



جامعة القاهرة

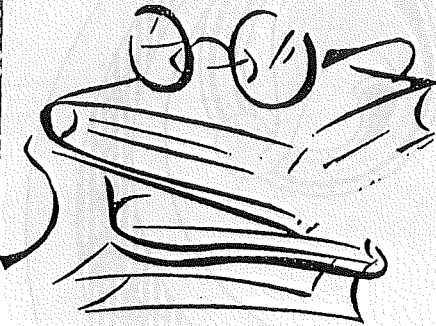


معهد الدراسات والبحوث الإحصائية

المؤتمر السنوى السادس والأربعون

للإحصاء وعلوم الحاسب

وبحوث العمليات



إحصاء تطبيقي



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فهرس الإحصاء التطبيقى

1	قياس عوائد التدريب الملموسة وغير الملموسة بقطاع البنوك المصرية باستخدام التحليل الإحصائى للشبكات العصبية أمل احمد طلعت الغنام	21-1
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قياس عوائد التدريب الملموسة وغير الملموسة بقطاع البنوك المصرية باستخدام التحليل الإحصائي
للشبكات العصبية
أمل احمد طلعت الغنام

ملخص:

أصبح عالم الاستثمار والبنوك اليوم يتسم بالمنافسة الشرسة والتغيرات التقنية المستمرة والانتقال إلى مفهوم المنافسة بالمعرفة وما ترتب على ذلك من تغيرات جذرية في عالم الصناعة المالية، ومن ناحية أخرى انعكس هذا على طبيعة العمل المصرفي وطبيعة المعارف والمهارات وقدرات التي يجب أن تمتلكها الموارد البشرية العاملة في القطاع المصرفي . من هذا المنطق فقد نبوء الاستثمار في تأهيل العنصر البشري مكانة متميزة بين أوجه الاستثمار المختلفة في البنوك والمؤسسات المالية نظرا لأهمية الموارد البشرية في تحقيق التنمية والتقدم ، حتى أضحت الاستثمار في المورد البشري من المقاييس الأساسية للمؤسسات المالية الناجحة اليوم باعتبار العامل الأساسي الذي في تقديم وصناعة الخدمات المالية والمصرفية المتميزة ، وباعتبار التدريب احد مكونات الاستثمار الرئيسية في رأس المال البشري لدى القطاع المصرفي ، حيث أن تزايد الإقبال على الإنفاق عليه يوما بعد يوم خصوصا مع التغيرات التقنية المتلاحقة التي تتسارع خطاها في العالم وتحاول المؤسسات المالية مواكبتها واللاحق بها ووجود أهداف وطنية ومتطلبات اجتماعية تستدعي دعم الكوادر الوطنية وتوجيهها للانخراط في العمل المصرفي وإدارة دفتها ، مما يتطلب إعطاء التدريب أولوية كاستثمار طويل الأجل على أن يحدد هذا الاستثمار بأساليب منهجية علمية وتطبيقية تضمن تحقيق المردود الاقتصادي من وراءه وتتجنب جوانب الهدر في الإنفاق ، من خلال التقييم المستمر لعوائد هذا الاستثمار من اجل علاج نقاط الضعف التي قد تقابله وتعزيز نقاط القوة التي تعزز فاعليته .

من هذا المنطلق يكتسب قياس اثر التدريب أهمية كبيرة لمعرفة مدى جدوى وانعكاس التدريب على العاملين في القطاع المصرفي فهو إحدى المراحل الأساسية التي يجب أن يمر بها التدريب بعد انخراطه في البرنامج التدريبي ، لكن الملاحظ في كثير من المصارف وخاصة البنوك المحلية غياب هذه الممارسة المهمة إذ يقتصر دور القائمين على عمليات التدريب في اغلب الأحيان على إرسال الموظفين والعاملين إلى الدورات التدريبية دون وجود آلية واضحة تحدد مدى الاستفادة من هذه الدورات . وبالتالي يعد هذا المشروع بحق من المشاريع المتميزة فضلا عن تنبئه من قبل مؤسسة المصر للتقدم العلمي خطوة غير مسبقة على مستوى القطاع المصرفي ككل في سبيل تشخيص وتحليل وتقييم وتطوير العملية التدريبية في القطاع المصرفي المصري ، وكذلك واقع الاستثمار في تأهيل الكوادر البشرية في هذا القطاع ومدى تناسبه مع تكلفته ، وبالتالي تحديد الاقتراحات التي يمكن من خلال تنفيذها تحقيق اكبر عائد على هذا الاستثمار ووضع رؤية متكاملة لتطوير مكونات العملية التدريبية ، وبما يعكس على تطوير وتحسين مستوى ونوعية التأهيل والتدريب الكوادر البشرية العاملة في هذا القطاع وتمكينها من تحقيق مستويات متقدمة من الجودة والتميز في الأداء بما يعود بالنفع العام على كافة قطاعات الاقتصاد الوطني ككل .

المدرس بكلية التجارة -جامعة الأزهر

المقدمة :

تتحقق الجدوى من أي عمل أو مشروع أو مخطط عندما تتفوق العوائد والفوائد المرجوة منه على التكاليف المبذولة في أدائه ، وتتنبأ الجدوى الاقتصادية في حسابات التكلفة والعائد مكانتها في كافة المجالات الاقتصادية ، إلا أن هناك بعض المجالات المستحدثة في مضمار تنمية الموارد البشرية واستثمار مواردها تمثلت بها عدة صعوبات عاقت تطبيق القواعد التقليدية في حسابات التكلفة والعائد وتمثلت هذه الصعوبات في عدم القدرة على تقييم المدخلات أو التعبير عن المخرجات بمقابلات مادية واضحة أو محددة .

من هذا المنطق حظي موضوع تحديد العائد من الاستثمار في التدريب باهتمام متزايد من قبل الممارسين في حقل التدريب ، ويعود الاهتمام بالموضوع لفشل النظام التقليدي للمحاسبة في تقديم معلومات دقيقة لمتخذي القرار للاستفادة من الموارد التدريبية المتاحة (Carnevale and Schulz,1990) كما يرى Bassi (1988 , and Van Bunen) أن مفهوم العائد من الاستثمار في التدريب تعود جذوره لحقل المحاسبة والمالية ، واحد الأساليب الشائعة الاستخدام في تحديد العائد من الاستثمار تحليل التكاليف والمنافع ، ويمثل التدريب استثمار من قبل المنشأة في الأفراد العاملين بها ، ولا يختلف الاستثمار في التدريب عن أوجه الاستثمار الأخرى التي تقوم به المنشأة .

وعلى هذا الأساس يسعى هذا المشروع إلى وضع نموذج محدد يصلح لإجراء تحليلات التكلفة والعائد وتقييم العائد التدريبي كما يمكن الاستفادة منه في تحليل كافة الأنشطة والمخططات التي ترتبط بمجال تنمية الموارد البشرية ، ويقدم الخطوات المنهجية لإجراء التحليل بدءاً بجمع البيانات التي يحتاجها التحليل وإجراء التحليلات التي يتطلبها ، وانتهاء بإعداد التقرير وتقديمه ومتابعته وتقييمه وبالتالي تعتمد فلسفة هذا المشروع في قياس الأثر التدريبي على مجموعة من النماذج والأساليب العلمية المتطورة في هذا المجال ومنها على سبيل المثال نموذج كيرك باتريك وهامبلين (واستخدامها لقياس العائد من التدريب سواء كانت هذه الفوائد ملموسة في الأداء الوظيفي أو غير ملموسة في الأداء الوظيفي بصورة مباشرة حيث أن أي من هذه النماذج يتم وفق عملية شاملة تتضمن قياس التالي :

١. قياس رد الفعل والإشباع : ويرتكز على مدى إشباع البرامج للاحتياجات التدريبية
٢. التعلم : ويرتكز على تحقيق تغيير في المعرفة والمهارات والاتجاهات .
٣. السلوك الوظيفي : ويرتكز على التغيير في السلوك الوظيفي ، نتيجة للعملية التدريبية .
٤. الأداء : ويعني مقدار الأثر التدريبي على أداء الأفراد والمنظمة .
٥. عائد أداء العمل : ويرتكز على المتغيرات التي حدثت في العمل بالمنظمة سواء من حيث قدرتها على تحقيق الربح أو تعزيز مكانتها وتطورها وغير ذلك من العوائد الغير ملموسة .
٦. العائد من الاستثمار : ويرتكز على المقارنة بين العوائد المالية النقدية بالتكاليف للبرامج من خلال التقارير .

أولاً: مشكلة الدراسة:

إن طبيعة العمل في المصارف تفرض على العاملين فيها خصوصية مميزة فهذه المصارف على الرغم من كونها مؤسسات مالية تخضع لكافة المعايير والضوابط المالية والقوانين المنظمة لها ، إلا أنها تتميز بمجموعة من المزايا تنطلق في مجملها من كون الخدمات المصرفية يجب أن تكون وفقاً لضوابط وتعليمات تفرضها العديد من الضوابط المحلية والإقليمية والدولية وقد انعكس هذا الوضع على طبيعة العمل في هذه المؤسسات سواء من حيث الحاجة لتصميم خدماتها المصرفية بما يتناسب واحتياجات عملائها ومراعاة ضوابط العمل وخلال العقدين الماضيين شهدت هذه الخدمات تطوراً وتنامياً ملحوظاً .

إذا فان هذا البحث يسعى للتعرف على مدى إنعكاس أثر التدريب على تطوير الأداء بالمصارف من وجهة نظر العاملين بها ، وذلك تحقيقاً للأهداف التالية :

1. تطوير أنشطة التدريب بالقطاع المصرفي بدولة مصر لدعم كفاءة الأفراد والوحدات الإدارية.
2. الارتقاء بمستويات الأداء الفردي والمؤسسي العام بالقطاع المصرفي المصري.
3. تطوير آلية تحديد الاحتياجات التدريبية وقياس اثر التدريب للبنوك المصرية.

ثانياً : أهمية الدراسة

تكتسب هذا الدراسة أهميتها النظرية والعملية ، من كونها تركز على بحث دور و أثر التدريب في تطوير الأداء على المستوى الفردي والمؤسسي في المصارف التجارية و الإسلامية باعتبارهما مؤسسات ومصارف فريدة يتطلب العمل بهما خصوصية واهتمام متزايد بالتدريب والتطوير ، هذا بالإضافة إلى زيادة الاهتمام بالعمل المصرفي التجاري والإسلامي خلال السنوات الماضية . وخاصة بعد الأزمة المالية العالمية واهتزاز بعض البنوك نتيجة تأثير هذه الأزمة المالية العالمية عليها.

وعلى مستوى أهمية هذه الدراسة لمؤسسات العمل المصرفي ذاتها ، فتنبع أهمية هذه الدراسة مما يلي :

1- توجيه نظر متخذي القرار في المصارف التجارية والإسلامية إلى أهمية دور التدريب في تطوير الأداء بها.

2- توجيه نظر مسؤولي التدريب إلى سبل تفعيل وزيادة الآثار المحققة من التدريب.

3- تحديد أهم الاعتبارات التي تضمن مراعاة الجدوى الاقتصادية فيما يتم تنفيذه من برامج تدريبية بحيث تبرر التكلفة الموجهة إليها.

ثالثاً : فرضيات الدراسة

- الفرضية الأولى : لا يوجد اختلاف معنوي بين عينة الدراسة حول درجة الموافقة على عوائد التدريب الأساسية حسب الخصائص الشخصية والوظيفية.

- الفرضية الثانية : لا يوجد اختلاف معنوي بين عينة الدراسة حول أسباب عدم تطبيق المعارف والمهارات المكتسبة من البرنامج التدريبي في مجال العمل بالبنوك المصرية حسب الخصائص الشخصية والوظيفية.

رابعاً : منهج الدراسة

سعت هذه الدراسة إلى المحاولة للكشف عن العلاقة بين التدريب و دوره في تطوير مستويات الأداء بالقطاع المصرفي المصري (التجاري . الإسلامي) ولتحقيق هذا الغرض فقد تم إجراء هذه الدراسة من خلال محورين رئيسيين كالتالي :

المحور الأول : الدراسة المكتبية (النظرية)

المحور الثاني : الدراسة الميدانية (التطبيقية)

المحور الأول : الدراسة النظرية

هدف الباحث من وراء الدراسة النظرية إلى عرض إطار عام للكيفية التي تتم بها تقييم أثار التدريب والمتغيرات المرتبطة بها ، والتي ستكون بمثابة إطار مرجعي عند عرض ومناقشة نتائج الدراسة الميدانية.

المحور الثاني : الدراسة الميدانية

تم إجراء الدراسة الميدانية بما يفي بمتطلبات اختبار فرضيات الدراسة وذلك على النحو التالي .

- تحديد جهات تنفيذ الدراسة.(لجميع المصارف التجارية والإسلامية مصر) .

- تقييم أثار التدريب في تطوير الأداء من خلال استقصاء آراء العاملين بهذه الجهات.

خامساً : حدود الدراسة

من المعروف إن لكل دراسة محدداتها الخاصة والتي تعكس مدى الدقة والالتزام بمنهجية الدراسة بشكل عام ويمكن بيان هذه الحدود من خلال المحاور التالية:

- استخدم في هذه الدراسة أسلوب العينة لصعوبة إجراء الحصر لآراء جميع المشاركين في البرامج

التدريبية في الجهات الخاضعة للدراسة فضلاً عن أن هذا الأسلوب يعد أكثر عملياً لواقعية نتائجه وتوفيره المزيد من الوقت والجهد .

- إجراء الدراسة على جميع المصارف التجارية والإسلامية بدولة مصر باعتبارهما عصب الجهاز المصرفي والمالي بالدولة.

المبحث الثاني

الإطار النظري للدراسة

أولاً: التدريب وأهميته

إن من أبرز سمات العصر الحديث تلك التغيرات الهائلة والمستمرة في المعارف الإنسانية وما يترتب علي ذلك من تغيرات مستمرة في نظم العمل وما يستتجبه ذلك من ضرورة إعداد وتنمية القوي العاملة لمواجهة تلك التغيرات واستيعابها والتكيف مع مقتضياتها لذلك تزايدت الحاجة إلي التدريب الفعال المستمر الذي يستجيب لهذه التغيرات المستمرة في مختلف المجالات وأصبح تدريب القوي العاملة ضرورة لا غني عنها في أي قطاع لاجني

ثمار ذلك التطور الهائل في المعرفة الإنسانية وتطبيقاتها المختلفة.

ولا شك أن هذه الأهمية المتزايدة للتدريب إذا كانت تمثل ضرورة ملحة لكافة المؤسسات بصفة عامة إلا أنها أكثر إلحاحا بالنسبة للمصارف بصفة خاصة وذلك نظرا للعبء المضاعف الملقى علي عاتق العاملين فيها نتيجة الطبيعة الخاصة التي تتميز بها هذه المصارف من خصوصية مصرفية ومالية وشرعية في ذات الوقت. وتبرز أهمية التدريب في:

- إنه يؤدي إلي تحسين الأداء في الحاضر، والتأهيل لمسؤوليات أكبر في المستقبل.
- أنه هام بالنسبة للأفراد الذين يلتحقون بالعمل لأول مرة وخاصة الأعمال التي لم يسبق لهم التدريب عليها فإنهم يحتاجون إلي التدريب على طبيعة هذه الأعمال.
- ومما لا شك فيه أن شعور المتدرب بأهمية التدريب أمر مهم وتوافر هذا الشعور يؤدي إلي تقبله للتدريب والاستفادة منه .

ثانياً: المراحل الرئيسية التي يمر بها العمل التدريبي

إن تصميم نظام تدريب وتطوير متكامل لمنظمة ما يقتضي أن يتم وفق مجموعة من المراحل كالتالي:

- المرحلة الأولى : تحديد الاحتياجات التدريبية .
 - المرحلة الثانية : تصميم البرامج التدريبية اللازمة لسد هذه الاحتياجات.
 - المرحلة الثالثة : تنفيذ البرامج التدريبية.
 - المرحلة الرابعة : متابعة وتقييم البرامج التدريبية التي تم تنفيذها.
- وفيما يخص كل مرحلة من تلك المراحل، فإنها تتضمن سلسلة من العناصر والمفاهيم والتي تتناولها هنا باختصار قبل الانتقال إلى مناقشة الموضوع الرئيسي لهذه الدراسة والخاص بتقييم أثار التدريب.

المرحلة الأولى: تحديد الاحتياجات التدريبية

تهدف هذه المرحلة بصورة أساسية إلى تحديد احتياجات التدريب الظاهرة والخفية للمؤسسة، واحتياجات التدريب "الظاهرة" Apparent وهي تلك التي تستطيع إدارة التدريب اكتشافها بسهولة من خلال المعلومات الروتينية التي ترد إليها من القطاعات المختلفة عن مستوى العمل بهذه القطاعات والعاملين بها . أما احتياجات التدريب "الخفية" Hidden فهي تلك الاحتياجات التي تظهر عند تحليل المشكلات والتعرف على أسبابها والحلول الممكنة لها، والبدائل والأولويات، والخطط اللازمة لتنفيذ تلك الحلول.

وفي هذه المرحلة يتم تحديد أولويات التدريب، ومتطلبات التنفيذ والبدائل والإستراتيجيات الواجب إتباعها، ومن ذلك كله يمكن إنتاج وتحديث ما يعرف بخطة التدريب الرئيسية Training Master Plan والتي تحوي التفاصيل الخاصة بالخطة السنوية الواجب إتباعها.

المرحلة الثانية: تصميم البرامج التدريبية.

وتتضمن هذه المرحلة وضع خطط التدريب وتصميم البرامج التي ستتضمنها وتحديد أهداف التدريب وإنتاج المواد التدريبية اللازمة لتنفيذ وإدارة البرامج التدريبية.

المرحلة الثالثة : تنفيذ البرامج التدريبية

ترتبط عملية التنفيذ بمفاهيم الجودة في الأداء والالتزام بالمواعيد والموضوعات والإجراءات السابق التخطيط لها، مع إجراء عمليات المتابعة المستمرة للوقوف على أية انحرافات أو أخطاء قد تصادف التنفيذ نتيجة لأية ظروف طارئة.

المرحلة الرابعة : متابعة وتقييم البرامج التدريبية

تعد عمليات المتابعة في التدريب بمثابة مراقبة لتنفيذ الخطة لضمان سيرها طبقا للوقت والمنهج المخطط لها وتحديد الانحراف أو المعوقات وتجميع البيانات والمؤشرات الإحصائية التي تساعد في التصحيح الفوري للأداء، أو في إعادة التخطيط مستقبلا. ويتم التعرف على درجة نجاح الأداء التدريبي وتحقيق الأهداف من خلال تقييم أداء كافة العناصر الداخلة في تنفيذ النشاط التدريبي .

وتهدف عملية تقييم أثر التدريب لتحقيق عدة أهداف أهمها :

1. التعرف على قدرة جهات التدريب التي تم التعاون معها على تنفيذ نشاط التدريب.
2. معرفة مدى تحقيق التدريب للغرض منه ومدى استجابة البرنامج التدريبي لحاجة المتدربين.
3. تحديد مدى الاستفادة التي عادت على المؤسسات الموفدة لموظفيها للبرامج التدريبية .
4. قياس مدى زيادة قدرات المتدربين على تطبيق المهارات التي حصلوا عليها خلال البرامج التدريبية.
5. التعرف على العائد من الاستثمار في التدريب مقارنة بالموارد المالية التي صرفت عليه .
6. تكوين قاعدة معلومات تسهم في معاونه الإدارة على اتخاذ قراراتها خاصة ما يتعلق بسياسات التدريب والموارد البشرية.

