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Using Nonparametric Techniques in Testing the Equality of Growth Curves of Independent Populations

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A thesis submitted to the department of statistics, Faculty of Economics and Political Science as a partial fulfillment of requirements for the Ph.D. Degree in Statistics

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I dedicate this work

To my father, my mother and my sisters who supported me every minute in my life

And

To my godfather Dr. Magued Osman who taught me to work with my hands, my mind and, before all, with my heart.

جامعة القاهرة

الإدارة العامة
للدراسات العليا والبحوث

استمارة معلومات للرسائل التي تمت مناقشتها

الكلية: الاقتصاد و العلوم السياسية **القسم:** الإحصاء

١. الدرجة العلمية: ماجستير [ ] دكتوراه [√]

٢. بيانات الرسالة:

عنوان الرسالة باللغة العربية: استخدام الأساليب اللامعلمية في اختبار تساوي منحنيات النمو للمجتمعات المستقلة

عنوان الرسالة باالغة الاجنبية: **Using Nonparametric Techniques in Testing the Equality of Growth Curves of Independent Populations**

التخصص الدقيق: إحصاء طبي

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٣. بيانات الطالبة:

الاسم: حنان جرجس شوقي الجنسية: مصرية النوع: أنثى

العنوان: ٣٣٢ شارع النيل–الكيت كات– الجيزة رقم التليفون: ٠٢٣٣١٤٠٠٢٠

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للدراسات العليا والبحوث

٤. المشرفون علي الرسالة:

الاسم	القسم	الكلية	الجامعة
أ.د. ماجد إبراهيم عثمان	الإحصاء	الاقتصاد والعلوم السياسية	القاهرة
أ.د. رمضان حامد محمد	الإحصاء	الاقتصاد والعلوم السياسية	القاهرة

٥. مستخلص الرسالة (Abstract)

باللغة العربية

تعد منحنيات النمو إحدى طرق عرض وضع الأفراد والمجتمعات بالنسبة لظاهرة معينة، وقد أجريت العديد من المحاولات لمقارنة منحنيات النمو ليس فقط للبشر ولكن للحيوانات أيضاً. وقد أعتمدت هذه المحاولات على تمهيد منحنيات النمو والتعبير عن المنحنيات بنفس التوزيعات ولكن باختلاف تقدير معالم التوزيعات.

وتهدف هذه الدراسة إلى تطوير اختبارات فروض لامعلمية لاختبار تساوي منحنيي النمو لمجتمعين مستقلين، وأخرى لاختبار تساوي مجموعتين من المنحنيات لمجتمعين مستقلين. وقد تم تطوير اختبارين لاختبار تساوي منحنيين هما اختبارPrecedence للمنحنيات واختبار كا^{2} للمنحنيات، كما تم توظيف اختبار كا٢ لاختبار تساوي مجموعتين من المنحنيات لمجتمعين مستقلين.

وقد تم دراسة جودة أداء الاختبارات التي تم تطويرها لاختبار تساوي منحنيات النمو للمجتمعات المستقلة حيث تم حساب قوة الاختبار في كل حالة.

وقد تم تطبيق اختبار تساوي منحنيات الوزن بالنسبة للعمر للأطفال أقل من ٦٠ شهر حيث تم تقسيم مصر إلى منطقتين ثم تم بناء منحنى الوزن بالنسبة للعمر لمصر ولكل من المنطقتين باستخدام بيانات المسح السكاني الصحي للأعوام ٢٠٠٠ و٢٠٠٣ و٢٠٠٥ وتطبيق الاختبارات المقترحة عليها.

كما تم أيضاً تقديم تطبيق جديد لمنحنيات النمو في مجال غير المجالات الطبية حيث تم بناء منحنيات سنوات التعليم بالنسبة للعمر لتطبيق الاختبارات المقترحة عليها.

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للدراسات العليا والبحوث

الكلمات الدالة

▪ مقاييس الجسد	▪ منحنيات النمو	▪ منحنيات المئينات
الوزن بالنسبة للعمر	▪ اختبار precedence	اختبار precedence للمنحنيات
▪ اختبار كا^{2} للمنحنيات	▪ اختبار كا^{2} لمجموعتي منحنيات	

باللغة الاجنبية

Percentile growth curve is a tool to present the status of different groups in a population regarding a certain phenomenon or index. Many trials were made to compare not only the growth curves of humans but also the growth curves of animals. These trials depended on smoothing and modeling the different growth curves using the same model with different values for the parameters. This study aims to construct tests that can test the equality of two percentile growth curves as well as the equality of two sets of percentile growth curves from two independent populations regardless the shape of these curves. The currently available tests allow us to make a decision on one group (e.g. one age group). To make a decision regarding the whole curve that reflects the values of several groups, a new test should be built. This study presents a new test, the curve precedence test, based on the concept of the precedence test to test the equality of two growth curves from two independent populations. To evaluate the performance of the precedence test, two other tests based on the concept of the χ^2 test, curve χ^2 test and curve set χ^2 test, were presented and the power of the precedence test was compared to the power of these tests. The weight-for-age growth curves of Egypt and of two sub-regions of Egypt were constructed and the tests were applied on these growth curves. The tests were applied also on the education years-for-age growth curves.

