.4..Diagnostics.Checking.**

To.obtain.the.validity.of.the.model.for.prediction,.diagnostic.tests.of.the.model.were.conducted..In.this.aspect,.the.fit.model.ARIMA.(AR.(1).MA.(9).MA.(12)).model.passed.all.the.diagnostic.tests,.where.Q.statistic.of..Ljung.Box.for.all.the.24.lags.has.probability.values.greather.than.0.05.which.indicates.that.cant.not.reject.null.hypothesis.that.meaning.that.residuals.are.white.noise.as.shown.in.figure.6..Moreover,.the.value.of.the.Jarque.Bera.probability.was.(0.75).which.is.larger.than.5%..It.is.meaning.that,.the.residuals.of.the.model.follow.normal.distribution...Also.in.heterosceda sticity.test,.the.P.value.for.the.F.statistics.was.(0.0525).and.larger.than.5%,.thus.there.is.no.heteroskedasticity.in.the.model.

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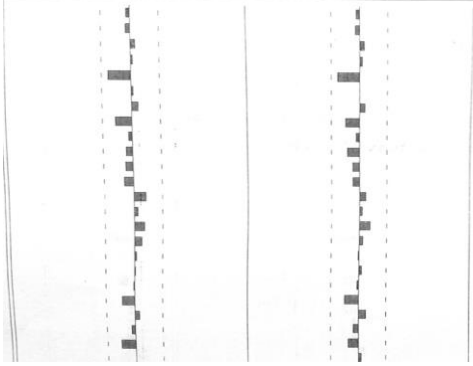
Correlogram of Residuals

Date: 04/27/24 Time: 23:01
Sample (adjusted): 1962 2022
Q-statistic probabilities adjusted for 3 ARMA terms



| | Autocorrelation | Partial Correlation | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| 1 | | | -0.027 | -0.027 | 0.0456 | |
| 2 | | | -0.033 | -0.034 | 0.1168 | |
| 3 | | | 0.047 | 0.045 | 0.2643 | |
| 4 | | | 0.023 | 0.025 | 0.3005 | 0.584 |
| 5 | | | -0.200 | -0.197 | 3.0503 | 0.218 |
| 6 | | | 0.017 | 0.007 | 3.0712 | 0.381 |
| 7 | | | 0.062 | 0.052 | 3.3470 | 0.502 |
| 8 | | | -0.144 | -0.130 | 4.8564 | 0.434 |
| 9 | | | -0.031 | -0.028 | 4.9280 | 0.553 |
| 10 | | | -0.053 | -0.108 | 5.1357 | 0.643 |
| 11 | | | -0.061 | -0.059 | 5.4201 | 0.712 |
| 12 | | | -0.079 | -0.061 | 5.9118 | 0.749 |
| 13 | | | 0.112 | 0.060 | 6.9221 | 0.733 |
| 14 | | | 0.036 | 0.032 | 7.0298 | 0.797 |
| 15 | | | 0.098 | 0.100 | 7.8323 | 0.798 |
| 16 | | | 0.066 | 0.039 | 8.2009 | 0.830 |
| 17 | | | 0.019 | -0.002 | 8.2325 | 0.877 |
| 18 | | | 0.013 | 0.032 | 8.2472 | 0.913 |
| 19 | | | -0.003 | -0.009 | 8.2483 | 0.941 |
| 20 | | | -0.114 | -0.126 | 9.4632 | 0.925 |
| 21 | | | 0.048 | 0.069 | 9.6841 | 0.942 |
| 22 | | | -0.028 | -0.046 | 9.7601 | 0.959 |
| 23 | | | -0.126 | -0.095 | 11.374 | 0.936 |
| 24 | | | 0.003 | 0.028 | 11.375 | 0.955 |

Figure6..The.Correlogram.of.Residuals

In.figure7.through.the.inverse.roots.diagram,.it.is.shown.that.the.estimated.ARIMA.process.is.(covariance).stationary.because.there.is.no.AR.root.lies.outside.the.unite.circle..In.same.time,.there.is.no.MA.root.lies.outside.the.unite.circle,.thus.the.estimated.ARIMA.process.is.invertible.