ثالثاً : وسائل ومؤشرات تقييم أثر التدريب

يعتبر تحديد الوسائل والطرق والتقنيات والوسائل الخاصة بتقييم الأثر الكمي والنوعي للتدريب أمراً ضرورياً ليكون الاستثمار في التدريب ذي جدوى أفضل . كما من المهم توفير مؤشرات وأدلة محددة لنتائج التدريب على المستويين القريب والبعيد ، ومن وسائل تقييم أثر التدريب :

1. الاستقصاءات وتشمل التعرف على آراء رؤساء المتدرب حول التغير الذي حدث في أداء وسلوك الموظف.
2. الملاحظة بالمشاركة ويقصد بها القيام بعملية رصد للكيفية التي يتم بها البرنامج التدريبي ودراسة جوانب محددة فيه ، ويعتبر من أكثر الطرق مباشرة في تقييم وقياس أثر التدريب .
3. الاختبارات الكتابية والشفوية التي تستهدف التعرف على الميول والمواقف قبل وبعد التدريب لقياس ما أحرزه المتدرب من تقدم.
4. اختبارات الأداء والتي تثبت مستوى المهارات والتحصيل العلمي والعمل الذي حصل عليه المتدرب .
5. تقارير الإنتاجية وحجم الإنتاج وتكاليفه لقياس التحسن الفعلي في الكفاءة الاقتصادية.

٦. المقابلات الشخصية والتي توفر معلومات عن نتائج التقييم ، وبصفة عامة فإنها تستلزم مهارة لتشجيع المتدربين على أن يعبروا عن أنفسهم بشكل كامل وبحرية فيما يخص درجة الاستفادة من البرنامج .
٧. التقارير والمعطيات المتوفرة عن أداء المتدربين قبل وبعد التدريب لتقييم التغير في المهارات السلوكية والاتجاهات.
٨. البحوث والدراسات الميدانية .
٩. استطلاعات الرأي والمسوح الدورية التي تتم بعد التدريب لقياس مدى التقدم ودرجة التحسن في الأداء.
١٠. التكلفة المالية وتحليل التكاليف التي أنفقت على المتدرب طوال فترة التدريب وربطها بالعائد .
١١. معدلات دوران العمل وتعد معدلات دوران العمل من الوسائل التي يمكن الاستعانة بها في تقييم أثر التدريب إذا أن انخفاض هذه المعدلات بعد التدريب يعطي مدلولاً هاماً على أثر التدريب في رفع كفاءة العاملين وبالتالي انخفاض معدل دورات العمل.
١٢. معدلات الغياب عن العمل تستخدم معدلات الغياب عن العمل كمؤشر على درجة الرضا عن العمل لدى العاملين ، وحيث أن التدريب يؤثر تأثيراً مباشراً على ارتفاع رضا العاملين عن العمل لذا يمكن الاستفادة من قياس معدلات الغياب عن العمل في تقييم أثر التدريب .
١٣. حجم الشكاوي المقدمة من العاملين وأيضاً من العملاء.

المبحث الثالث

الدراسة الميدانية

أولاً : توصيف مجتمع الدراسة:

اعتمدت الدراسة على خمس بنوك مصرية ٣ قطاع عام (مصر - القاهرة - الأهلـى) ٥ قطاع خاص واجنبي (التجاري الدولي - الإسكندرية - عودة - البركة - المصري الخليجي).

ثانياً : أداة الدراسة:

اعتمد الباحث في إجراء هذه الدراسة الميدانية بشكل رئيسي - كما سبق التوضيح - على استمارة الاستقصاء التي تم تصميمها وفقاً للأسلوب العلمي المتبع في هذا المجال ، حيث تم إعدادها وتبويبها وصياغة الأسئلة التي تحويها لتدور حول تساؤلات الدراسة ، وكذلك تم مراعاة المنطقية والترتيب وتسلسل المعلومات وترابطها واتساقها مع مشكلة الدراسة.

أ - بناء أداة الدراسة : في ضوء دراسة الأدبيات التي تضمنها الإطار النظري لهذا الدراسة ، وفي ضوء مطالعات الدراسات السابقة ، قام الباحث بتصميم إستبانة الدراسة لجمع البيانات والمعلومات من أفراد مجتمع الدراسة ، وقد جاء البناء على النحو التالي :

١- البيانات الأولية: بيانات عامه عن المستقصى عنه وقد اشتملت على (٦) أسئلة

٢- أسئلة الاستبيان: وقد احتوت على (٢٠) سؤالاً مقاسه على مقياس ليكرت الخماسي.

٣ الآراء والملاحظات: وقد اشتملت على سؤال للآراء والآخر للملاحظات . ب- الصدق والثبات : قام

الباحث بعرض الصورة الأولية للتأكد من صدق النتائج وثباتها من خلال عدة مراحل تمثلت في تحديد

أهداف استمارة الاستقصاء مع مراعاة خصائص مجتمع الدراسة ، كما تم ترتيب الموضوعات و الأسئلة بالشكل الذي يجعلها واضحة ومفهومة ومتدرجة.

وقد تم بالفعل اختبار استبانة الدراسة للتأكد من صدق وثبات النتائج:-

الصدق:

الهدف من اختبار الصدق هو أن تؤدي الأداة إلى الكشف عن الظاهرة أو السمة التى يجرى البحث من أجلها .

الثبات

يقصد به اختبار أداة جمع البيانات والمعلومات للتأكد من درجة الاتساق بما يتيح قياس ما تقيسه من ظاهرات ومتغيرات بدرجة عالية من الدقة والحصول على نتائج متطابقة أو متشابهة إذا تكرر استخدامها أكثر من مرة فى جمع نفس المعلومات أو قياس نفس المتغيرات سواء من باحث واحد أو عدة باحثين فى أوقات وظروف مختلفة ، وباستخدام معامل كرونباخ ألفا Cronbach's Alpha وبالتطبيق على البيانات التى تم الحصول عليها كانت قيمة معامل الثبات بين (0.968) وهى قيمة جيدة حيث تزيد عن (0.600) ، وهو معامل جيد ويدل على ثبات الأداة ويمكن الاعتماد عليها.

ثالثاً : عينة الدراسة

مجتمع الدراسة: يتمثل مجتمع الدراسة فى العاملين بكل القطاع المصرفي المصري ممثلة فى البنوك الخاصة الأجنبية وكذلك البنوك العامة من المشتركين فى برامج تدريبية وهم توصيف مجتمع وعينة الدراسة.

توصيف العينة :

أ- حجم العينة: لتحديد حجم العينة المناسب، حددت $\alpha = 5\%$ و $\beta = 10\%$ ومقدار الخطأ المسموح به 1% ، وبدرجة صلاحية 99% ، والمجتمع غير محدود، أظهرت النتائج* أن الحجم الأمثل يجب ألا يقل عن 700 مفردة بكل البنوك المصرية الثمان. وتم اختيار عينة الدراسة بطريقة طبقية حسب الخصائص المحددة من بين إطار العاملين بكل مصرف Frame (تم سؤالهم عن عوائد التدريب)، وداخل كل طبقة تم أخذ العينة البسيطة، وجاء توزيع العينة طبقاً للوزن النسبي لحجم كل طبقة بالمجتمع (Bonett, 2002, P338)، وللحرص فى الحصول على الأعداد المطلوبة لعينة البحث تم زيادة أعداد الاستمارات الموزعة على عينة البحث لتصل الى 960 استمارة بالتساوي على الثمان مصارف، استوفى منهم 800 بنسبة استجابة 83% ، وتم تحديد أفراد العينة عشوائياً، وبالتالي فإن عينة البحث من العاملين جاء توزيعها حسب خصائصها لتكون ممثلة للمجتمع.

شكل (1) تحديد حجم العينة

ب- اختبار صدق وصلاحية نموذج القياس:

تم اختبار صلاحية *Validity* المقاييس التي اعتمدت عليها الدراسة الحالية، باستخدام أسلوب التحليل العاملي *Factor Analysis*، مستخدماً في ذلك طريقة العناصر الأساسية (*Principal Component Analysis*) وذلك في محاولة للتوصل إلى الأبعاد الحقيقية في كل البيانات الخاضعة للتحليل، بما يساعد على استخدام عدد أقل من المتغيرات ودرجة عالية من الصلاحية، وأكد اختبار *KMO and Bartlett's* وهو اختبار كفاية العينة، وتنحصر قيمته بين الصفر والواحد، ولا بد وأن تكون أكبر من ٠,٥، وقد كانت قيمته ٠,٧٨٤ مما يدل على أن التحليل يعطى عوامل موثوق فيها، ويوضح جدول (1) المحاور الرئيسية ومعامل ثباتها وصدقها.

جدول (1) معاملات الثبات والصدق لبنود المقياس

عدد البنود	معامل الثبات	معامل الصدق الظاهري	الصدق التمييزي
٢٠	٠,٩٦٨	٠,٩٨٣	٠,٧١٠

وتم تبويب وتحليل البيانات باستخدام برنامج الحزم الإحصائية للعلوم الاجتماعية SPSS 19، وتتوزع الأساليب الإحصائية بما يتوافق مع طبيعة البيانات، وفروض الدراسة والمنهج الذي صار عليه الباحث وفي هذا الإطار تم تقديم أحد الأساليب الإحصائية الحديثة وهو أسلوب الشبكات العصبية جنباً إلى جنب مع الأساليب الإحصائية التقليدية الأخرى لوصف بيانات قياس عوائد التدريب الملموسة وغير الملموسة على الفرد والجهة والبالغة ٢٠ بنداً بقطاع البنوك المصرية ودمجها بالتحليل العاملي والتي تظهر تفصيلاً بالجزء التالي.

رابعاً : أساليب التحليل الإحصائي :

تعتمد الدراسة على أساليب التحليل الإحصائي المناسبة لنوعية البيانات وذلك لتحقيق الأهداف التي تسعى إليها الدراسة، والإجابة على تساؤلاتها، بهدف الوصول إلى مستوى عالي من دقة النتائج، ومن الأساليب المزمع استخدامها في التحليل (المقاييس الأساسية - النماذج الإحصائية)، علماً بأنه تم جمع وتبويب ومراجعة البيانات الأولية، ثم فرغت ورمزت، وأدخلت هذه البيانات إلى الحاسب باستخدام برنامج SPSS 19، وهذه الأساليب هي:

١- تحليل الموثوقية (الثبات) *Reliability Analysis*: للتأكد من صحة مقاييس متغيرات النموذج، وقد تم استخدام العديد من الأساليب الإحصائية مثل تحليل الارتباط ألفا *Alpha Correlation Coefficient* وتم استخدامه للتحقق من درجة الاعتمادية والثبات في المقاييس متعددة المحتوى، وقد تم استخدامه في هذه الدراسة لاختبار العلاقة بين متغيرات الدراسة.

- ٢- التحليل الإحصائي الوصفي *Descriptive Statistical Analysis*: وتم استخدام تلك الأساليب بغرض التعرف على المقاييس الأساسية للبند.
- ٣- أسلوب تحليل الشبكات العصبية *Neural Network* لبيان الوزن النسبي لأبعاد عوائد التدريب الملموسة وغير الملموسة على الفرد والجهة (المؤسسة) بالبنوك المصرية.
- وصف خصائص عينة الدراسة:

في هذا الجزء نتناول وصف خصائص عينة الدراسة حسب أهم الخصائص الشخصية والوظيفية للعاملين بالبنوك المصرية والتي يوضحها الجدول (٢)

جدول (٢) التوزيع النسبي للخصائص الشخصية والوظيفية للعاملين بالبنوك المصرية

الخصائص وتقسيماتها	البنك										عامة	خاصة	جملة
	مصر	الأهلى	القاهرة	الاسكندرية	التجارى	عودة	البركة	الخليجي					
النوع	ذكر	45.0	45.0	51.0	44.0	53.0	56.0	70.0	67.0	47.6	64.3	53.9	
	انثى	55.0	55.0	49.0	56.0	47.0	44.0	30.0	33.0	52.4	35.7	46.1	
المستوى	قطاع	33.0	10.0	15.0	44.0	17.0	48.0	41.0	37.0	23.8	42.0	30.6	
	ادارة	44.0	69.0	46.0	46.0	56.0	51.0	37.0	49.0	52.2	45.7	49.8	
	قسم	19.0	13.0	31.0	9.0	16.0	0.0	9.0	8.0	17.6	5.7	13.1	
	وحدة	4.0	8.0	8.0	8.0	1.0	11.0	13.0	6.0	6.4	6.7	6.5	
الوظيفة	عليا	19.0	9.0	11.0	36.0	11.0	48.0	26.0	38.0	17.2	37.3	24.8	
	وسطى	34.0	24.0	33.0	54.0	25.0	48.0	25.0	33.0	34.0	35.3	34.5	
	اشرافية	31.0	17.0	20.0	7.0	33.0	0.0	27.0	7.0	21.6	11.3	17.8	
	تنفيذية	16.0	50.0	36.0	3.0	31.0	4.0	22.0	22.0	27.2	16.0	23.0	
التعليم	دكتوراة	9.0	3.0	8.0	0.0	5.0	2.0	2.0	1.0	5.0	1.7	3.8	
	ماجستير	53.0	41.0	51.0	6.0	43.0	5.0	37.0	31.0	38.8	24.3	33.4	
	جامعي	21.0	35.0	30.0	13.0	30.0	1.0	22.0	9.0	25.8	10.7	20.1	
	دبلوم	17.0	18.0	11.0	40.0	17.0	46.0	21.0	24.0	20.6	30.3	24.3	
الخبرة	ثانوي وأقل	0.0	3.0	0.0	41.0	5.0	46.0	18.0	35.0	9.8	33.0	18.5	
	< 5	49.0	43.0	27.0	47.0	24.0	50.0	32.0	44.0	38.0	42.0	39.5	
	١٠-٥	26.0	26.0	37.0	49.0	35.0	46.0	39.0	40.0	34.6	41.7	37.3	
	10+	25.0	31.0	36.0	4.0	41.0	4.0	29.0	16.0	27.4	16.3	23.3	

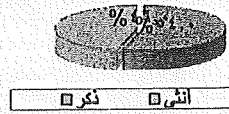
يظهر جدول (٢) أن الذكور بالعينة يمثلون حوالي ٥٤%، والإناث يمثلون ٤٦%، وجاء توزيعهم حسب المستوى الوظيفي ٣١% بالقطاع، و٥٠% بالإدارة، و١٣% بالأقسام، و٧% بالوحدات، ومنهم ٢٥% بالوظائف العليا، والوسطى ٣٥%، و١٨% بالإشرافية، و٢٣% بالتنفيذية، وجاء توزيع العينة حسب مستوى التعليم أعلى من الجامعي ٣٧%، والجامعيون ٢٠%، وحملة الدبلوم ٢٤%، وحملة الثانوي وأقل ١٩%، وحسب الخبرة أقل من خمس سنوات يمثلون ٤٠%، ومن ١٠-٥ سنة يمثلون ٣٧%، وأكثر من عشر سنوات يمثلون ٢٣%.

أن الذكور بعينة المصارف التجارية يمثلون حوالي ٤٨%، والإناث يمثلون ٥٢%، وجاء توزيعهم حسب المستوى الوظيفي ٢٤% بالقطاع، و٥٢% بالإدارة، و١٨% بالأقسام، و٦% بالوحدات، ومنهم ١٧% بالوظائف العليا، والوسطى ٣٤%، و٢٢% بالإشرافية، و٢٧% بالتنفيذية، وجاء توزيع العينة حسب مستوى التعليم أعلى من الجامعي ٤٤%، والجامعيون ٢٦%، وحملة الدبلوم ٢١%، وحملة الثانوي وأقل ١٠%، وحسب الخبرة أقل من خمس سنوات يمثلون ٣٨%، ومن ١٠-٥ سنة يمثلون ٣٥%، وأكثر من عشر سنوات يمثلون ٢٧%.

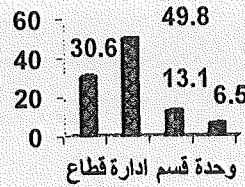
أن الذكور بعينة المصارف الإسلامية يمثلون حوالي ٦٤%، والإناث يمثلون ٣٦%، وجاء توزيعهم حسب المستوى الوظيفي ٤٢% بالقطاع، و٤٦% بالإدارة، و٦% بالأقسام، و٧% بالوحدات، ومنهم ٣٧% بالوظائف العليا، والوسطى ٣٥%، و١١% بالإشرافية، و١٦% بالتنفيذية، وجاء توزيع العينة حسب مستوى التعليم أعلى من الجامعي ٢٦%، والجامعيون ١١%، وحملة الدبلوم ٤٢%، وحملة الثانوي وأقل ١٦%، وحسب الخبرة أقل من خمس سنوات يمثلون ٤٢%، ومن ٥-١٠ سنة يمثلون ٣٧%، وأكثر من عشر سنوات يمثلون ٢٣%

وتوضح الأشكال التالية التوزيع النسبي لخصائص العينة الإجمالية:

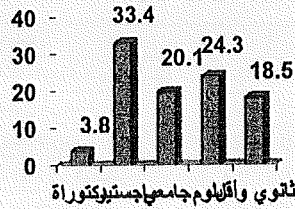
شكل (٢) توزيع العينة الإجمالية حسب النوع



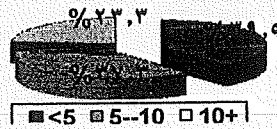
شكل (٣) توزيع العينة الإجمالية حسب المستوى الإداري



شكل (٤) توزيع العينة الإجمالية حسب مستوى التعليم



شكل (٥) توزيع العينة الإجمالية حسب الخبرة



وتظهر الجداول التالية التوزيع النسبي لبنود عوائد التدريب ومتوسطها وترتيبها حسب البنوك.