Key Words

- Anthropometric measures
- Percentile curves
- Precedence test
- Curve chi-square test
- Growth curve
- Weight-for-age
- Curve precedence test
- Curves set chi-square test

٦. أهم النتائج التطبيقية التي تم التوصل إليها:

(لا تزيد عن سطرين لكل منها)

- بناء منحنيات الوزن بالنسبة للعمر لمصر ولمنطقتين داخل مصر تضم المنطقة الأولى المحافظات الحضرية والوجه البحري وتضم المنطقة الثانية الوجه القبلي ومحافظات الحدود.
- بناء اختبارات احصائية لاختبار تساوي منحنيات النمو للمجتمعات المستقلة.
- تقديم تطبيق جديد لمنحنيات النمو في موضوعات غير طبية لأول مرة، حيث تم بناء منحنيات سنوات التعليم بالنسبة للعمر وتطبيق الاختبارات عليه.

٧. ماهي الجهات التي يمكن ان تستفيد من هذا البحث:

(اذكر هذه الجهات مع شرح أهمية البحث لهذه الجهة بما لا يزيد عن أربعة سطور لكل جهة)

٧.١. **الجامعات والكليات الأكاديمية:** يمكن الاستفادة من الاختبارات المقترحة في الأبحاث العلمية التي تطبق على النمو أو التطور الكمي للظواهر.

٧.٢. **وزارة الصحة ومعاهد التغذية: يمكن الاستفادة من الاختبارات المقترحة لاختبار الوضع التغذوي للمجموعات المختلفة والمستقلة.**

٨. هل توجد علاقة بأحدي هذه الجهات: نعم ☐ لا ☑

في حالة نعم اذكر هذه الجهات:

ما هي طبيعة العلاقة:

مشروع بحثي ☐

تعاون أكاديمي ☐

مشروع ممول من جهة ثالثة ☐ (أذكر ما هي:)

أخري ☐ (تذكر:)

جامعة القاهرة

الإدارة العامة

للدراسات العليا والبحوث

٩. هل توافق علي التعاون مع جهات مستفيدة من خلال الجامعة:

لا ☐ (لماذا)

نعم ☑

(ا) لتطبيق البحث: ☑

(ب) لاستكمال البحث: ☑

(ج)اخري: ☐ (تذكر)

١٠.هل تم نشر بحوث مستخرجة من الرسالة في مجلات او مؤتمرات علمية: لا

11.هل سبق التقدم لتسجيل براءات اختراع

نعم ☐ لا ☑

١٢.هل توافق علي إعطاء البيانات المذكورة في هذه الاستمارة لجهات أخري

نعم ☑ لا ☐

توقيع الطالب:

حنان جرجس شوقي

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أ.د. ماجد إبراهيم عثمان

أ.د. رمضان حامد محمد

وكيل الكلية للدراسات العليا و البحوث:

التاريخ:

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Abstract

Percentile growth curve is a tool to present the status of different groups in a population regarding a certain phenomenon or index. Many trials were made to compare not only the growth curves of humans but also the growth curves of animals. These trials depended on smoothing and modeling the different growth curves using the same model with different values for the parameters. This study aims to construct tests that can test the equality of two percentile growth curves as well as the equality of two sets of percentile growth curves from two independent populations regardless the shape of these curves. The currently available tests allow us to make a decision on one group (e.g. one age group). To make a decision regarding the whole curve that reflects the values of several groups, a new test should be built. This study presents a new test, the curve precedence test, based on the concept of the precedence test to test the equality of two growth curves from two independent populations. To evaluate the performance of the precedence test, two other tests based on the concept of the χ^2 test, curve chi-square test and curve set chi-square test, were presented and the power of the precedence test was compared to the power of these tests. The weight-for-age growth curves of Egypt and of two sub-regions of Egypt were constructed and the tests were applied on these growth curves. The tests were applied also on the education years-for-age growth curves.

Key Words

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Title of the thesis:

Using Nonparametric Techniques in Testing the Equality of Growth Curves of Independent Populations

Executive Summary

In the second half of the 20th century, a great attention has been paid to malnutrition and its impact on health status, especially on children health status. The importance of nutritional status assessment raised from the effect of nutritional status on growth and resistance to diseases. Nutritional status indices are also considered indirect indicators for the population quality of life.