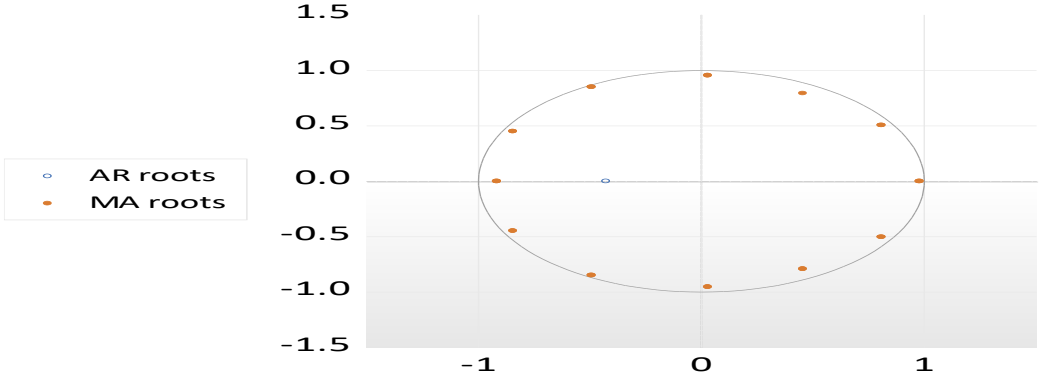



Figure7..Inverse.Roots.of.AR/MA.Polynomial(s).Specification:.D.(WHEAT).C.AR.(1).MA.(9).MA.(12).

### 7.5..Forecasting

Forecasting.is.the.main.goal.of.the.study.to.identify.future.wheat.production.in.Libya.and.accordingly.on.the.fitted.model.ARIMA.(Ar.(1),.Ma.(9),.and.MA.(12)).can.be.applied.in.order.to.forecast.of.wheat.production.process.after.passing.the.diagnostic.tests.during.the.next.six.years.(2023,.2024,.2025,.2026,.2027,.and.2028)..The.future.values.of.wheat.production.from.2023.to.2028.were.predicated.as.shown.in.Table.6..Also,.the.predict.power.of.this.model.is.strong.which.the.model.has.better.forecasting.ability.because.the.Thiel's.index.is.smaller.(23.31).

Table6..Future.value.of.Wheat.Production.Tons.(.2023.–.2028).

| Years | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
|---|---|---|---|---|---|---|
| Quantities | 141 684 .9 | 143 471 .6 | 145 258 .2 | 147 044 .9 | 148 831 .5 | 150 618 .2 |

### 8.CONCLUSION

The.aim.of.the.study.was.forecasting.wheat.production.in.Libya.for.the.six.years.(2023.to.2028)..ADF.and.PP.stationarity.tests.indicate.that.the.wheat.production.series.is.stationary.at.the.first.difference..

The.fin.ing.of.the.Correlogram.at.the.first.difference.found.the.appropriate.number.of.autoregressive.terms.(".p").=.1.and.the.appropriate.number.of.moving.average.terms.Ma.("q").=12,.after.reestimation.found.the.ARIMA.....(AR.(1),.MA.(9),.MA.(12)).model.was.the.most.appropriate.model.among.the.selected.models.in.terms.of.significant.coefficients.numbers,.lowest.volatility,.highest.AdjR2,.and.lowest.AIC.criterion..As.for.diagnostic.test,.the.fit.model.successfully.passed.all.these.tests.and.did.not.suffer.from.any.statistical.problem,.such.as.Q.statistic.of.Ljung.Box.for.all.the.24.lags.had.probability.values.greather.than.0.05..Besides.that,.the.value.of.the.Jarque..Bera.probability.was.(0.75).which.is.larger.than.5%...Also.in.heteroscedasticity.test,.the.P.value.for.the.F.statistics.was.(0.0525).and.larger.than.5%..Moreover,.inverse.roots.diagram.showed.that.there.is.no.AR.root.lies.outside.the.unite.circle.and.there.is.no.MA.root.lies.outside.the.unite.circle..In.addition,.the.predict.po

wer.of.this.model.is.strong.which.the.model.has.better.forecasting.ability.because.the.Thiel's.index.is.smaller.(23.31)...The.study.finding.indicated.that.the.trend.of.wheat.production.during.2023-2028.will.be.increasing..

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