جدول (٣) التوزيع النسبي لبنود عوائد التدريب

بنود عوائد التدريب	1	2	3	4	5
مساهم البرنامج التدريبي في تلبية احتياجات الوحدة التي اعمل بها	22.3	27.6	20.9	20.5	8.8
مشاركتي في البرنامج انعكست على التطبيق في العمل	18.1	25.6	23.4	20.5	12.4
تطورت معارف ومهاراتي وسلوكياتي نتيجة التدريب	18.1	23.3	21.8	21.0	15.9
ساعدت مشاركتي في البرنامج علي تحسين أدائي الوظيفي	15.5	22.9	21.6	24.4	15.6
قمت بتطبيق ما تدرت عليه في البرنامج بدافع ذاتي	12.9	20.3	23.1	24.9	18.9
نظم العمل تساهم في قيامي بتطبيق المهارات التي تم التدريب عليها	13.8	21.6	29.9	20.9	13.9
ظروف العمل تساعدني على تطبيق المهارات المكتسبة في التدريب	12.4	23.8	29.3	21.6	13.0
هناك تحسين في أداء الوحدة نتيجة تطبيق ما تم التدريب عليها	11.0	22.8	28.6	23.6	14.0
كفاءة الوحدة زادت بتطبيق نتائج التدريب	10.9	22.5	29.4	24.3	13.0
أشعر أن هناك عالدا ملموسا في تطوير الأداء الوظيفي	9.8	21.4	30.0	25.3	13.6
أشعر أن هناك عالدا ملموسا بعد تطبيق نتائج التدريب على الوحدة	10.4	21.5	32.4	23.4	12.4
هناك عوائد غير ملموسة للتدريب انعكست على شخصا	9.1	20.5	31.5	23.8	15.1
هناك عوائد غير ملموسة للتدريب انعكست على الوحدة	8.9	19.8	34.9	23.4	13.1
كنتيجة للتدريب زاد حجم انجازي في العمل	9.6	18.4	31.6	24.8	15.6
كنتيجة للتدريب زادت سرعة أدائي للعمل	8.4	16.0	33.3	26.0	16.4
كنتيجة للتدريب زادت دقتي في أداء العمل	7.6	17.1	31.3	26.4	17.6
كنتيجة للتدريب تم تطبيق أفكار جديدة في العمل	8.5	16.3	32.5	26.8	16.0
كنتيجة للتدريب تحسنت سلوكياتي مع الآخرين بعد التدريب	6.9	15.4	34.9	25.3	17.6
زيادة الإلتفاق علي التدريب تنعكس إيجابيا على الفرد سلوكياً ومهارياً	5.5	15.1	26.0	27.4	26.0
الإلتفاق علي التدريب ينعكس في صورة فوائد ماثية علي البنك	6.8	14.0	27.5	26.1	25.6

جدول (٤) التوزيع النسبي لبنود عوائد التدريب ومتوسطها وترتيبها بالمصارف التجارية

بنود عوائد التدريب	1	2	3	4	5
مساهم البرنامج التدريبي في تلبية احتياجات الوحدة التي اعمل بها	15.0	24.2	24.0	25.4	11.4
مشاركتي في البرنامج انعكست على التطبيق في العمل	10.2	22.2	25.8	25.6	16.2
تطورت معارف ومهاراتي وسلوكياتي نتيجة التدريب	12.4	18.0	24.0	24.8	20.8
ساعدت مشاركتي في البرنامج علي تحسين أدائي الوظيفي	9.4	18.6	22.6	28.8	20.6
قمت بتطبيق ما تدرت عليه في البرنامج بدافع ذاتي	7.0	15.4	23.8	30.4	23.4
نظم العمل تساهم في قيامي بتطبيق المهارات التي تم التدريب عليها	8.4	17.8	31.0	24.8	18.0
ظروف العمل تساعدني على تطبيق المهارات المكتسبة في التدريب	8.2	19.2	29.0	27.0	16.6
هناك تحسين في أداء الوحدة نتيجة تطبيق ما تم التدريب عليها	6.0	19.4	27.6	30.8	16.2
كفاءة الوحدة زادت بتطبيق نتائج التدريب	7.0	19.0	29.0	30.0	15.0
أشعر أن هناك عالدا ملموسا في تطوير الأداء الوظيفي	7.2	18.2	30.0	30.0	14.6
أشعر أن هناك عالدا ملموسا بعد تطبيق نتائج التدريب على الوحدة	9.2	19.4	31.0	27.6	12.8
هناك عوائد غير ملموسة للتدريب انعكست على شخصا	7.2	19.6	30.0	24.8	18.4
هناك عوائد غير ملموسة للتدريب انعكست على الوحدة	8.0	17.6	33.0	27.0	14.4
كنتيجة للتدريب زاد حجم انجازي في العمل	8.2	16.6	28.2	28.4	18.6
كنتيجة للتدريب زادت سرعة أدائي للعمل	7.2	14.8	29.2	29.0	19.8
كنتيجة للتدريب زادت دقتي في أداء العمل	7.0	16.0	27.4	29.2	20.4
كنتيجة للتدريب تم تطبيق أفكار جديدة في العمل	7.8	14.6	28.8	30.6	18.2
كنتيجة للتدريب تحسنت سلوكياتي مع الآخرين بعد التدريب	6.0	14.0	32.0	27.2	20.8
زيادة الإلتفاق علي التدريب تنعكس إيجابيا على الفرد سلوكياً ومهارياً	4.4	12.8	23.4	30.4	29.0
الإلتفاق علي التدريب ينعكس في صورة فوائد ماثية علي البنك	5.8	11.4	25.2	28.0	29.6

جدول (٥) التوزيع النسبي لبنود عوائد التدريب بالمصارف الإسلامية

بنود عوائد التدريب	1	2	3	4	5
ساهم البرنامج التدريبي في تلبية احتياجات الوحدة التي اعمل بها	34.3	33.3	15.7	12.3	4.3
مشاركتي في البرنامج انعكست على التطبيق في العمل	31.3	31.3	19.3	12.0	6.0
تطورت معارفي ومهاراتي وسلوكياتي نتيجة التدريب	27.7	32.0	18.0	14.7	7.7
ساعدت مشاركتي في البرنامج علي تحسين أدائي الوظيفي	25.7	30.0	20.0	17.0	7.3
قمت بتطبيق ما تدرت عليه في البرنامج بدافع ذاتي	22.7	28.3	22.0	15.7	11.3
نظم العمل تساهم في قيامي بتطبيق المهارات التي تم التدريب عليها	22.7	28.0	28.0	14.3	7.0
ظروف العمل تساعدني على تطبيق المهارات المكتسبة في التدريب	19.3	31.3	29.7	12.7	7.0
هناك تحسين في أداء الوحدة نتيجة تطبيق ما تم التدريب عليها	19.3	28.3	30.3	11.7	10.3
كفاءة الوحدة زادت بتطبيق نتائج التدريب	17.3	28.3	30.0	14.7	9.7
أشعر أن هناك عائدا ملموسا في تطوير الأداء الوظيفي	14.0	26.7	30.0	17.3	12.0
أشعر أن هناك عائدا ملموسا بعد تطبيق نتائج التدريب على الوحدة	12.3	25.0	34.7	16.3	11.7
هناك عوائد غير ملموسة للتدريب انعكست على شخصا	12.3	22.0	34.0	22.0	9.7
هناك عوائد غير ملموسة للتدريب انعكست على الوحدة	10.3	23.3	38.0	17.3	11.0
كنتيجة للتدريب زاد حجم انجازي في العمل	12.0	21.3	37.3	18.7	10.7
كنتيجة للتدريب زادت سرعة أدائي للعمل	10.3	18.0	40.0	21.0	10.7
كنتيجة للتدريب زادت دقتي في أداء العمل	8.7	19.0	37.7	21.7	13.0
كنتيجة للتدريب تم تطبيق أفكار جديدة في العمل	9.7	19.0	38.7	20.3	12.3
كنتيجة للتدريب تحسنت سلوكياتي مع الآخرين بعد التدريب	8.3	17.7	39.7	22.0	12.3
زيادة الإتفاق علي التدريب تعكس إيجابيا على الفرد سلوكياً ومهارياً	7.3	19.0	30.3	22.3	21.0
الإتفاق علي التدريب ينعكس في صورة فوائد مادية علي البنك	8.3	18.3	31.3	23.0	19.0

جدول (٦) متوسط و ترتيب بنود عوائد التدريب بالمصارف التجارية حسب البنك

	الوطني		الأمل		برقان		الخليج		التجاري	
	المتوسط	الترتيب	المتوسط	الترتيب	المتوسط	الترتيب	المتوسط	الترتيب	المتوسط	الترتيب
ساهم البرنامج التدريبي في تلبية احتياجات الوحدة التي اعمل بها	63.8	20	58.4	16	65.2	18	37.8	20	68.8	17
مشاركتي في البرنامج انعكست على التطبيق في العمل	76.2	16	59.4	12	68.6	9	39.4	19	71.8	8
تطورت معارفي ومهاراتي وسلوكياتي نتيجة التدريب	80.0	7	60.0	10	70.0	5	42.0	5	71.6	9
ساعدت مشاركتي في البرنامج علي تحسين أدائي الوظيفي	80.8	3	60.6	9	70.8	4	47.0	4	73.4	4
قمت بتطبيق ما تدرت عليه في البرنامج بدافع ذاتي	80.4	5	70.8	3	74.0	2	48.4	2	74.2	3
نظم العمل تساهم في قيامي بتطبيق المهارات التي تم التدريب عليها	78.6	12	59.6	11	68.4	11	48.2	11	71.4	11
ظروف العمل تساعدني على تطبيق المهارات المكتسبة في التدريب	78.8	11	58.2	17	68.0	13	50.2	14	69.4	14
هناك تحسين في أداء الوحدة نتيجة تطبيق ما تم التدريب عليها	74.0	19	64.2	4	69.0	8	52.6	8	72.0	6
كفاءة الوحدة زادت بتطبيق نتائج التدريب	75.8	17	59.0	14	66.2	17	56.0	17	70.0	13
أشعر أن هناك عائدا ملموسا في تطوير الأداء الوظيفي	78.2	14	57.8	19	67.0	15	54.6	15	69.0	16
أشعر أن هناك عائدا ملموسا بعد تطبيق نتائج التدريب على الوحدة	75.4	18	55.6	20	64.6	19	54.2	19	65.6	20
هناك عوائد غير ملموسة للتدريب انعكست على شخصا	79.2	9	58.6	15	67.6	14	54.8	14	67.4	19
هناك عوائد غير ملموسة للتدريب انعكست على الوحدة	76.4	15	58.0	18	63.8	20	56.6	20	67.4	18
كنتيجة للتدريب زاد حجم الانجازي في العمل	78.4	13	61.0	8	66.8	16	57.4	16	69.0	15
كنتيجة للتدريب زادت سرعة أدائي للعمل	78.8	10	63.2	6	69.4	6	56.2	6	71.8	7
كنتيجة للتدريب زادت دقتي في أداء العمل	79.6	8	64.0	5	68.6	10	56.8	10	71.0	12
كنتيجة للتدريب تم تطبيق أفكار جديدة في العمل	80.6	4	59.0	13	68.2	12	57.4	12	71.6	10
كنتيجة للتدريب تحسنت سلوكياتي مع الآخرين بعد التدريب	82.0	1	61.2	7	69.4	6	57.0	6	73.2	5
زيادة الإتفاق علي التدريب تعكس إيجابيا على الفرد سلوكياً ومهارياً	81.6	2	72.4	2	77.2	1	57.8	1	77.8	1

جدول (٧) متوسط وترتيب بنود عوائد التدريب بالمصارف الإسلامية حسب البنك

الدولى	التمويل		بوبيان		
	المتوسط	الترتيب	المتوسط	الترتيب	
20	43.6	20	52.4	20	35.4
19	45.0	18	57.0	19	36.0
18	47.0	15	60.4	18	38.2
17	48.0	13	61.6	17	40.6
12	52.6	12	62.8	16	43.4
16	49.4	17	59.4	15	44.2
14	51.0	19	56.6	14	46.4
13	52.2	16	59.6	13	47.4
14	51.0	14	61.2	12	50.4
11	56.0	11	63.0	11	53.0
9	56.8	10	64.0	10	53.2
7	58.6	9	64.6	9	53.6
8	57.4	7	65.0	7	54.8
10	56.8	5	65.8	8	54.2
6	61.0	8	64.8	6	56.4
3	63.2	4	66.4	5	57.2
5	61.4	6	65.0	3	57.6
4	62.2	3	67.8	4	57.4
2	67.6	1	73.2	2	57.6
1	68.2	2	69.4	1	58.0

ويتضح من الجداول (٧) متوسط بنود عوائد التدريب العشرون وترتيبها وأن هناك شبه اتفاق على أن أهم ثلاث بنود بالترتيب هي:

١. زيادة الإنفاق على التدريب تنعكس إيجابياً على الفرد سلوكياً ومهارياً
٢. الإنفاق على التدريب ينعكس في صورة فوائد مالية على البنك
٣. كنتيجة للتدريب تحسنت سلوكياتي مع الآخرين بعد التدريب.

وأخر ثلاث بنود وفق ترتيبها حسب المتوسط من وجهة عينة الدراسة هي:

- ١- ساهم البرنامج التدريبي في تلبية احتياجات الوحدة التي اعمل بها
- ٢- مشاركتي في البرنامج انعكست على التطبيق في العمل
- ٣- تطورت معارفى ومهاراتى وسلوكياتى نتيجة التدريب .

ومما سبق يتضح أن زيادة الإنفاق على التدريب ينعكس إيجابياً على الفرد سلوكياً ومهارياً، وينعكس في صورة فوائد مالية على البنك، ويحسن السلوكيات مع الآخرين.

الوزن النسبي لأبعاد عوائد التدريب باستخدام الشبكات العصبية:

ولبيان الوزن النسبي لأبعاد عوائد التدريب الملموسة وغير الملموسة على الفرد والجهة بالبنوك المصرية، وتطوير وتحسين الأداء والمهارات الناتجة عن التدريب تم استخدام أسلوب الشبكات العصبية، وتعد الشبكات العصبية واحدة من طرق الذكاء الاصطناعي بوجه عام و واحدة من طرق التعلم الآلي بوجه خاص وتعد الشبكات العصبية حقل متشعب من ناحية الدراسة حيث تقدم طريقة مناسبة في تمثيل العلاقات بين المتغيرات بشكل

مختلف عن الطرق التقليدية ولقد طورت الشبكات العصبية لاستخدام الحاسب في تخصصات كانت محصورة فقط للذكاء الإنساني. وهذه التخصصات تشمل التعلم من الخبرة والتجارب السابقة لاستنتاج خبرات وتجارب جديدة تفقدنا التجارب التي أصبحت غير صالحة. وقد تم قياس الشبكات العصبية الاصطناعية والنظام العصبي الحيوي حيث تماثل هذه الشبكات مخ الإنسان في عملية تعلم المعرفة واستخدامها وتمثل بنموذج الخلية العصبية الحويية وذلك من خلال انتقال الإشارة ومعالجتها وبهذا وجد الباحثون أن طرق المعالجة للإشارة في الشبكات العصبية الاصطناعية بدأت تقترب من طرق المعالجة في العصبونات الحويية وبذلك تم استخدامها في مجالات عدة منها الطب، والتنبؤات، البنوك، والتأمين ... الخ.

وتستخدم معظم الشبكات العصبية -التي تسمح بالتعلم من الخبرة والتجارب السابقة لإستنتاج خبرات وتجارب جديدة- كأداة لتحليل البيانات لنفس المجالات التي تتناولها الأساليب الإحصائية التقليدية وتقدم الشبكات العصبية طريقة مناسبة في تمثيل العلاقات بين المتغيرات بشكل مختلف عن الطرق التقليدية وينظر إليها (العباسي، ٢٠١٠) كأداة إحصائية حديثة.

وتعرف الشبكات العصبية بنماذج الشبكات العصبية الذكية صناعياً وهي دوال غير خطية مرنة حيث لا تتطلب توافر الافتراضات المقيدة عن العلاقة بين المتغيرات التابعة والمتغيرات المستقلة وتعالج البيانات اللامعلمية بقدر عالي من الدقة هذا بالإضافة الى دقتها فيما يتعلق بالبيانات المعلمية .

وقد أوضحت العديد من الدراسات أن الشبكات العصبية تقدم مستويات أفضل من التنبؤ مقارنة بالأساليب الإحصائية التقليدية الأخرى فضلاً عن أن الشبكات العصبية يمكن أن تدير مهام تحليلية وتنبؤية بشكل أكثر سرعة مما ينعكس إيجابياً على عنصر الوقت (المرجع السابق) وتنقسم الشبكات العصبية إلى نوعين من النماذج هي :

-النماذج الشبكية العصبية الذكية صناعياً (ANNs) Artificial Neural Networks

-النماذج الشبكية العصبية الرياضية (NNA) Neural Networks Algorithm

ولقد تم التعامل مع النوع الأول (ANNs) وهي تشبه وتماثل النماذج الإحصائية التقليدية شائعة الاستخدام غير أن هناك اختلافات فيما يتعلق ببعض الاصطلاحات فالمتغيرات المستقلة تسمى مدخلات والمتغيرات التابعة تسمى قيم التدريب أو قيم مستهدفة، والقيم المنتبأ بها تسمى مخرجات والتقدير يسمى تدريب أو تعليم أو التنظيم الذاتي والمعلمات تسمى أوزان .

وتعرف الشبكات العصبية بنماذج الشبكات العصبية الذكية الصناعية، وهي دوال غير خطية مرنة. والشكل العام لدالة الشبكات العصبية المستخدمة في التنبؤ يمكن أن تكتب كالتالي:

$$Y = F[H1(X), H2(X), \dots, HN(X)] + U$$

حيث أن : Y تمثل المتغير (المتغيرات) التابع (Dépendent variable(s)،
و X تمثل المتغيرات التفسيرية أو المتغيرات المستقلة (Independent variables)،
F و H تمثل دوال الشبكات العصبية،

أما U تمثل Error Term حد الخطأ في الدالة.

وحسب لغة الشبكات العصبية يكون :

تسمى مجموعة متغيرات X بالمدخلات Input.

يسمى المتغير Y بالمخرجات أو الناتج Output.

تسمى H بدوال التحفيز الطبقات الخفية Hidden Layer Activation Fonction.

تسمى F مخرجات دالة التحفيز الخفية.

■ تم معالجة البيانات وقامت الشبكة بالتدريب على هذه البيانات بمعنى أن تقوم الشبكة بالتعلم والتعرف على البيانات

والعلاقات بين المتغيرات المختلفة

■ تم استخدام برنامج لتصميم الشبكة العصبية وتدريبها تبعاً لذلك ووضع معيار لإنهاء التدريب وهو عدم ملاحظة أى تغيير في متوسط الخطأ أما المعايير الإحصائية فهي مجموع مربعات الخطأ MSE ومتوسط الخطأ النسبي MEP.

■ تم استخدام الشبكة العصبية للبيانات المتاحة بنسبة (90%) للتدريب Training وبنسبة (10%) للاختبار Testing

وتمثلت مدخلات الشبكة في عدد اثنين عامل مستقل تعبر عن العوائد التدريبية الملموسة والغير ملموسة للتدريب للفرد والجهة بالبنوك المصرية، وتطوير وتحسين الأداء والمهارات، أما المخرجات فتتمثل في متوسط درجة الاستفادة الكلية من التدريب، وبالتطبيق على البيانات:

■ أوضح التحليل الإحصائي معنوية العلاقة بين المخرجات والمدخلات باستخدام اختبار F وذلك عند مستوى معنوية 0.000 .

■ بلغ متوسط الخطأ النسبي Relative Error الذي يقيس التباين أو الاختلاف بين المخرجات الفعلية والمخرجات التقديرية 0.056 وهو يشير إلى انخفاض مستوى التباين علماً بأنه كلما اقتربت القيمة من الصفر كلما كان ذلك أفضل.

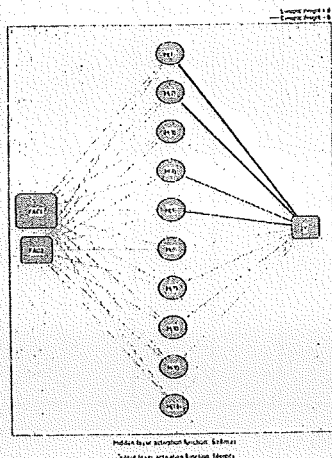
■ بلغت القدرة التفسيرية للمدخلات $R^2 = 99.9\%$ ، وهى نسبة مرتفعة حيث تشير للأهمية النسبية للمتغيرات المستقلة بمقارنة المعايير الإحصائية سالفة الذكر يتبين أن الشبكة العصبية قد تدربت بدرجة عالية وأوضح المعيار الإحصائي لمتوسط الخطأ النسبي MEP (0.056) انه مع استمرار تدريب الشبكة وصل الانخفاض في هذا المتوسط إلى أدنى حد له وأستقر مما يعني أن الشبكة العصبية قامت بالتعلم والتدريب بشكل مناسب ، وكما سبق القول فإنه تم إختبار صلاحية $Validity$ المقاييس التى اعتمدت عليها الدراسة الحالية، باستخدام أسلوب التحليل العاملى $Factor Analysis$ ، مستخدماً فى ذلك طريقة العناصر الأساسية $Principal Component Analysis (PCA)$ وذلك فى محاولة للتوصل إلى الأبعاد الحقيقة فى كل البيانات الخاضعة للتحليل، بما يساعد على استخدام عدد اقل من

المتغيرات وبدرجة عالية من الصلاحية، وأكد اختبار *KMO and Bartlett's* وهو اختبار كفاية العينة، وتنحصر قيمته بين الصفر والواحد، ولا بد وأن تكون أكبر من ٠,٥، وقد كانت قيمته ٠,٧٨٤ مما يدل على أن التحليل سيعطى عوامل موثوق فيها.