This study aims to construct a test for the equality of percentile growth curves of independent populations. Many nonparametric tests were reviewed. The currently available tests allow us to make a decision on one group (e.g. one age group). To make a decision regarding the whole curve which reflects the values of several groups, a new test should be built. The objectives of the study could be summarized as follows:

1- To construct tests that can test the equality of two percentile growth curves as well as the equality of two sets of growth curves from two independent populations regardless of the shape of these curves. In other words, applying the tests will not require to fit a mathematical model for the curves.
2- To investigate the performance of the tests through studying the power properties of the tests under different distributions.
3- To construct the weight-for-age growth curves of Egypt and of two sub-regions of Egypt: Region 1 includes Urban governorates and Lower Egypt and Region 2 includes Upper Egypt and Frontier governorates. The tests will be applied on these growth curves.

4- To present a new application for growth curves in other fields than measuring the nutritional status. The curves will be built for education years-for-age. Real data collected from Qanater district (Qaliubia Governorate) will be used to build the education years-for-age growth curves of both urban and rural areas. The tests will also be applied on these growth curves.

CHAPTER ONE of the thesis discusses the most important nutritional status measures with focus on weight-for-height, height-for-age and weight-for age indices. The chapter also presents the growth curves and the different approaches of classification of nutritional status, and the most important reference charts that were obtained to determine malnourished individuals and populations. The chapter finally discusses the nonparametric tests and suggests that new tests should be built to test the equality of two growth curves of independent populations.

CHAPTER TWO presents various versions of the precedence test. The chapter also discusses the new tests obtained to test the equality of the growth curves. The curve precedence test and the curve chi-square test were developed to test the equality of two growth curves of two independent populations. The curves set chi-square test was developed to test the equality of two sets of percentile growth curves from two independent populations.

CHAPTER THREE illustrates the strategy and the results of the simulation that was performed to study the power of the three tests. The power was tested for curves with three age groups. For the curve chi-square test and the curve precedence test the power was estimated for the 10^{th} percentile curve and the 75^{th} percentile curve. For the curves set chi-square test the power was estimated for a set consists of the 10^{th} percentile curve, the 50^{th} percentile curve and the 90^{th} percentile curve. The powers of the tests were

estimated in the case of symmetric distributions applying on the normal distribution and in the case of skewed distribution applying on the gamma distribution. To estimate the parameters of the distributions, the distributions were fitted to the weight-for-age data using the data of Egypt Demographic and Health Survey 2000, 2003, 2005 (EDHS). The power was tested under the shift in the location parameter as well as under the shift in the scale parameter through Monte Carlo simulations using "MATLAB R2007b". Under the shift of the location parameter, the power of the three tests increases with increasing sample sizes and with increasing values of the shift "k". The power reaches 1 with a shift ranges from 0.1, in the case of $n_1 = n_2 = 500$, to 0.25, in the case of $n_1 = n_2 = 50$. Comparing the power of the curve chi-square test and the curve precedence test reveals that the precedence test performs better than the chi-square test.

Under the shift of the scale parameter, the power of the three tests increases also with increasing sample sizes and with increasing values of the shift "k". In the case of the normal distribution, the three tests are less sensitive to the shifts in the scale parameter than the shifts in the location parameter. The comparison of the power of the curve precedence test and the curve chi-square test reveals that under the normal distribution the curve precedence test is more powerful than the curve chi-square test in the case of the 75^{th} percentile, while it is less powerful than the curve chi-square test in the case of the 10^{th} percentile curve. Under the Gamma distribution the curve precedence test is more powerful than curve chi-square test in testing both the 10^{th} percentile and the 75^{th} percentile curve.

CHAPTER FOUR presents an application for the three tests on the weight-for-age percentile growth curves. Egypt was divided into two regions in a way that could be useful for decision makers. The weight-for-age percentile

growth curves of children age less than five of Egypt was constructed for the first time. The curves of the two regions were obtained also, and the equality of each pair of the growth curves as well as the equality of the two sets of curves was tested. The results suggest that the 2 regions have different nutritional status based on the weight-for-age percentile growth curves.

CHAPTER FIVE presents a new application for the percentile growth curves in other fields than the medical applications. The percentile growth curves of education years-for-age of urban and rural Qanater were obtained and the three tests were used to test the equality of these curves. The results suggest that the 2 regions have different educational status based on the education years-for-age curves.

CHAPTER SIX discusses the conclusions regarding the performance of the tests, testing the equality of weight-for-age growth curves of Egyptian regions and testing the equality of education years-for-age growth curves. The chapter also suggests some topics for further studies.