ويعرض شكل (١١) مخرجات تدريب الشبكة و أوزانها.

شكل (١١) مخرجات تدريب الشبكة لأبعاد قياس عوائد

التدريب بقطاع البنوك المصر



■ يوضح شكل (١١) مخرجات تدريب الشبكة حيث يتضح أن الشبكة قد تدربت من خلال دوال تحفيز الطبقات الخفية *Function layer Activation Hidden* وتم تقدير ١٠ عصبونات مخفية *Hidden Neurosis*

■ أوضحت أن النموذج تمكن من تفسير الظاهرة محل البحث بمتوسط خطأ نسبي قدره (0.056)

ويوضح الشكل سالف الذكر مستوى معنوية عدد أربعة عصبونات كانت أوزانها أقل من الصفر.

وباستخدام المعايير الإحصائية يستنتج بدون شك أن الشبكة العصبية فعلا تدربت بدرجة ممتازة حيث ببين المعيار الإحصائي *MEP* مع استمرار عملية تدريب الشبكة الانخفاض إلى أن وصل إلى أدنى حد له واستقر مما يعني أن الشبكة العصبية قامت بالفعل بالتعلم والتدرب بشكل سليم وجيد. وتجدر الإشارة إلى أنه لم يطرأ تحسن ملحوظ على أداء الشبكة العصبية عند تغيير بعض المواصفات الداخلية لها. ولم نلاحظ أثر تغيير لهذه المواصفات على أداء الشبكة من خلال المعايير الإحصائية التي سبق ذكرها،

جدول (٨) الأهمية النسبية لأوزان أبعاد قياس عوائد التدريب بقطاع البنوك المصرية

البعد (المحور)	الأهمية	الأهمية الطبيعية %
عوائد التدريب الملموسة وغير الملموسة على الفرد والجهة	٠.607	100.0
تطوير وتحسين الأداء والمهارات الناتجة عن التدريب	٠.393	64.8

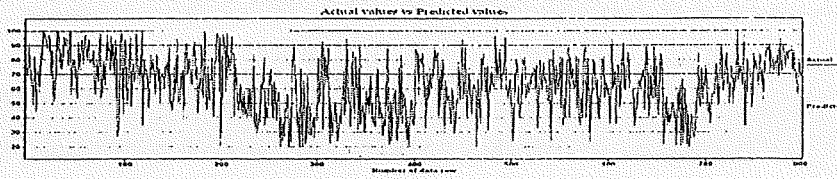
ويتضح أن الأهمية النسبية لأبعاد قياس عوائد التدريب تمثل ٦١% لعوائد التدريب الملموسة وغير الملموسة على الفرد والجهة، و ٣٩% لتطوير وتحسين الأداء والمهارات الناتجة عن التدريب بقطاع البنوك المصرية. ويظهر الجدول التالي تقدير معالم النموذج:

جدول (9) تقدير معالم النموذج الناتجة من تدريب الشبكة

Predictor	Predicted										
	Hidden Layer ^a										Output Layer
	H(1)	H(2)	H(3)	H(4)	H(5)	H(6)	H(7)	H(8)	H(9)	H(10)	Y
Input Layer FAC1	-2.025-	-1.067-	-.416-	-.127-	.365	.740	1.206	.206	.477	1.988	
FAC2	-.608-	-.607-	.676	-.637-	-1.611-	-.277-	.933	1.545	.665	-1.746-	
Hidden Unit Width	.419	.433	.486	.298	.370	.389	.407	.285	.236	.666	
Hidden Layer H(1)											-1.978-
H(2)											-1.254-
H(3)											.105
H(4)											-.500-
H(5)											-.997-
H(6)											.443
H(7)											1.662
H(8)											1.391
H(9)											.807
H(10)											.321

Displays the center vector for each hidden unit.

شكل (١٢) الفعلي والمقدر الناتج من الشبكة



أهم النتائج:

يعتبر التدريب جزءاً رئيساً من إستراتيجية الموارد البشرية في معظم منظمات الأعمال والإدارات الحكومية. ويتفاوت التزام الإدارة العليا بتطبيق مراحل التدريب التي تشمل تحديد الاحتياجات التدريبية وتصميم البرامج التدريبية وتنفيذها وتقييمها من إدارة إلى أخرى ولأسباب متنوعة. ومن هذه الأسباب توفر الإمكانيات المادية والكوادر المؤهلة للتدريب والقدرة على استخدام التكنولوجيا المتطورة في البرامج التدريبية. والقدرة على تقييم ومتابعة نتائج البرامج التدريبية وتحديد آثارها على المدى القريب والبعيد. ويعتمد أحياناً على رغبة المنظمات في

الانتفاع من التقدم العلمي والتكنولوجي وتسخيره لرفع مستوى الأداء لمختلف الكوادر بالمنظمة.

هدفت هذه الدراسة إلى تقييم أثار التدريب في البنوك المصرية من خلال التعرف على آراء وتوجهات العاملين في البنوك التجارية والإسلامية باستخدام مجموعة من المتغيرات التي تعبر عن أثار وعوائد التدريب من وجهة نظر الفرد والمؤسسة (الجهة) والتي استخدمت بالتالي في قياس الأثر الكلي للتدريب سواء الملموس وغير الملموس.

وقد أشارت النتائج التي توصلت إليها الدراسة والملاحظات الواردة بالاستقصاء إلى الانطباع الإيجابي عن آثار التدريب في جميع المصارف بالمصر سواء من ناحية الآثار على المستوى الفردي أو المستوى المؤسسي ، وأما فيما بتطبيق المهارات والمعارف التي تم التدريب عليها فقد أشارت النتائج إلى أن هناك بعض المعوقات التي تحول دون التطبيق والاستفادة من عائد التدريب في الواقع العملي ، مما يدل على أن أجهزة التدريب في هذه البنوك بحاجة إلى استحداث آليات ونظم تضمن من خلالها نقل أثر التدريب إلى واقع العمل وهو ما يضمن تحقيق اعتبارات الجدوى الاقتصادية من الإنفاق على التدريب، ومنها على سبيل المثال :

- (١) إيجاد نظام حوافز ومتابعة فعال في مجال العمل لتشجيع الموظفين على تطبيق ما تم التدريب عليه.
 - (٢) مراجعة الإجراءات والتعقيدات التي تحول دون منح الموظف فرص التطبيق العملي للمهارات والمعارف التي تم التدريب عليها .
 - (٣) التأكيد على ضرورة تكليف المتدرب بالتطبيق العملي لما تم التدريب عليه عند العودة للعمل، وأن يكون ذلك الأمر بمثابة مسئولية مباشرة توضع على عاتق المسئول المباشر.
- وجد أن متوسط تقييم العاملين في البنوك التجارية والإسلامية المصرية لآثار البرامج التدريبية التي شاركوا فيها سواء على المستوى الفردي أو المؤسسي بلغ حوالي ٦٣%.
- أن البرامج التدريبية لها مساهمة فعالة في زيادة معارف ومهارات وسلوكيات الموظف وبلغ متوسط درجة الموافقة على ذلك حوالي ٥٩%.
- أن البرامج التدريبية تساهم في تحسين أداء الموظف، حيث بلغ متوسط درجة الموافقة على ذلك بلغت حوالي ٦٠%.
- أن انعكاس مشاركة الموظف في البرنامج التدريبي على التطبيق في العمل، تبين أن متوسط درجة الموافقة بلغت حوالي ٦٠%.
- وعن مدى مساهمة نظم وظروف العمل في قيام الموظف بتطبيق ما تم التدريب عليه؟، أشارت النتائج أن متوسط درجة الموافقة بلغت حوالي ٦٠%.
- وعن تحسن الأداء المؤسسي نتيجة تطبيق ما تم التدريب عليه، توصلت النتائج أن متوسط درجة الموافقة بلغت حوالي ٦١% عبر تقسيمات الخصائص الشخصية والوظيفية عند مستوي معنوية ٥%.

التوصيات:

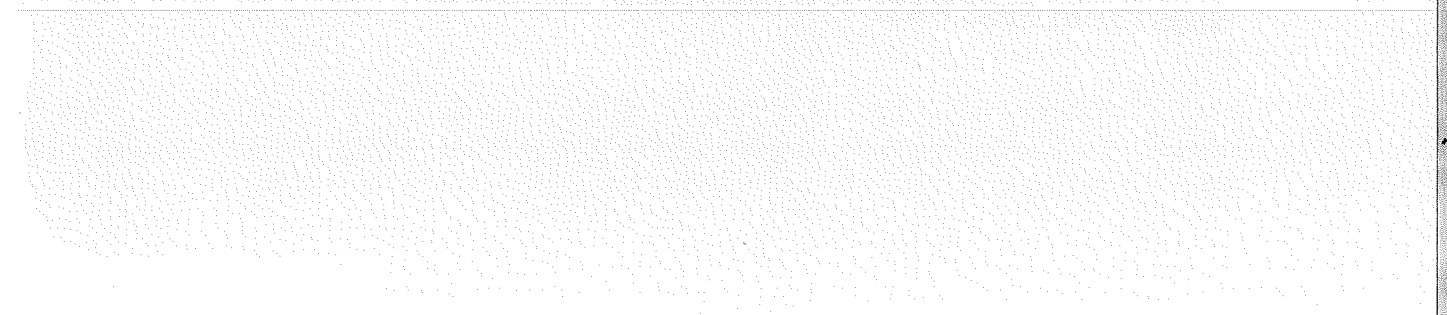
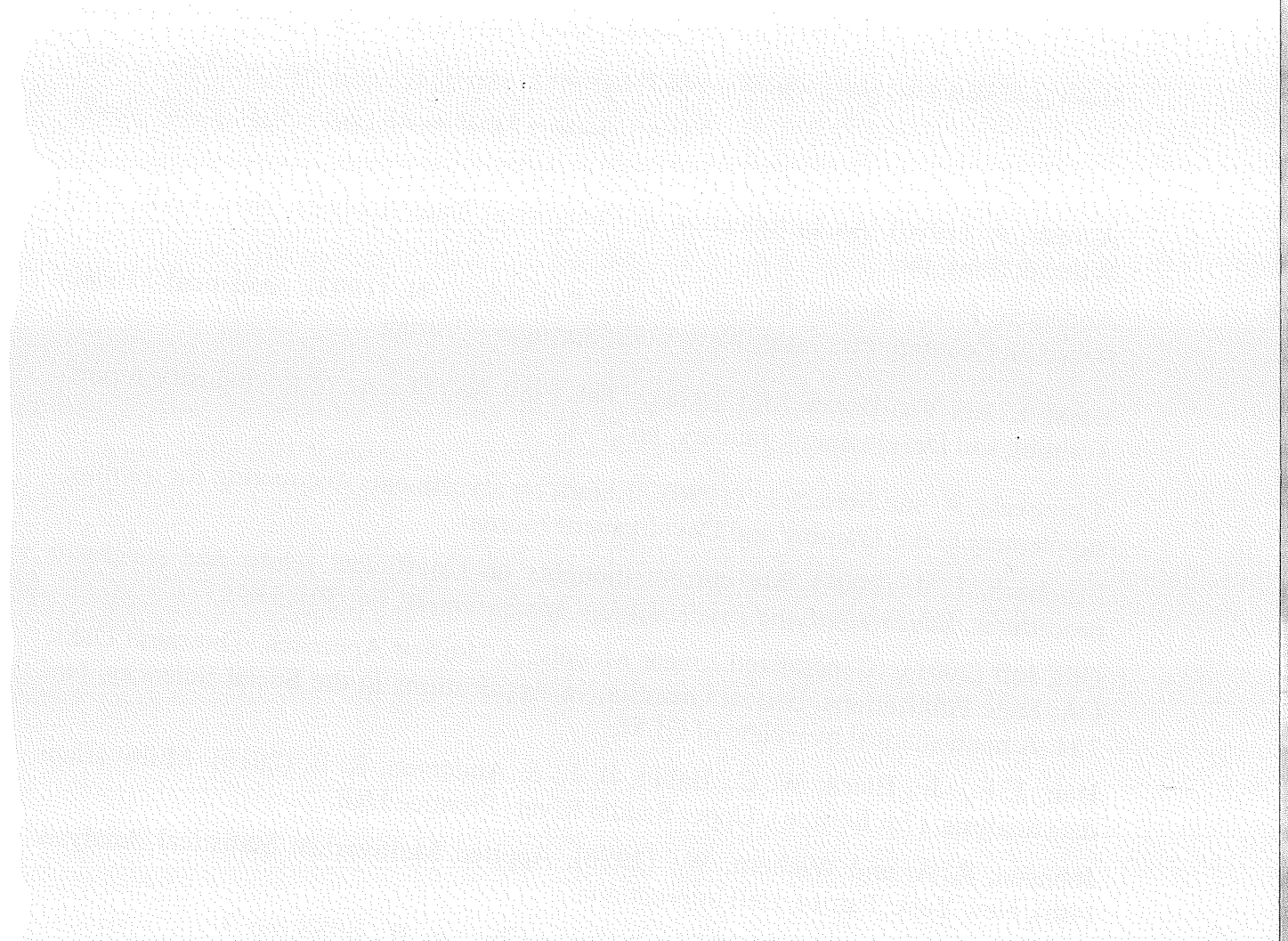
أصبح الاهتمام بالتدريب والتطوير من سمات المنظمات الحديثة الرغبة في التطور والتقدم وجودة الأداء، وهذا بدوره أسهم في جعل التدريب من أولويات هذه المنظمات لزيادة فاعلية مواردها البشرية، ولعل أسباب الاهتمام بالتدريب والتطوير تعود لأسباب يقف في طليعتها المنافسة والجودة والإبداع والتغيير المستمر في متطلبات العصر واحتياجات الناس والتقنيات المتغيرة والمطلوبة وتطور تحديات الموارد البشرية. وهذه العوامل زادت من أهمية قيمة التدريب وضرورة قياس تكلفته وعوائده. وتم تطوير التوصيات على ضوء التحليل لنتائج الدراسة وهي:

١. توصي الدراسة إدارات المصارف في مصر بضرورة الاهتمام بمرحلة تقييم البرامج التدريبية. لمعرفة اثر التدريب على أداء العاملين بالإضافة إلى التقييم الذي يتم في نهاية البرنامج التدريبي وذلك بمتابعة أداء العاملين في مواقع العمل وفي الفترة الزمنية التي تلي انتهاء البرنامج، وبصفة مستمرة.
٢. توصي الدراسة كذلك بضرورة التركيز على الأساليب التدريبية الحديثة نسبياً ومنها أسلوب الأدوار والمباريات ودراسة الحالات.
٣. توصي الدراسة بضرورة تطوير ثقافة تنظيمية داعمة للنشاطات التدريبية ومركزة على قيمة الانجاز والكفاءة والفاعلية التنظيمية. وكذلك تفعيل وإعادة النظر بالقوانين والأنظمة والتعليمات لإزالة الجمود المتعلق بالأنشطة التدريبية .
٤. التركيز على نشاط تحليل الوظائف والاستفادة من النتائج في تحديد الاحتياجات التدريبية والعمل على تطوير استراتيجيات وظيفية واضحة للعاملين في المستويات الإدارية المختلفة بقطاع البنوك المصرية.
٥. مراعاة اعتبارات الكفاءة الجودة في اختيار المدربين وكافة العناصر المتعلقة بتنفيذ البرامج التدريبية وهو ما ينعكس من ناحية أخرى على مستوى الاستفادة المحققة في العمل.
٦. تكثيف الدراسات التي تعنى بقياس عائد التدريب على مستوى القطاع المصرفي بصورة عامة مع إمكانية استحداث نموذج محدد يمكن الاعتماد عليه في القياس والتقييم .
٧. مراعاة اختيار المرشحين للبرنامج من حيث الخبرة والمستوى العلمي وتطبيق شروط الترشيح على المرشحين بدقة وموضوعية حتى يضمن ذلك درجة عالية من التجانس في المستوى بين المرشحين ومن خلال وضع آلية للاختيار لمن يمكنهم الاستفادة الأعلى.
٨. مراعاة الدقة في اختيار المرشحين بناء على الاحتياجات التدريبية الفعلية للمرشح ، حيث أن ذلك يساهم بدرجة كبيرة في نتائج التدريب وزيادة العوائد من البرنامج .
٩. توفير الدعم المناسب لجهود التدريب من جانب الجهات الإدارية على مختلف المستويات والقياس من جانب ديوان الخدمة المدنية بصفته الجهة المركزية المسؤولة عن التدريب أن يراعي توعية المستويات الإشرافية بأهمية التدريب وكذا المهارات و المعارف الحديثة في مجال العمل، وهو ما سينعكس على مساندة هذه المستويات لنقل اثر التدريب وتشجيع العاملين على التطبيق العملي .
١٠. التأكيد على دور الإدارة العليا في دعم سياسات ونظم التدريب وهو ما يعطي أهمية للتدريب ويزيد من الاهتمام بالتطبيق ونقل اثر التدريب إلى واقع العمل.
١١. إيجاد نظم مستحدثة لتحفيز الموظفين على تطبيق التدريب مثل الحوافز المادية والمعنوية والشهادات التقديرية لتشجيعهم على تطبيق ما تم التدريب عليه.
١٢. أهمية إيجاد نظم وآليات لمتابعة العاملين بعد الانتهاء من التدريب وذلك للتأكد من تطبيق ما تم التدريب عليه ومن ثم تقصي أسباب عدم التطبيق والعمل على تلافيها.

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استبيان

قياس العائد من التدريب لدى القطاع المصرفي
((استبيان المشاركين في الدورات التدريبية))

الأخ الفاضل/ الأخت الفاضلة
يهدف هذا الاستبيان إلى قياس العائد من التدريب للبرامج التدريبية التي يتم تنظيمها للعاملين في قطاع المصرفي. ومن ثم يمكن تحديد المعايير والمؤشرات التي تساهم في تطوير عملية التدريب في قطاع المصرفي. وحيث أنكم قد شاركتكم في البرامج التدريبية خلال الفترة الماضية , فإننا نأمل في دعمكم ومساندتكُم في سبيل تحقيق هذه الدراسة لأهدافها , وذلك من خلال استكمال هذا الاستبيان والذي يمكن من خلاله تقييم التدريب على الأداء الوظيفي سواء على المستوى الشخصي أو أعلى مستوى الوحدة التي تعملون بها.

شاكرين ومقدرين لكم تعاونكم

البناء , , , ,

الباحث

الجزء الأول : البيانات الأساسية

اسم البنك			
الجنس ☐ ذكر ☐ أنثى			
المستوى التنظيمي التابع له ☐ قطاع ☐ إدارة ☐ قسم ☐ وحدة			
الغلة الوظيفية ☐ عليا ☐ وسطى ☐ إشرافية ☐ تنفيذية			
المستوى التعليمي ☐ دكتوراه ☐ ماجستير ☐ بكالوريوس ☐ دبلوم ☐ ثانوي ☐ أقل من الثانوي			
سنوات الخبرة ☐ أقل من 5 ☐ من 5-10 ☐ 10 سنوات فأكثر			

الجزء الثاني : تعريفات

لأغراض هذه الدراسة فإننا نقصد بالتعريفات ما يلي:

- العائد الملموس للتدريب : زيادة إنتاجية الفرد أو الوحدة الإدارية والتي ترجع أساسا إلى التدريب.
- العوائد غير الملموسة: ما يتحقق نتيجة التدريب مثل الرضا الوظيفي . انخفاض حدة الصراع الرضا عن النفس . الولاء الوظيفيالخ

الجزء الثالث: أسئلة الاستبيان

يرجى وضع درجة الموافقة التي تراها مناسبة لك علما بأن درجات الموافقة كالتالي :
القيمة 0= ليس له أي تأثير الي القيمة 100%

م	العبارة	التقييم	ملاحظات
1	ساهم البرنامج التدريبي في تلبية احتياجات الوحدة التي اعمل بها		
2	مشاركتي في البرنامج انعكست على التطبيق في العمل		
3	تطورت معارفي ومهاراتي وسلوكياتي نتيجة التدريب		
4	ساعدت مشاركتي في البرنامج علي تحسين أدائي الوظيفي		
5	قمت بتطبيق ما تدربت عليه في البرنامج بدافع ذاتي		
6	نظم العمل تساهم في قيامي بتطبيق المهارات التي تم التدريب عليها		
7	ظروف العمل تساعدني على تطبيق المهارات المكتسبة في التدريب		
8	هناك تحسين في أداء الوحدة نتيجة تطبيق ما تم التدريب عليها		
9	كفاءة الوحدة زادت بتطبيق نتائج التدريب		
10	اشعر ان هناك عائدا ملموسا في تطوير الاداء الوظيفي		
11	اشعر ان هناك عائدا ملموسا بعد تطبيق نتائج التدريب على الوحدة		
12	هناك عوائد غير ملموسة للتدريب انعكست على شخصا		
13	هناك عوائد غير ملموسة للتدريب انعكست على الوحدة		
14	كنتيجة للتدريب زاد حجم انجازي في العمل		
15	كنتيجة للتدريب زادت سرعة أدائي للعمل		
16	كنتيجة للتدريب زادت دقتي في أداء العمل		
17	كنتيجة للتدريب تم تطبيق أفكار جديدة في العمل		
18	كنتيجة للتدريب تحسنت سلوكياتي مع الآخرين بعد التدريب		
19	زيادة الإنفاق علي التدريب تنعكس إيجابيا على الفرد سلوكيا ومهاريا		
20	الإنفاق علي التدريب ينعكس في صورة فوائد مالية علي البنك		

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Table(5)
Wald Test SURE

Wald Test:
System: WALDTESTSURE

Test Statistic	Value	df	Probability
Chi-square	2860.076	28	0.0000

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2) - C(30)	2.074638	0.149973
C(3) - C(30)	-0.214409	0.057595
C(4) - C(30)	181.6655	116.2869
C(5) - C(30)	0.322665	0.184250
C(6) - C(30)	-0.007389	0.067636
C(7) - C(30)	337.2380	87.34244
C(8) - C(30)	2.815779	0.439390
C(9) - C(30)	-0.113883	0.044482
C(10) - C(30)	5.551252	30.84331
C(11) - C(30)	2.527474	0.202608
C(12) - C(30)	-0.144901	0.055618
C(13) - C(30)	108.8515	58.30614
C(14) - C(30)	0.184621	0.912442
C(15) - C(30)	1.585873	0.237411
C(16) - C(30)	-6.849691	7.401823
C(17) - C(30)	0.679536	0.274087
C(18) - C(30)	0.177242	0.049399
C(19) - C(30)	182.2419	53.73191
C(20) - C(30)	4.817411	0.601813
C(21) - C(30)	-0.642191	0.296046
C(22) - C(30)	20.01008	18.94216
C(23) - C(30)	0.957803	0.415780
C(24) - C(30)	0.038685	0.039134
C(25) - C(30)	188.1375	42.10504
C(26) - C(30)	2.543754	0.742064
C(27) - C(30)	0.011832	0.150592
C(28) - C(30)	2.774918	1.753577
C(29) - C(30)	1.074433	0.169668

Restrictions are linear in coefficients.

Adjusted R-squared	0.867781	S.D. dependent var	111.3275
S.E. of regression	40.48088	Sum squared resid	27857.93
Durbin-Watson stat	1.567259		

Equation:
 $C_{05} = C(13) + C(14) * I_{05} + C(15) * F_{05}$
 Observations: 20

R-squared	0.695047	Mean dependent var	486.7650
Adjusted R-squared	0.659171	S.D. dependent var	191.7395
S.E. of regression	111.9387	Sum squared resid	213014.5
Durbin-Watson stat	0.245970		

Equation:
 $C_{06} = C(16) + C(17) * I_{06} + C(18) * F_{06}$
 Observations: 20

R-squared	0.924332	Mean dependent var	104.2850
Adjusted R-squared	0.915430	S.D. dependent var	67.44070
S.E. of regression	19.61240	Sum squared resid	6538.986
Durbin-Watson stat	0.517569		

Equation:
 $C_{07} = C(19) + C(20) * I_{07} + C(21) * F_{07}$
 Observations: 20

R-squared	0.717644	Mean dependent var	314.9450
Adjusted R-squared	0.684426	S.D. dependent var	126.6290
S.E. of regression	71.13511	Sum squared resid	86023.47
Durbin-Watson stat	0.700360		

Equation:
 $C_{08} = C(22) + C(23) * I_{08} + C(24) * F_{08}$
 Observations: 20

R-squared	0.471227	Mean dependent var	85.64000
Adjusted R-squared	0.409018	S.D. dependent var	62.26494
S.E. of regression	47.86639	Sum squared resid	38950.25
Durbin-Watson stat	0.277428		

Equation:
 $C_{09} = C(25) + C(26) * I_{09} + C(27) * F_{09}$
 Observations: 20

R-squared	0.450930	Mean dependent var	297.9000
Adjusted R-squared	0.386334	S.D. dependent var	93.70553
S.E. of regression	73.40597	Sum squared resid	91603.43
Durbin-Watson stat	0.255652		

Equation:
 $C_{10} = C(28) + C(29) * I_{10} + C(30) * F_{10}$
 Observations: 20

R-squared	0.595595	Mean dependent var	5.941500
Adjusted R-squared	0.548018	S.D. dependent var	3.164479
S.E. of regression	2.127468	Sum squared resid	76.94403
Durbin-Watson stat	0.541849		

Table(4)
Seemingly Unrelated Regression

System: UNTITLED

Estimation Method: Seemingly Unrelated Regression

Date: 06/01/11 Time: 22:07

Sample: 1935 1954

Included observations: 20

Total system (balanced) observations 200

Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	325.9463	178.1563	1.829552	0.0691
C(2)	2.072671	0.152993	13.54752	0.0000
C(3)	-0.216375	0.047715	-4.534717	0.0000
C(4)	181.6636	116.2846	1.562233	0.1201
C(5)	0.320699	0.180399	1.777720	0.0772
C(6)	-0.009355	0.066805	-0.140041	0.8888
C(7)	337.2360	87.34021	3.861177	0.0002
C(8)	2.813813	0.436396	6.447845	0.0000
C(9)	-0.115849	0.041587	-2.785683	0.0059
C(10)	5.549285	30.84356	0.179917	0.8574
C(11)	2.525507	0.201131	12.55654	0.0000
C(12)	-0.146867	0.050169	-2.927444	0.0039
C(13)	108.8496	58.30302	1.866963	0.0636
C(14)	0.182655	0.913560	0.199937	0.8418
C(15)	1.583907	0.238084	6.652731	0.0000
C(16)	-6.851658	7.399234	-0.925996	0.3558
C(17)	0.677569	0.275844	2.456347	0.0150
C(18)	0.175275	0.042083	4.164979	0.0000
C(19)	182.2399	53.73203	3.391645	0.0009
C(20)	4.815444	0.603284	7.982051	0.0000
C(21)	-0.644158	0.293695	-2.193288	0.0296
C(22)	20.00811	18.93921	1.056438	0.2923
C(23)	0.955837	0.414786	2.304408	0.0224
C(24)	0.036718	0.034005	1.079798	0.2818
C(25)	188.1355	42.10510	4.468236	0.0000
C(26)	2.541787	0.741470	3.428038	0.0008
C(27)	0.009865	0.148802	0.066298	0.9472
C(28)	2.772952	1.731653	1.601332	0.1112
C(29)	1.072466	0.164802	6.507620	0.0000
C(30)	-0.001967	0.023623	-0.083252	0.9337

Determinant residual
covariance 3.10E+28

Equation: C_01=C(1)+C(2)*I_01+C(3)*F_01

Observations: 20

R-squared	0.872375	Mean dependent var	648.4350
Adjusted R-squared	0.857360	S.D. dependent var	630.1641
S.E. of regression	237.9982	Sum squared resid	962933.4
Durbin-Watson stat	0.511929		

Equation: C_02=C(4)+C(5)*I_02+C(6)*F_02

Observations: 20

R-squared	0.213302	Mean dependent var	294.8550
Adjusted R-squared	0.120749	S.D. dependent var	156.9194
S.E. of regression	147.1408	Sum squared resid	368057.0
Durbin-Watson stat	0.429316		

Equation: C_03=C(7)+C(8)*I_03+C(9)*F_03

Observations: 20

R-squared	0.569977	Mean dependent var	400.1600
Adjusted R-squared	0.519386	S.D. dependent var	250.6188
S.E. of regression	173.7448	Sum squared resid	513183.4
Durbin-Watson stat	0.291028		

Equation:

C_04=C(10)+C(11)*I_04+C(12)*F_04

Observations: 20

R-squared	0.881699	Mean dependent var	121.2450
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Table(3)
Hausman Test

Correlated Random Effects - Hausman Test
Pool: RANDOM
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	2.131366	2	0.3445

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
C_?	0.310065	0.308113	0.000006	0.4332
F_?	0.110124	0.109781	0.000031	0.9506

Cross-section random effects test equation:

Dependent Variable: I_?

Method: Panel Least Squares

Date: 06/12/11 Time: 22:36

Sample: 1935 1954

Included observations: 20

Cross-sections included: 10

Total pool (balanced) observations: 200

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-58.74394	12.45369	-4.716990	0.0000
C_?	0.310065	0.017355	17.86656	0.0000
F_?	0.110124	0.011857	9.287901	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.944073	Mean dependent var	145.9582
Adjusted R-squared	0.940800	S.D. dependent var	216.8753
S.E. of regression	52.76797	Akaike info criterion	10.82781
Sum squared resid	523478.1	Schwarz criterion	11.02571
Log likelihood	-1070.781	Hannan-Quinn criter.	10.90790
F-statistic	288.4996	Durbin-Watson stat	0.716733
Prob(F-statistic)	0.000000		

Table(2)
Random Model

Dependent Variable: $\dot{I}_?$
Method: Pooled EGLS (Cross-section random effects)
Date: 05/28/11 Time: 03:28
Sample: 1935 1954
Included observations: 20
Cross-sections included: 10
Total pool (balanced) observations: 200
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-57.83441	28.88930	-2.001932	0.0467
C_?	0.308113	0.017175	17.93989	0.0000
F_?	0.109781	0.010489	10.46615	0.0000
Random Effects				
(Cross)				
01--C	-9.524296			
02--C	157.8910			
03--C	-172.8958			
04--C	29.91198			
05--C	-54.67901			
06--C	34.34613			
07--C	-7.897758			
08--C	0.672638			
09--C	-28.13935			
10--C	50.31444			

Effects Specification		S.D.	Rho
Cross-section random		84.20095	0.7180
Idiosyncratic random		52.76797	0.2820

Weighted Statistics			
R-squared	0.769503	Mean dependent var	20.25556
Adjusted R-squared	0.767163	S.D. dependent var	109.3928
S.E. of regression	52.78556	Sum squared resid	548904.1
F-statistic	328.8369	Durbin-Watson stat	0.682684
Prob(F-statistic)	0.000000		

Unweighted Statistics			
R-squared	0.803304	Mean dependent var	145.9582
Sum squared resid	1841062.	Durbin-Watson stat	0.203539

12.1 Summery and Conclusion:

There are two method for pooling data (i.e. combining time series and cross section) data. in this study two method application in the balance panel data sets of Grunfeld Investment Data, 10 Firms, 20 Years (1935-1954), First: pooling PTSCS (panel data) model, using fixed versus random, and Second: seemingly unrelated correlation (SUR) model. both method appear efficiency, the differ depend on the assumptions mad about the coefficient and error vector in each equation.

Table(1)
Fixed Model

Dependent Variable: I_?
Method: Pooled Least Squares
Date: 05/28/11 Time: 03:18
Sample: 1935 1954
Included observations: 20
Cross-sections included: 10
Total pool (balanced) observations: 200

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-58.74394	12.45369	-4.716990	0.0000
C_?	0.310065	0.017355	17.86656	0.0000
F_?	0.110124	0.011857	9.287901	0.0000
Fixed Effects (Cross)				
01--C	-11.55278			
02--C	160.6498			
03--C	-176.8279			
04--C	30.93464			
05--C	-55.87287			
06--C	35.58264			
07--C	-7.809534			
08--C	1.198282			
09--C	-28.47833			
10--C	52.17610			

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.944073	Mean dependent var	145.9582
Adjusted R-squared	0.940800	S.D. dependent var	216.8753
S.E. of regression	52.76797	Akaike info criterion	10.82781
Sum squared resid	523478.1	Schwarz criterion	11.02571
Log likelihood	-1070.781	Hannan-Quinn criter.	10.90790
F-statistic	288.4996	Durbin-Watson stat	0.716733
Prob(F-statistic)	0.000000		

Statistical Association, 57, 1962, pp. 348-368 for analyses of these data. See table (1) in appendix.

11.1 Applying Statistical models and Statistical Analysis:

- **First:** we apply fixed model on data and use the least square dummy variable (LSD) to estimate the parameter of model see table (1). The result show that: R-squared = 0.944073 these meaning that the model interpretation 94% from explanatory variable, the low value of Durbin Watson statistics 0.716733 gives evidence for model misspecification. F-Statistics value 288.4996 is significant so we reject the null hypotheses H_0 and conclude that the intercept of the 10 Firms Cost function are not all the same.
- **Second:** applied Error component as a random model, and estimation the parameter using generalized least square (GLS) see table (2)..The result show that: R-squared = 0.76953 these meaning that the model interpretation 76% from explanatory variable, by calculate Lagrange multipliers LM- Statistics value $\lambda = NT \times R^2$, $\lambda = 200 \times 0.769503$ then $\lambda = 153.9 \chi^2$, fined the tabulating value at $\alpha = 0.05$ $\chi^2_{(1)} = 3.84$, λ is significant so we reject the null hypotheses $H_0: \delta_M^2 = 0$ and conclude that there is cross sectional heteroscedasticity.
- **Third:** applied Hausman test to choose the appropriate model for balance panel data sets (fixed versus random) to test cross section random effects see table (3).the result show that small the Hausman test value $2.131366 \chi^2$, the p-value equal 0.3445 not significant at $\alpha = 0.05$, so we accept H_0 that the random effects estimator are consistent and efficient, and the random model is more appropriate.
- **Forth:** *According to the results in parts (second and third), we can advice the researchers after using the models that combine the cross-section time series data not to stop at the comparison between the fixed and random models. If the Hausman test indicates that the random model is the appropriate one.(i.e., the slopes of the various equations are different), it is important to use any more information exit between the errors of these equations. Therefore, we apply the seeming unrelated regression (SUR) model to benefit from the contemporaneous covariance across the investment equations under study.*
- **Finally:** applied **Seemingly unrelated Regression(SUR) model** see table(4). treats each cross-section and the time series within that cross-section as a separate equation that is unrelated to any other cross-section in the pooled data set., and test the significant between coefficients use Walled test see table (5). ,the result show that the test statistics value 2860.076 and the p-value significant so reject H_0 and conclude that the coefficient are not all the same. The residual correlated test matrix see table (6) in appendix, which display that there is high correlation between different disturbances at a given point in time is known as Contemporaneous correlation, this meaning that there is a more gain in efficiency.

All individuals have their own regression parameters, but these are restricted to be constant over time. The regression relations for the different individuals are only related via the correlation of the error terms, but the error covariance across individuals is unrestricted. No error covariance across time: no serial correlation, or serial cross correlation.

Estimating the parameters by OLS per equation is consistent, but is inefficient if the disturbances for the different individuals display contemporaneous correlation and the regressors sets differ from individual (equation) to individual (equation). This is easily shown if we combine data for all the units in one big transformed regression model, where we can apply OLS

8.1 Basic linear SUR model:

$$\underset{T \times 1}{y} = \underset{T \times K}{X} \underset{K \times 1}{\beta} + \underset{T \times 1}{u}$$

$$\text{where } K = \sum_{i=1}^L k_i$$

now the error term have the following properties

$$E \left(\underset{T \times 1}{u} \right) = \underset{T \times 1}{0}$$

$$\text{cov} \left(\underset{T \times 1}{u} \right) = \underset{L \times L}{\Sigma} \otimes I_T$$

where $\underset{L \times L}{\Sigma}$ is known matrix

9.1 Data Description:

- Deal the balance panel data sets of Grunfeld Investment Data, 10 Firms, 20 Years (1935-1954).
- **Cross-Section:** n=10 Firms (GM, US Steel, GE, Chrysler, Atlantic Refining, IBM, Union Oil, Westinghouse, Goodyear, Diamond Match).
- **Time Series:** T=20 years per firm (1935-1954), Grunfeld estimated the following regression model:

$$I_{it} = \beta_1 + \beta_2 F_{it} + \beta_3 C_{it} + u_{it}$$

- I = Investment
- F = Real Value of the Firm
- C = Real Value of the Firm's Capital Stock

10.1 Data Source:

- From Greene sites to panel data sets:
<http://pages.stern.nyu.edu/~wgreene/Econometrics/PanelDataSets.htm>
- Data are fined in Ph.D. dissertation of Y. Grunfeld (Univ. of Chicago, 1958), See, e.g., Zellner, A., "An Efficient Method of Estimating Seemingly Unrelated Regression Equations and Tests for Aggregation Bias," *Journal of the American*

6.1 Seemingly unrelated regressions:

In econometrics, the **seemingly unrelated regressions (SUR)** or **seemingly unrelated regression equations (SURE)** model, proposed by Arnold Zellner in (1962), is a generalization of a linear regression model that consists of several regression equations, each having its own dependent variable and potentially different sets of exogenous explanatory variables. Each equation is a valid linear regression on its own and can be estimated separately, which is why the system is called *seemingly unrelated*, although some authors suggest that the term *seemingly related* would be more appropriate, since the **error terms** are assumed to be correlated across the equations. See Zellner, Arnold (1962).

The model can be estimated equation-by-equation using standard **ordinary least squares (OLS)**. Such estimates are consistent, however generally not as efficient as the SUR method, which amounts to **feasible generalized least squares** with a specific form of the variance-covariance matrix. Two important cases when SUR is in fact equivalent to OLS, are: either when the error terms are in fact uncorrelated between the equations (so that they are truly unrelated), or when each equation contains exactly the same set of regressors on the right-hand-side.

The SUR model can be viewed as either the simplification of the **general linear model** where certain coefficients in matrix B are restricted to be equal to zero, or as the generalization of the **general linear model** where the regressors on the right-hand-side are allowed to be different in each equation. The SUR model can be further generalized into the **simultaneous equations model**, where the right-hand side regressors are allowed to be the endogenous variables as well.

A seemingly unrelated regression (SUR) system comprises several individual relationships that are linked by the fact that their disturbances are correlated. Such models have found many applications. The correlation among the equation disturbances could come from several sources such as correlated shocks to household income. Alternatively, one could model the demand of a household for different commodities, but adding-up constraints leads to restrictions on the parameters of different equations in this case.

7.1 Two main motivations for use of SUR.

First one is to gain efficiency in estimation by combining information on different equations.

Second motivation is to impose and/or test restrictions that involve parameters in different equations.

5.1 The Hausman Test1

Fixed or Random Effects: Dummy Variables versus error component models:

For the panel data the appropriate choice between the fixed effects and the random effects methods investigates whether the regressors are correlated with the individual (unobserved in most cases) effect. The advantage of the use of the fixed effects estimator is that it is consistent even when the estimators are correlated with the individual effect.

In other words, given a panel data model where fixed effects would be appropriate the Hausman test investigates whether random effects estimation could be almost as good.

Hausman assumed that there are two estimators, $\hat{\beta}_0$ and $\hat{\beta}_1$ of the parameter vector β and he added two hypothesis-testing procedures. Under H_0 , both estimators are consistent but $\hat{\beta}_0$ is inefficient, and under H_1 , $\hat{\beta}_0$ is consistent and efficient, but $\hat{\beta}_1$ is inconsistent.

we actually test H_0 , that random effects are consistent and efficient, versus H_1 , that random effects are inconsistent (as the fixed effects will be always consistent). The Hausman test uses the following test statistic:

$$H = (\hat{\beta}^{\text{FE}} - \hat{\beta}^{\text{RE}})' [\text{Var}(\hat{\beta}^{\text{FE}}) - \text{Var}(\hat{\beta}^{\text{RE}})]^{-1} (\hat{\beta}^{\text{FE}} - \hat{\beta}^{\text{RE}}) \sim \chi^2(k)$$

If the value of the statistic is large, then the difference between the estimates is significant, so we reject the null hypothesis that the random effects model is consistent and we use the fixed effects estimators. In contrast, a small value of the Hausman statistic implies that the random effects estimator is more appropriate.

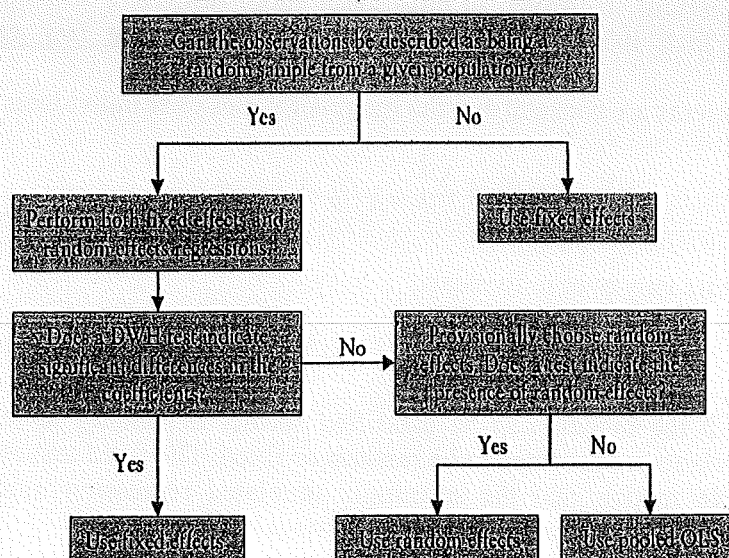


Figure (1)
Choice of regression model for panel data

3.1 BALANCED AND UNBALANCED PANELS:

- a “panel” data set will consist of n sets of observations on individuals to be denoted $i = 1, \dots, n$. If each individual in the data set is observed the same number of times, usually denoted T , the data set is a **balanced panel**.
- An **unbalanced panel** data set is one in which individuals may be observed different numbers of times. We will denote this T_i .
- A **fixed panel** is one in which the same set of individuals is observed for the duration of the study.
- A **rotating panel** is one in which the cast of individuals changes from one period to the next

4.1 Pooling Time Series – Cross section (PTSCS) data Dummy Variables and error component models:

In general, the models considered can be written as:

$$Y_{it} = \beta_{1it} + \sum_{k=2}^k \beta_{kit} X_{kit} + e_{it}, \quad i=1,2,\dots,N, t=1,2,\dots,T$$

where $i = 1, 2, \dots, N$ refers to a cross-sectional unit, hereafter referred to as an individual, and $t = 1, 2, \dots, T$ refers to a given time period. Thus Y_{it} is the value of the dependent variable for individual i at time t and X_{kit} is the value of the k th nonstochastic explanatory variable for individual i at time t . The stochastic term e_{it} is assumed to have mean zero. $E[e_{it}] = 0$, and constant variance, $E[e_{it}^2] = \sigma_e^2$

The β_{kit} are unknown parameters or response coefficients and. As the subscripts suggest, for the most general case they can be different for different individuals and in different time periods. However, in most cases more restrictive assumptions will be made and, in fact, this is a convenient way the following tow cases will be considered:

1. Slope coefficients are constant and the intercept varies over individuals

$$Y_{it} = \beta_1 + \sum_{k=2}^k \beta_k X_{kit} + e_{it}$$

2. All coefficients vary over individuals,

$$Y_{it} = (\beta_1 + \mu_i) + \sum_{s=2}^s \beta_s X_{sit} + e_{it}$$

In cases 1 to 2 the models can be classified further depending upon whether the variable coefficients are assumed to be random or fixed. The fixed assumption leads to dummy variable models and the seemingly unrelated regression model while the random assumption leads to error components models.

Given this preamble, we can write the generic pooled linear regression model estimable by Ordinary Least Squares (OLS) procedure.

$$Y_{it} = b_1 + \sum_{k=2}^K b_k X_{kit} + e_{it}$$

Where $i = 1, 2, \dots, N$; refers to a cross-sectional unit; $t = 1, 2, \dots, T$; refers to a time period and $k = 1, 2, \dots, K$; refers to a specific explanatory variable. Thus, Y_{it} and X_{kit} refer respectively to dependent and independent variables for unit i and time t ; and e_{it} is a random error and β_1 and β_k refer, respectively, to the intercept and the slope parameters. Moreover we can denote the $NT \times NT$ variance-covariance matrix of the errors with typical element $E(e_{it}e_{js})$ by Ω .

Estimating this kind of model and some of its variants, solves many problems of traditional methods of the comparative research (i.e. time series analysis and cross-sectional analysis).

Detailed discussion of the methods described in the following sections can be found in:

Greene, William H. (2011), Judge, George G., W.E. Griffiths, R. Carter Hill, Helmut Lütkepohl, and Tsoung-Chao Lee, Federico Podestà (2011), Baltagi, B.H., (2008), Asteriou and Hall (2007), Wooldridge, Jeffrey M. (2006), Moon, H.R. and P. Perron (2004), Jeffrey. M. Wooldridge (2010).

If the same units of observation in a cross-sectional sample are surveyed two or more times, the resulting observations are described as forming a **panel** or **longitudinal** data set. Time-series-cross-section (TSCS) data consist of comparable time series data observed on a variety of units. researchers have been able to use time-series cross-sectional data to examine issues that could not be studied in either cross-sectional or time-series settings alone. Another name of pooled TSCS analysis is panel analysis.

2.1 Several reasons for the increasing interest in panel data sets.

A First reason An important one is that their use may offer a solution to the problem of bias caused by unobserved heterogeneity, a common problem in the fitting of models with cross-sectional data sets.

A second reason is that it may be possible to exploit panel data sets to reveal dynamics that are difficult to detect with cross-sectional data.

A third attraction of panel data sets is that they often have very large numbers of observations. If there are n units of observation and if the survey is undertaken in T time periods, there are potentially nT observations consisting of time series of length T on n parallel units.

Methods of Pooling Time Series – Cross section (PTSCS) Data: A comparative Study

*Abeer Ibrahim Zidan Mohamed**

Abstract:

Data sets that combine time series and cross sections are common in economics. **Pooled analysis** combines time series for several cross-sections. Pooled data are characterized by having repeated observations on fixed units. If the same units of observation in a cross-sectional sample are surveyed two or more times, the resulting observations are described as forming a **panel data set**. these paper investigate Pooling Time Series – Cross section (PTSCS) data with Fixed and Random Effects using **Dummy Variables** versus **Error Component** Models, and comparative with **Seemingly unrelated Regression model** treats each cross-section and the time series within that cross-section as a separate equation that is unrelated to any other cross-section in the pooled data set. Most specifically, this model is interpretable as a series of a nation specific regression analysis that utilizes contemporaneous cross-equation error correlations among the error of a system of equation to improve the efficiency of the equation's estimates. The comparative study implementations in Grunfeld Investment Data, 10 Firms, 20 Years (1935-1954) as a **balance panel data** Sets.

Key Word:

Pooling analysis – panel data - Dummy Variables - Error Component - Seemingly unrelated Regression model.

1.1 INTRODUCTION:

Data sets that combine time series and cross sections are common in economics. Pooled analysis combines time series for several cross-sections. Pooled data are characterized by having repeated observations (most frequently years) on fixed units (most frequently states and nations). This means that pooled arrays of data are one that combines cross-sectional data on N spatial units and T time periods to produce a data set of $N \times T$ observations.

However, when the cross-section units are more numerous than temporal units ($N > T$), the pool is often conceptualized as a “cross-sectional dominant”. conversely, when the temporal units are more numerous than spatial units ($T > N$), the pool is called “temporal dominant”.

Given this preamble, we can write the generic pooled linear regression model estimable by Ordinary Least Squares (OLS) procedure.

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chemical industries and social services as being key sectors in the Egyptian economy. Furthermore, maximum jobs could be attained in case the disbursed funds are to be allocated to the government selected sectors or to social services alone or to the construction and buildings sectors plus social services and key sectors as a third best option.

Policy makers should make a two-dimensional trade-off. The first is whether to target specific sectors of interest or to apply a more uniform allocation across sectors. The sectoral distribution of the fiscal spending gains much importance, since the I-O multipliers differ significantly across sectors. The second trade-off reflects the choice of realizing a maximum target of job creation versus GDP growth target. In fact, the current situation revealed a good combination of achieving both targets; however a re-allocation of resources resulted in a better position for both targets. The analytical framework proposed in this paper seems both relevant and appropriate for making decisions related to the optimal allocation of spending. The optimality of FSP 2009/2010 allocation is based on the structure of Egypt I-O2007/2008 since it is the only available sectoral database for the analysis. Thus, the results of the alternative scenarios are very sensitive to the inter-linkages and structural characteristics besides, the detailed available breakdown of the sectors. The optimal allocation of the stimulus spending could guide policy makers in the allocation of targeted investments in the annual socio-economic plan.

To maximize the benefits of government expenditure in terms of economic growth and employment, it is recommended that a detailed analysis of the key sectors in Egypt is conducted with regard to the Egypt I-O table. More recent, comprehensive and representative data for the structure of the Egyptian economy and the interrelationships among sectors should be provided by the concerned authorities. In order to have an accurate estimate for the impact of specific amount of money directed to specific sectors, it is very crucial to have the right multipliers derived from the right structure of the economy given the inter-linkages among sectors. The sectoral distributional issue of the government budget in general and especially for the stimulus expenditure is an important one. Setting the priorities of investment spending is one of the critical issues that policy makers need to resolve. Further research is needed to explore the sectoral relations and inter-linkages with their potentials to contribute to achieve the targets of the socio-economic development plan associated with the welfare and distributional aspects.

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The analysis of the performance of the key selected sectors in the scenarios 6 and 7 shows that agriculture-vegetarian has two interesting attributes. Agriculture-vegetarian occupies the second ranking in scenarios 6-a and 7-a (that are pro-growth). It is ranked fourth in scenarios 6-b and 7-b (that are pro-job creation). This may be related to the high share in labor and GDP respectively. Besides, agriculture-vegetarian sector enjoys stronger forward linkages than backward linkages and has moderate value added multiplier. It is also ranked the second highest sector in the number of workers in the economy following the social services sector and is among the first five sectors that have higher shares in GDP. Being one of the selected key sectors, spinning and weaving is ranked second in scenario 6-b since it shows higher performance in terms of employment multiplier and share in labor. Besides, high backward linkages, it is considered the third ranked in scenario 6-a (pro-growth) since it has a high value added multiplier. Being ranked lower among sectors in both scenario 7-a and 7-b is due to lower performance in terms of share in GDP and low wages and moderate jobs multiplier.

Finally, chemical industries as one of the key sectors, exhibits higher performance in scenario 6-b as ranked third among key sectors and fourth in scenario 6-a and that can be interpreted in light of high job vacancies, high wages, high forward and backward linkages and high value added multiplier. The relatively lower position in scenario 7-a and 7-b is owing to that other sectors in this scenario enjoy higher share in labor, higher employment multiplier and higher share in GDP.

In brief, diversity in characteristics and linkages in the sectors comprising Egypt I-O 2007/2008 lead to disparity in performance in capturing FSP allocation, and hence the contribution to GDP growth and job creation in the Egyptian Economy. The scenarios of optimal FSP allocation discussed above in the ranking matrix provide alternative options for policy maker considering maximizing the benefit of distributing FSP across different sectors.

5. CONCLUSION AND POLICY IMPLICATIONS

This study provides policy makers with criteria to guide the allocation of fiscal stimulus spending across different sectors in the economy. This is mainly achieved through setting the government current allocation as a benchmark case upon which each alternative proposed scenario is evaluated. It seems that the government choice to direct the fiscal stimulus spending towards the infrastructure sectors plus social services proved to be a good policy choice, yet not optimal. The government allocation stood in the middle of achieving both the growth and employment targets. Maximum GDP growth can be achieved if the FSP2009/2010 is directed to social services only or to the three construction and building sectors plus social services as a second best solution. A third suitable choice is to target agriculture vegetarian, spinning and weaving,

opportunities vis-à-vis the government current allocation. However, there is a disparity among them in terms of growth performance (below, equal and above the benchmark case). The positive values in column five reflect an increase in jobs created, and hence the different remaining scenarios (1 and 5) range between 127 thousand jobs created as a lower bound for the difference compared with the current allocation-and reaching 132 thousand jobs created as an upper bound. The fourth scenario reflects a number of lost employment opportunities accounted for 313 thousand jobs in the first scenario, and this in turn may lead to conclude that concentration of the stimulus spending is better than distributing it among all the sectors with their different characteristics, inter-linkages and capabilities in contributing to growth or creating more jobs in the economy. We can easily detect that the structural characteristics play an important role in determining the sectoral share in FSP 2009/2010 allocation in each scenario. Social services sector occupies the first rank among the sectors capturing the FSP 2009/2010 in the three proposed scenarios. This might be due to three main attributes. First, social services sector enjoys a high value added multiplier. Second, it is ranked the first among sectors in the share in total workers in the economy. Third, it has the highest third position among sectors concerning the share of GDP. Moreover, social services sector has high forward linkages and a little bit lower backward linkages (figure 2 in the appendix). The wages in this sector is considered above the national average (Moursi et al 2009). Since ranked second among sectors in scenarios 1 and 7-b, water and sewage sector perform very well in terms of value added and employment multipliers, and it has moderate linkages with other sectors in the economy. However, water and sewage and roads and bridges share low performance in terms of the jobs multiplier, wages, share in workers in the economy and share in GDP. Water and sewage exceeds in terms of value added and employment multiplier and hence no wonder that roads and bridges succeed water and sewage in the ranking among sectors. It is also noticed that the share in labor in roads and bridges is higher than water and sewage sector.

While water and sewage, roads and bridges, and building sectors achieve higher ranking in the pro-job creation scenario (7-b), the building sector occupies a good ranking in the scenario that is pro-growth (7-a). Therefore, building is ranked fourth in the first scenario and ranked fifth in scenario (7-b) compared to other construction and building sectors. This position is realized mainly due to the high value added and employment multipliers that are translated to higher shares in GDP and labor in the economy. It is obvious that building enjoys higher investments per unit of output, higher shares in GDP and labor than roads and bridges and water and sewage. Output per worker is also higher in building than in roads and bridges. Furthermore, building stands in the middle between water and sewage and roads and bridges in backward linkages and share with them low level of wages.

4.2 Comparison of Government Allocation Vis-à-vis Alternative proposed Scenarios of the Allocation of FSP 2009/2010

To evaluate the performance of the different proposed scenarios in achieving both GDP growth and job creation targets, a ranking is attached to each scenario in order to reflect the relative position of the scenario in realizing each target separately. The deviation between the jobs attained in each scenario and the benchmark case is illustrated below in order to offer policy makers guidelines in choosing the optimal allocation of FSP 2009/2010.

The results of the alternative scenarios of distributing FSP 2009/2010 across sectors shows that the highest increase in GDP growth can be achieved with the second best number of jobs created according to the fifth scenario (only SOS). Comparing both ranking for attaining the highest growth rate in GDP and achieving maximum employment opportunities, we find that the first scenario is quite good in fulfilling both targets compared with the announced government allocation. In the second scenario, we can detect that a trivial change in the allocation of FSP 2009/2010 from the selected four sectors to the rest of the economy leads to a drop in the number of jobs created in the whole economy to nearly 265 thousand jobs compared to the first scenario, and about 134 thousand jobs lost in comparison with the benchmark case. Moving to the third scenario would not improve the situation but it worsens the extra growth attained and number of jobs created. The policy maker can exclude the third scenario from the choice set, since it does achieve neither a higher growth nor higher jobs. However, the third scenario gives a space to all sectors to benefit from the FSP. If we shift to the fourth scenario, to compare another proposed set of governments preferences based on the sectoral shares in planned investments, we can easily notice that the same level of additional growth in GDP is encountered but with the number of jobs created in favor of the sectoral allocation represented in the first scenario.

Contrary to the first scenario, the increase in jobs created according to the sixth scenario will be around 500 thousand jobs that still below the level attained by the government choice of the distribution of FSP 2009/2010 in the first scenario. Adding social services, water and sewage, roads and bridges and building to the four key sectors in the seventh scenario resulted in a lower growth rate in GDP compared to the sixth and first scenarios but still the same growth in the benchmark case. Moreover, the increase in jobs created for the seventh scenario ranges from 522-546 thousand jobs which are higher than the sixth scenario and greater than the current allocation provided in the benchmark case but still lower than the first scenario.

It is worth noting that the deviation in jobs encountered in each scenario compared with the benchmark case is also computed. It is very clear that only scenarios 2, 3-a, 3-b, and 4 are responsible for a great lost employment

into consideration. To evaluate this argument we will resort to another two additional scenarios that would reveal some of the mystery about the concentration issue. Therefore, the sixth scenario assumes the optimal allocation will be achieved if the government directs the FSP towards key sectors that will be determined based on their performance regarding the forward and backward linkages (figure 3 in the appendix). The key sectors according to this scenario are the social services, spinning & weaving, chemical industries and agriculture-vegetarian. If seeking a more reasonable distribution of FSP, the policy maker may find scenario 6-a appropriate in narrowing the disparity between the shares of the three building blocks of the Egyptian economy and maximizing GDP growth simultaneously. Thus, the agriculture sector according to this scenario captures 26% of FSP allocation and industry has 38% and services 36%. Moreover, scenario 6-b gives more weight to industry to account for 44% of FSP, the same share for services 36% and a slightly lower share for agriculture nearly 20%. The most interesting issue arises from the choice of the sectors that are eligible for capturing a significant share of FSP. Again the conclusion reached earlier that when policy makers concentrate the stimulus spending in a small number of sectors that are capable of generating employment opportunities is better than having the funds distributed among a large number of sectors.

The seventh scenario tries to evaluate the argument of concentration of the disbursed funds among a limited number of sectors. A nice feature about the seventh scenario is that it represents a mixed bundle of sectors combining both key sectors which have strong backward and forward linkages with the four selected sectors by the government current allocation of FSP. It seems that the seventh scenario is counting on the construction and building sectors to play a significant role in the stimulus spending, for which 40% of FSP is allocated, besides, giving equal weights for services and industry sectors to have 22% and 23% of FSP respectively and allocating 15% of FSP to the agriculture sector.

To sum up, each of the above discussed scenarios offer policy makers criteria to take decisions related to the optimal allocation of FSP2009/2010 across sectors. It seems that there will be a dual trade-off that needs to be considered. The first trade-off is related to whether to distribute the disbursed funds to the whole set of sectors, so that benefits will spread across all sectors. Otherwise, policy makers need to consider uneven distribution of the stimulus spending and hence a selective choice of sectors should be made. The second trade-off is concerning the compromise between higher growth in GDP and higher jobs generated. Furthermore, the GOE should determine which target seems to be crucial for this phase of economic and social development in the Egyptian economy. Therefore, an analysis of the sectors that are capable of achieving that target will be considered further.

for construction and building sectors (24%), a little bit lower share for services (14.6%) agriculture (9%), and almost the same share to the industry sectors (52%).

Table 3. Optimal Sectoral Allocation for Government FSP 2009/2010 versus Alternative Scenarios

Sectors	Government FSP Allocation	Scenario1	Scenario2	Scenario 3-a	Scenario 3-b	Scenario4	Scenario5	Scenario 6-a	Scenario 6-b	Scenario 7-a	Scenario 7-b
Sectoral Allocation for FSP (%)											
Agriculture	0.00	0.00	0.03	4.95	4.41	1.55	0.00	25.89	19.54	15.03	13.01
Vegetarian	0.00	0.00	0.03	4.83	4.62	1.72	0.00	0.00	0.00	0.00	0.00
Animal	0.00	0.00	0.03	4.83	4.62	1.72	0.00	0.00	0.00	0.00	0.00
Industry	0.00	0.00	0.02	5.04	3.47	18.56	0.00	0.00	0.00	0.00	0.00
Oil & Mineral Extract.	0.00	0.00	0.03	4.45	5.42	0.05	0.00	0.00	0.00	0.00	0.00
Food and Tobacco	0.00	0.00	0.03	4.18	4.24	0.15	0.00	20.14	24.47	10.46	11.98
Spinning & Weaving	0.00	0.00	0.02	4.04	4.08	0.02	0.00	0.00	0.00	0.00	0.00
Clothing	0.00	0.00	0.03	4.83	3.98	0.32	0.00	18.14	19.70	12.33	11.64
Chemical Industry	0.00	0.00	0.03	4.98	3.28	2.93	0.00	0.00	0.00	0.00	0.00
Petroleum Products	0.00	0.00	0.03	5.30	4.27	0.29	0.00	0.00	0.00	0.00	0.00
Non-Metal Industry	0.00	0.00	0.03	5.06	5.01	4.22	0.00	0.00	0.00	0.00	0.00
Base Metals	0.00	0.00	0.03	4.30	5.49	0.15	0.00	0.00	0.00	0.00	0.00
Metal Industry	0.00	0.00	0.03	3.67	4.50	5.74	0.00	0.00	0.00	0.00	0.00
Eng. & Machinery	0.00	0.00	0.02	2.71	3.57	0.62	0.00	0.00	0.00	0.00	0.00
Other Industry	0.00	0.00	0.03	4.31	5.07	7.52	0.00	0.00	0.00	0.00	0.00
Electricity	0.00	0.00	0.03	4.31	5.07	7.52	0.00	0.00	0.00	0.00	0.00
Construction & Building	5.91	18.87	20.01	4.65	4.96	1.88	0.00	0.00	0.00	14.66	12.65
Building	1.82	20.76	20.30	3.70	4.93	3.03	0.00	0.00	0.00	11.48	13.98
Roads and Bridges	84.11	23.52	23.05	4.35	4.84	8.31	0.00	0.00	0.00	14.28	14.99
Water and Sewage	0.00	0.00	0.03	4.98	4.55	0.00	0.00	0.00	0.00	0.00	0.00
Electricity Stations	0.00	0.00	0.02	4.64	4.68	2.30	0.00	0.00	0.00	0.00	0.00
Other Constr. & Bldg	0.00	0.00	0.02	4.64	4.68	2.30	0.00	0.00	0.00	0.00	0.00
Services	0.00	0.00	0.03	3.81	3.70	14.42	0.00	0.00	0.00	0.00	0.00
Transport & Comm.	0.00	0.00	0.02	4.97	4.41	4.96	0.00	0.00	0.00	0.00	0.00
Other Prod. Services	8.16	36.85	36.14	6.25	6.53	21.26	100.00	35.84	36.29	21.76	21.75
Social Services	1.36	1.48	1.48	1.26	1.25	1.38	1.81	1.46	1.45	1.39	1.39
Change in GDP (%)	1.36	1.48	1.48	1.26	1.25	1.38	1.81	1.46	1.45	1.39	1.39
Jobs Created (thousand jobs)	484.19	616.28	350.63	312.24	331.09	302.78	610.79	498.13	496.56	522.66	546.56
Change in Labor Income	3093.62	4605.71	4637.05	2764.54	2822.84	3288.23	7949.19	4475.01	4506.49	3745.25	3761.23

Source: Computed from Egypt I-O 2007/2008 (IDSC 2009) and simulation analysis.

The first three scenarios illustrated above obtain an optimal allocation for FSP 2009/2010. Contrary to this, the fourth scenario demonstrates the sectoral shares in FSP if the government decides to distribute the funds according to the current investment plan 2009/2010. Therefore, the fourth scenario depicts that there will be a concentration of the shares of the stimulus spending in the industry sector that accounted for about 41% of FSP 2009/2010 followed by the social services (21%) and then other productive services (19 %), and finally construction & building sectors (16%), and the agriculture sector (3%). Contrary to the above findings, the fifth scenario favoring only one sector represented in the social services, proves to be the optimal selection in all the optimal cases presented above since it achieves 1.8% additional growth in GDP and 611 thousand jobs generated that is very close to the first scenario. Nevertheless, this could be considered a very extreme choice for the policy maker since it is difficult to direct the entire stimulus spending to only one sector.

Till now, the results attached with each scenario seem very much pro the argument of concentration of the distribution to limited number of sectors than to target a more equal distribution, which takes all the sectors of the economy

4.1 Results of Alternative Proposed Scenarios of the Sectoral Allocation of FSP 2009/2010

The announced allocation of the stimulus expenditure reveals that the government kept an eye on specific sectors on both the first and second rounds of stimulus. The fiscal expenditure was concentrated in the construction and building sectors (water and sewage, roads and bridges, building) and social services sector. Table 3 illustrates the sectoral shares of FSP2009/2010 according to the alternative scenarios vis-à-vis the government current allocation. The table also shows the impact of the sectoral allocation of FSP on GDP growth, jobs creation and extra labor income generated[^]. The results pointed out that some scenarios extend the benefits of the stimulus spending to the whole economy through distributing the funds among all the sectors (Scenario 2, 3 and 4), while the remaining scenarios allocates the share in fiscal stimulus package to a limited number of sectors (scenario1, 5, 6 and 7).

The only difference between scenarios (3-a, 6-a and 7-a) and (3-b, 6-b and 7-b) is that the former is related to the sectoral allocation of FSP 2009/2010 that is pro-growth in GDP and the latter is illustrating the allocation of FSP across sectors that is pro-job creation. In other words, the sectoral allocation that achieves maximum growth GDP differs from that responsible for attaining maximum of employment opportunities. Otherwise, the remaining scenarios describe the sectoral optimal allocation that achieves both targets together.

The government FSP allocation given in the first column (the benchmark case) in table 3 shows that water and sewage sector captures most of the fiscal spending that accounts for 84% of FSP 2009/2010. The rest of the funds are directed to social services (8%), building (6%) and roads and bridges (2%). The Optimal Allocation according to the first scenario is to distribute the stimulus expenditure among the four selected sectors but with different shares. Therefore, 19%, 21%, 23% and 37% of FSP should be directed towards building, roads and bridges, water and sewage and social services respectively. This would result in achieving higher extra growth (1.5%) and higher employment opportunities (616 thousand jobs) associated with higher labor income. The second scenario which is a variant of the first scenario after permitting the rest of the economy to have a small share in FSP, allocates around 63% of FSP to the construction and building sectors and about 36% to the social services. While senario 3-a achieves maximum GDP growth through allocating more than half of the FSP to industry sectors (53%) followed by construction and building (22%), services (15%) and agriculture (10%), scenario 3-b realizes maximum jobs through allocating a slightly higher share

[^] Tables 3 and 4 in the appendix depict the detailed results for the impact of each sectoral allocation according to each scenario separately on the value added inducement, jobs, and labor income respectively.

٦. Optimal allocation for which the FSP is allocated to key sectors (allocation taking into consideration inter-linkages between sectors): this scenario assumes that the government directs the FSP towards key sectors that will be determined based on their performance regarding the forward and backward linkages^١ (figure 3 in the appendix). A decision related to the choice of key sectors in the Egyptian economy is made to include a combination of the well-performing sectors on backward linkages such as: Social services, spinning & weaving, and chemical industries, this in turn reveals the importance of those sectors in stimulating activity throughout the economy, due to high demand for output from the other sectors. While the well-performing sectors on forward linkages are: Social services, agriculture-vegetarian and chemical industries. So, the set of sectors are the social services, spinning & weaving, chemical industries and agriculture-vegetarian^٢. Only one set of key sectors that prove to achieve good performance in terms of attaining maximum employment and growth in GDP. The data is then generated from symmetric beta distribution as previously mentioned.
٧. Optimal allocation in case of adding key sectors to the selected four sectors of which the government announced FSP is absorbed: Adding social services, water and sewage, roads and bridges and building to the four key sectors in the sixth scenario, then the data is generated as previously mentioned. The last scenario is a mixture of the sixth and first scenarios to envisage the impact of the sectoral allocation if we expand the set of choice in front of the government but making it narrower enough to exclude other irrelevant sectors in the economy.

4. RESULTS

This section summarizes the main findings of the proposed alternative scenarios of the optimal allocation of FSP 2009/2010. A comparison of the performance of each scenario in terms of achieving the growth and employment targets is also discussed in details.

^١ Linkages reflect the increase in the output level owing to an increase in the final demand. Buying (selling) products from (to) other sectors denotes backward (forward) linkages (Kula 2008). To allow for comparability between sectors, the forward and backward linkages (FL and BL, respectively) are normalized to have the mean for each equal unity. Four classes of sectors are identified according to the normalized linkages: Key sectors exhibiting strong FL and BL (both FL/BL greater than 1), sectors exhibiting strong FL and weak BL (FL greater/BL less than 1), sectors exhibiting weak FL and strong BL (FL less/BL greater than 1) and sectors exhibiting weak FL and BL (both FL/BL less than 1).

^٢ There are other two sets of a mixture of four key sectors that were tested according to a variant of the Rasmussen forwards and backward linkages and also Watanabe forward and backward linkages. The results are not reported in the paper but available upon request.

scenario. If the highest growth and highest job creation are related to the same allocation then we have one optimal distribution for the FSP across sectors but if the highest growth is corresponding to a specific allocation that is different from the one creating the highest job creation, then we will have two optimal distributions for the FSP across sectors; one with respect to the highest growth and the other with respect to the highest job creation.

- Υ. Optimal allocation with restriction to the above four sectors getting 99% of the total amount of the stimulus package and about 1% is distributed on the rest of the economy: the same above process is repeated again in this scenario while distributing 10942.5 million on the four sectors and only 55 million on all other sectors. The main idea in this scenario is to give all economy sectors shares of the stimulus package even if they are very small portions. So this scenario permitting the rest of the economy to have a very limited shares in FSP 2009/2010.
- Ψ. Optimal allocation without restrictions to all sectors: in this scenario no restrictions are assumed, all 22 economy sectors have equal opportunities. The data is generated from symmetric beta distribution as mentioned before; the optimization is based on the highest growth or highest job creation or both.
- Ω. Allocation according to the planned investment shares: the data in this scenario is not generated from beta distribution but it is based on the investment plan announced by the Ministry of Economic Development (MOED) 2009/2010. So there is no optimality in this scenario, but in fact, this scenario shows the impact of allocating the stimulus package on the sectors in the light of the investment plan on the growth and job creation. This scenario in turn reflects one set of government preferences in distribution of FSP across different sectors vis-à-vis the current status of the announced government allocation.
- Θ. Optimal Allocation with restrictions that some sectors could not obtain a share in FSP: the data in this scenario is generated from skewed beta distribution that forces the sectors with small shared of the FSP to get nothing (exactly zero) of the stimulus package while the sectors that have high shares get more of the FSP. This scenario is an extreme case of government choice where the distribution of the optimal FSP is forced to completely exclude sectors altogether from the allocation of the stimulus spending, therefore the optimal result came out to be that only one sector will capture all the funds which may appear as unrealistic choice for the government.

2008/2009 in order to gain insight about the government allocation of the investment plan.

3. METHODOLOGY

This section proposes seven alternative scenarios for the allocation of the government FSP 2009/2010, where six of which represent optimal allocation across sectors according to each scenario restrictions. The fourth scenario is not an optimal allocation as it is only assuming that the GOE will direct the funds towards the sectors according to their shares in the investment plan announced by the Ministry of Economic Development (MOED) 2009/2010. The simulation size contains two millions trails. In each trail, the sectors shares in the FSP 2009/2010 are computed based on random number generation process from beta distribution with parameters depend on the scenario restrictions and at the same time has small variance to assure the stability of the simulation. For each data trail, we multiply FSP sectoral shares by I-O multipliers, namely we use two main multipliers derived from Egypt I-O2007/2008 (IDSC 2009); employment and value added inducement multipliers. This method enables us first to carry out the simulation runs for FSP allocation across sectors. Second, we can measure the impact of specific sectoral allocation of FSP on the economy and then compute the optimal combination of sectoral shares that achieves both maximum GDP and employment. Employment multiplier is defined as the change in labor income across sectors in the economy owing to a change in any sector. As pointed out in Mouhammed (2000) and He et al (2009), the value added coefficients are the ratios of the value added to the gross output for each sector. The sectoral value added inducement multipliers and coefficients determine the direct, indirect and induced effects on the value added resulting from an exogenous change in final demand expenditure⁴. We follow He et al (2009) and Moursi et al (2009) in computing Type II multipliers to include the induced effect on households⁵. The proposed alternative scenarios in this paper could be summarized as follows:

1. Optimal allocation with restriction to the same four sectors (building, roads and bridges, water and sewage, social services) as announced in the government allocation: the two millions data sets are generated from beta distribution with equal parameters to assure symmetry. For each data set, the impact of the allocation on growth and employment are computed based on employment and value added multipliers derived from Egypt IO 2007/2008 table. Then the allocation with the highest growth or job creation or both is considered as the optimal allocation for this specific

⁴ Interested reader can refer to Mouhammed (2000) for detailed analysis of I-O model and computation of multipliers.

⁵ Type II employment multipliers are calculated as the ratio of the sum of the changes in direct, indirect, and induced employment to the change in direct employment (Mouhammed 2000; Moursi et al 2009).

Table 1. FSP 2009/2010 Sectoral Expenditure Allocation
(EGP Million)

Sectoral Distribution	Outlays
Water and Sewage	9250
I. Water and sewage projects	9000
II. River Nile projects	250
Roads and Bridges	200
Social Services	897.5
I. Health programs	206
II. Subsidies	571.5
III. Commodities	164
II2. Infrastructure and geographical targeting	407.5
Domestic development projects and poor households empowerment	150
Geographical targeting program and household empowerment	57.5
Domestic development: Geographical targeting	150
Environmental: Financing activities in the poorest villages	50
III3. Youth and sports sector subsidies	120
Buildings	650
I. Housing and utilities: Nuba housing project	150
II. Reconstructure of desert villages	500
Total Expenditure	10997.5

Source: MOED (2010).

It is worth noting that the government orientation towards favoring investments directed to infrastructure is dominant for the second stimulus plan. Therefore, it is not surprising that the water and sewage sector received the bulk of the funds (84%) of which about 97.3% going to water and sewage projects and the remaining 2.7% allocated for the River Nile projects. The table demonstrates that building has only 5.9% of the total stimulus expenditure with the most is allocated to the re-construction of the desert villages (77%) and about 23% directed towards Nuba housing project. The roads and bridges sector has about 2% of the total spending while the social services sectors emerged to attract about 8.2% of the second stimulus package of which 23% are directed to health programs, 13.3% allocated to youth and sports sector and about 63.7% to subsidies whether commodities or achieving infrastructure and geographical targeting projects. It is worth noting that geographical targeting comprises about 3.7% of the total FSP 2009/2010 and around 71.3% of total subsidies (LE 407.5 million) excluding subsidies directed to youth and housing. The interesting feature about subsidies is that it accounts for 7.65% of the stimulus spending if both youth and housing subsidies are added to it to reach about EGP 841.5 million.

In Brief, the second stimulus package 2009/2010 followed the first package in favoring specific sectors and hence depriving the rest of the economy from the benefits of investment expenditure due to the uneven distribution of spending across sectors. The privileged sectors are the three construction and building sectors in addition to the new sector introduced in the FSP 2009/2010 that is social services. Therefore, the paper proposes to take a snapshot of the sectoral shares of the executed investments in the socio-economic plan

2. SYNOPSIS ON THE FISCAL STIMULUS PACKAGE 2009/2010 AND EGYPT I-O 2007/2008

The GOE announced the implementation of a stimulus program late in 2008 that began to take place in March 2009 after the ratification by the parliament. The first Egyptian Fiscal stimulus package (FSP) 2008/2009 gave priority to infrastructure projects concentrating on the sectors achieving goals related to social dimensions like potable water and sewage projects, building roads, bridges, schools and basic health care centers. The first FSP also included a significant spending committed to achieve the government program for sales tax and custom duties reduction on some industrial inputs and capital goods for supporting internal trade and industrial zones and increasing export competitiveness¹. The second stimulus program was planned to further facilitate carrying out some of the projects financed at the earlier stage of stimulus spending in addition to encouraging other socio-economic projects related to poverty geographical targeting.

Egypt I-O 2007/2008 is designed to incorporate a detailed breakdown of the construction and building sectors (decomposed into building, roads and bridges, water and sewage, electricity stations and other construction and building), thus in turn allows for evaluating the impact of the first and second stimulus packages on employment and growth. Egypt I-O 2007/2008 comprises 22 sectors representing 2 agricultural, 17 industrial and 3 productive and social services sectors (IDSC 2009; Moursi et al 2009). Egypt I-O 2007/2008 reflects a mixture of the structural characteristics and production linkages between sectors in the Egyptian economy. It is worth noting that the building sector has higher shares in GDP and labor compared to roads & bridges and water & sewage. However, labor productivity and capital intensity as measured by output per worker and output per unit of capital respectively are higher in water and sewage sector. Moreover, all construction and building sectors suffers from very low level of wages that is below the national average (Moursi et al 2009). Contrary to this, social services sector has relatively higher consumption per unit of output ratio and very low investment per unit of output ratio. Besides, higher value added share in GDP and very low output per worker due to ranking the first in the number of workers employed and also it has higher wages compared to construction and building sectors. Table 1 portrays the distribution of the FSP 2009/2010 expenditures across different sectors according to the sectoral structure of Egypt I-O 2007/2008 table. The FSP 2009/2010 amounted to over EGP 10.997 billion equivalent to 1.2 percent of GDP².

¹ For a detailed breakdown of first FSP 2008/2009, see Ramadan (2009) and Moursi et al (2009).

² The First stimulus package 2008/2009 amounted to over EGP 15.53 billion equivalent to 1.5 percent of GDP (Ramadan 2009; Moursi et al 2009; El Ashram and Zakareya 2010).

sectoral composition of public expenditure in developing countries (Estache et al. 2007). It is also noticed that no well-defined rules for expenditure allocation across sectors exist (Stefano et al 2007). Most of the empirical studies uses endogenous growth framework to investigate the optimal allocation of government spending between health, education, and infrastructure. Stefano et al (2005) investigated to how extent the composition of public spending matters for growth, equity and poverty-reduction objectives within the broad framework proposed in the literature by Ferroni and Kanbur (1992). Therefore, the taxonomy of the public spending is thus between “social expenditure” and “infrastructure expenditure” with the objective being to maximize the standard of living. Agénor & Neanidis (2010) provided a full characterization of both the growth- and welfare-maximizing structures of expenditure. Agénor (2005) pointed out that the government can choose to achieve maximization of growth through spending on infrastructure, therefore consumption and welfare increases and spending on health reduces, which leads to lower welfare in case the supply of health services falls. Agénor (2005) also claimed that the government is better off reducing the share of spending that it allocates to infrastructure as long as the elasticity of output of health services with respect to spending on infrastructure is not too high, and the supply of health services increases.

Using simulations approach in the analysis of public spending are only reported in wide applications of computable general equilibrium (CGE) models combining micro-simulations with distributional analysis in developing countries (James 2009; Norris and Matovu 2002; Lofgren and Robinson 2004; Jung and Thorbecke 2003). Simulations derived from CGE are one of the research tools utilized by Jung and Thorbecke (2003) applied on Tanzania and Zambia. Their simulations suggest that well-targeted education expenditure can be effective for growth and poverty alleviation. They also suggest that a sufficiently high level of physical investment is required to achieve growth. This study differs from the previous literature in two respects. Firstly, we are interested in finding the optimal allocation of fiscal stimulus package across a large number of sectors, nearly 22 sectors given the structure of Egypt I-O 2007/2008. Secondly, the methodology adopted in this paper is different in combining I-O multipliers with a simulation analysis that seeks to solve the optimization problem.

The rest of the paper is organized as follows. Section two introduces a snapshot of the second fiscal stimulus package 2009/2010 and demonstrates the Egypt I-O data used in the analysis. Then section three illustrates the methodology applied in the analysis of the optimal allocation of the FSP 2009/2010. Furthermore, section four summarizes the results of the simulation experiments by presenting the proposed alternative scenarios and comparing them with the current government allocation of FSP 2009/2010. Finally section five concludes and proposes some policy recommendations.

1. INTRODUCTION

The Egyptian policy maker is mindful of the need to stimulate the economic activity in Egypt and achieving reasonable employment opportunities in the aftermath of the economic crisis. The Government of Egypt (GOE) announced the implementation of the first stimulus package in 2008/2009 with the aim of preserving and stimulating domestic demand, supporting the sectors affected by the crisis and accelerating carrying out national infrastructure projects contributing to social welfare (Ramadan 2009; Moursi et al. 2009). The first round of stimulus spending accounted for EGP 15.532 billion that represent about 1.5 percent of GDP. Moursi et al (2009) pointed out that government allocated around 65% of the first fiscal stimulus to the building, roads and bridges, water and sewage and other construction and building sectors.

The main objective of this study is to find the optimal sectoral allocation of funds committed to the second stimulus expenditure 2009/2010 in order to maximize the impact on both employment and growth. The paper adapts a mathematical approach based on simulation in targeting the optimal allocation of the Egyptian fiscal stimulus package 2009/2010 across the different economic sectors of the Egyptian Economy. Following Moursi et al. (2009), the paper relies on a recent Input-Output table for Egypt 2007/2008 as the core sectoral database to represent the structure of the Egyptian Economy (IDSC 2009). Egypt I-O 2007/2008 enables us to derive the employment and value-added multipliers in order to compute the impact of a certain allocation of FSP 2009/2010 on job creation and economic growth.

The paper sets the government allocation to the four selected sectors as a benchmark case where other seven alternative scenarios are proposed for the allocation of the government second FSP 2009/2010 that resulted from the simulation of the allocation across sectors. The simulation model adopted in the analysis relies on random number generation process for the sectoral shares in the fiscal stimulus package that is carried over two million trails. For each trail, we compute the impact of the allocation on GDP growth and employment using the employment and value added multipliers derived from Egypt IO 2007/2008 table. Accordingly, the optimal allocation is obtained based on the highest GDP growth attained or the highest employment achieved or both. It is worth noting that each scenario could be evaluated in light of the government allocation in terms of the relative importance of each sector in fiscal stimulus package. A detailed analysis of the impact of each scenario on economic growth and job creation is also provided in the paper.

Although the interest in obtaining an optimal allocation of the government expenditure across sectors is an old issue since the work by Devarajan, Swaroop, and Zou (1996), we find a few empirical studies investigated the

OPTIMAL ALLOCATION FOR FISCAL STIMULUS PACKAGE ACROSS SECTORS IN EGYPT (2009/2010): A SIMULATION ANALYSIS

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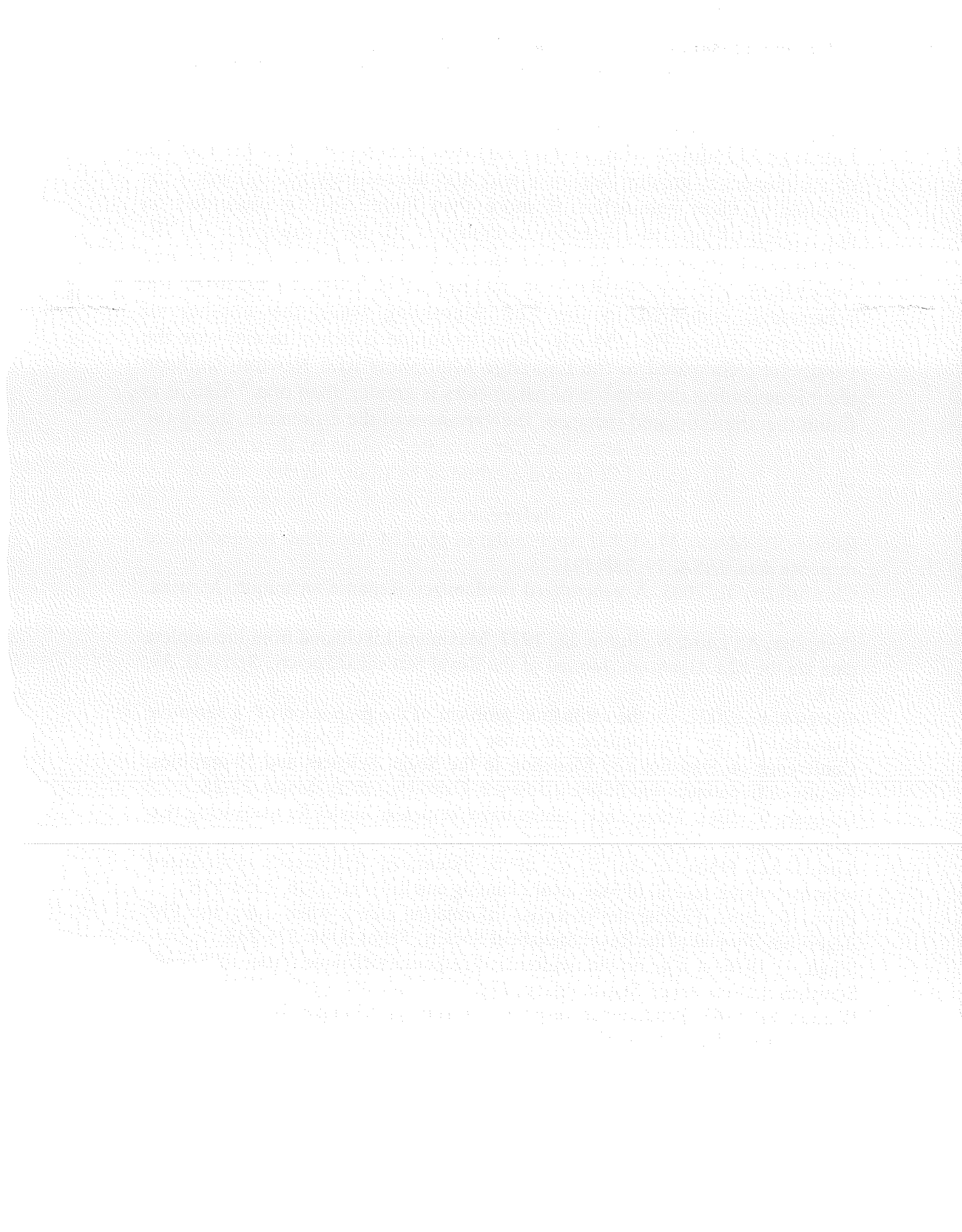
ABSTRACT

This paper presents a set of policy scenarios related to the choice of the optimal allocation of the second fiscal stimulus package 2009/2010 across sectors in Egypt. The analysis is based on a simulation-optimization approach for obtaining the best combinations of sectoral allocation that produce the maximum values for both growth in GDP and employment opportunities. The paper relies on a recent Input-Output table for Egypt 2007/2008 as the core sectoral database (IDSC 2009). The structural characteristics and interrelationships among sectors are retrieved from the derivation of the employment and value added inducement multipliers. The government of Egypt directed the stimulus spending for only four sectors. The main findings of this paper pointed out that these selected sectors proved to be a suitable policy choice with respect to GDP growth and employment, however, optimality requires a re-allocation of the shares of FSP 2009/2010 among the four sectors. The optimal case among the proposed scenarios revealed that the highest GDP and labor opportunities could be achieved if the social services sector captures all the funds dispersed of FSP2009/2010. However, this choice might be an acute choice. Some of the proposed scenarios need the policy makers to make a trade-off regarding the choice of realizing a maximum target of job creation versus GDP growth target. The paper also proposed one scenario of the sectoral allocation of FSP2009/2010 according to the sectoral shares of the investment plan, though not optimal, the results in terms of GDP growth and jobs created seems more reasonable and achieving higher targets than the case of the government current allocation. Finally, it is important to note that the structural characteristics of the sectors play a significant role in determining the optimal allocation, and hence those sectors that has a higher share of FSP2009/2010 in the optimal case proved to be capable of generating employment opportunities and contributing to GDP growth.

JEL Classification Numbers: C15, C61, C67, H11, H50, H54

Keywords: expenditure allocation, fiscal stimulus, fiscal policy, simulation, input-output model

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results , for the first and second devices, or by the Louis' results, for the third device.

8. Conclusions

This article presents ML estimates of the parameters of the model suggested by Guirguis (2011) by using EM algorithm. He showed, in his research, that there is a difficulty to estimate the parameters using the Lagrange Multipliers with Newton-Raphson techniques when the number of parameters is greater than one, and it is almost impossible , when the number of these parameters is more than three. So, we presented an application of the EM algorithm to Guirguis' Model to compute the ML estimates of the parameters of the model. It is found that the Lagrange Multipliers with Newton-Raphson techniques is better, to estimate the parameters, compared to the EM Algorithm, when the number of parameters is one. The EM Algorithm technique is better, to estimate the parameters, compared to the Lagrange Multipliers with Newton-Raphson techniques, when the number of parameters is greater than one. Also, it is found that the estimated values of the variances of the estimators, using the Information matrix, are less than the estimated values of these variances obtained by Maximum Likelihood method or by Louis' results.

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Table (8) presents the estimated values for the parameters $\pi_{3k}'s$ using the Lagrange Multipliers with Newton-Raphson and EM Algorithm techniques, and the estimated values of $Var(\hat{\pi}_{3k}); k = 1, 2, 3, 4$ using the Information matrix and Louis' results.

Table (8): The estimated Values of $\pi_{3k}'s$ using Lagrange Multipliers with Newton-Raphson and EM Algorithm techniques and their estimated variances

The Technique	$\hat{\pi}_{31}$			
Lagrange Multipliers with Newton-Raphson methods	0.00467	0.001302	0.08316	0.001355
EM Algorithm technique	0.00458		0.08325	
1. Using Louis' results		0.004436		0.004659
2. Using the Information matrix		0.001302		0.001355
The Technique	$\hat{\pi}_{33}$			
Lagrange Multipliers with Newton-Raphson method	0.01743	0.001718	0.89474	0.001787
EM Algorithm technique	0.01752		0.89465	
2. Using Louis' results		0.042123		0.006421
1. Using the Information matrix		0.001718		0.001787

From Table (5), we find that;

1. The Lagrange Multipliers with Newton-Raphson and EM Algorithm techniques, approximately, give the same estimated values for the parameters $\pi_{3k}'s$.
2. The estimated values of $Var(\hat{\pi}_{3k}) ; k = 1, 2, 3, 4$ by the Information matrix are less than the estimated values by the results of Louis.

In general;

1. If the randomized device aims to estimate one parameter, as in the first and second device, and Maximum Likelihood method give inadmissible estimate of this parameter, then the Lagrange Multipliers technique, with Newton-Raphson method, is the better computing technique compared to the EM Algorithm technique because it is simpler and easier.
2. When the number of parameters is greater than one, as in the third device, The EM Algorithm is the better technique compared to the Lagrange Multipliers with Newton-Raphson methods because it is simpler and easier and can be used whatever the number of the parameters of the model.
3. The Information matrix gives less estimated values to the variances of all estimators of the suggested model, compared to the corresponding estimated values obtained by Maximum Likelihood method or Louis'

Table (7): The iterations of the EM algorithm for obtaining the estimates of $\pi'_{3k,s}$ at $p_{31} = 0.35, p_{32} = 0.30, p_{33} = 0.20, p_{34} = 0.15, m_{31} = 103, m_{32} = 95, m_{33} = 168$ and $m_{34} = 192$

Iteration	k	z'_{3khl}				$\hat{\pi}_{31}$	$\hat{\pi}_{32}$	$\hat{\pi}_{33}$	$\hat{\pi}_{34}$
		$h = 1$							
0						0.01			
1	1	0.02131	0.14213	0.01473		0.00997			
	2	0.01415	0.12845	0.00856			0.07786		
	3	0.00695	0.04055	0.01471				0.01213	
	4	0.00447	0.04637	0.01081					0.90004
2	1	0.02124	0.14218	0.01477		0.00994			
	2	0.01410	0.12850	0.00858			0.07789		
	3	0.00693	0.04056	0.01474				0.01216	
	4	0.00445	0.04638	0.01084					0.90001
10	1	0.02088	0.14249	0.01497		0.00977			
	2	0.01386	0.12878	0.00870			0.07806		
	3	0.00681	0.04065	0.01495				0.01233	
	4	0.00438	0.04649	0.01099					0.89984
20	1	0.02041	0.14290	0.01524		0.00955			
	2	0.01355	0.12914	0.00886			0.07828		
	3	0.00665	0.04077	0.01522				0.01255	
	4	0.00428	0.04662	0.01119					0.89962
...	...	...	...	...	...	...	...	...	
∞	1	0.00978	0.15201	0.02132		0.00458			
	2	0.00649	0.13738	0.01239			0.08325		
	3	0.00319	0.04336	0.02128				0.01752	
	4	0.00205	0.04959	0.01565					0.89465

1. The Maximum Likelihood, Lagrange Multipliers with Newton-Raphson and EM Algorithm techniques give the same estimated value for the parameter π_{21} .
2. The estimated value of $Var(\hat{\pi}_{21})$, obtained by the Information matrix, is less than the estimated value obtained by either the Maximum Likelihood method or the results of Louis.

7.3 For the Third Device

Guirguis (2011) performed the third device to measure the proportion π_{31} of the female students, in the Faculty of Commerce, Benha University, having both the two related sensitive characteristics, informal marriage and induced abortion. He used $p_{31} = 0.35$, $p_{32} = 0.30$, $p_{33} = 0.20$ and $p_{34} = 0.15$, and got $m_{31} = 103$, $m_{32} = 95$, $m_{33} = 168$ and $m_{34} = 192$.

Table (7) shows the iterations of the EM algorithm for the third device (see Sections (3) and (6)) and the estimated values of π_{3k} 's, for $p_{31} = 0.35$, $p_{32} = 0.30$, $p_{33} = 0.20$, $p_{34} = 0.15$, $m_{31} = 103$, $m_{32} = 95$, $m_{33} = 168$ and $m_{34} = 192$.

Table (5): the iterations of the EM algorithm of π_{21} at $p_{21} = 0.65$, $p_{22} = 0.35$, $m_{21} = 199$ and $m_{22} = 359$

Iteration	k			$\hat{\pi}_{21}$
		$h = 1$	$h = 2$	
0				0.03
1	1	0.05432	0.94568	0.02991
	2	0.01638	0.98362	
2	1	0.05416	0.94584	0.02982
	2	0.01633	0.98367	
3	1	0.05400	0.94600	0.02973
	2	0.01628	0.98372	
...		...	...	...
...		...	...	...
10	1	0.05298	0.94702	0.02916
	2	0.01596	0.98404	
20	1	0.05167	0.94833	0.02843
	2	0.01555	0.98445	
∞	1	0.04028	0.95972	0.02210
	2	0.01202	0.98798	

Table (6) presents the estimated values for the parameter π_{21} using the Maximum Likelihood, Lagrange Multipliers with Newton-Raphson and EM Algorithm techniques, and the estimated values of $Var(\hat{\pi}_{21})$ using Maximum Likelihood method, Information matrix and Louis' results.

Table (6): The estimated Values of $\hat{\pi}_{21}$ using Maximum Likelihood, Lagrange Multipliers with Newton-Raphson and EM Algorithm techniques and their estimated variances

The Technique	$\hat{\pi}_{21}$	$Var(\hat{\pi}_{21})$
Maximum Likelihood method	0.02210	0.002490
Lagrange Multipliers with Newton-Raphson methods	0.02210	0.001303
EM Algorithm technique	0.02210	
1. Using Louis' results		0.004568
2. Using the Information matrix		0.001303

From Table (6), we find that;

Table (4) presents the estimated values for the parameter π_{11} using the Maximum Likelihood, Lagrange Multipliers with Newton-Raphson and EM Algorithm techniques, and the estimated values of $Var(\hat{\pi}_{11})$ using the Maximum Likelihood, Information matrix and Louis' results.

Table (4): The estimated Values of $\hat{\pi}_{11}$ using Maximum Likelihood, Lagrange Multipliers with Newton-Raphson and EM Algorithm techniques and their estimated variances

The Technique	$\hat{\pi}_{11}$	$Var(\hat{\pi}_{11})$
Maximum Likelihood method	0.08783	0.001448
Lagrange Multipliers with Newton-Raphson methods	0.08783	0.001122
EM Algorithm technique	0.08783	
1. Using Louis' results		0.002495
2. Using the Information matrix		0.001122

From Table (4), we find that;

1. The Maximum Likelihood, Lagrange Multipliers with Newton-Raphson and EM Algorithm techniques give the same estimated value for the parameter π_{11} .
2. The estimated value of $Var(\hat{\pi}_{11})$, by the Information matrix, is less than the obtained estimated value by Maximum Likelihood method or results of Louis.

7.2 For the Second Device

Guirguis (2011) performed the second device to measure the proportion π_{21} of the female students who had abortion, in the Faculty of Commerce, Benha University. He used $p_{21} = 0.65$ and $p_{22} = 0.35$, and got $m_{21} = 199$ and $m_{22} = 359$.

Table (5) shows the iterations of the EM algorithm for the second device (see Sections (3) and (5)) and the estimated values of π_{21} for $p_{21} = 0.65$, $p_{22} = 0.35$, $m_{21} = 199$ and $m_{22} = 359$

its allocation to the different strata, using the proportion allocation, are shown in table (2).

Table (2): The sizes of study population in each stratum and the allocated of the sample to the different strata

Classes	First	Second	Third	Fourth	Total
Female Students	375	1386	1160	1668	4589
Sample	46	168	141	203	558

7.1 For the First Device

Guirguis (2011) performed the first device to measure the proportion π_{11} of the informal marriage for the female students, in the Faculty of Commerce, Benha University. He used $p_{11} = 0.7$ and $p_{12} = 0.3$, and got $m_{11} = 187$ and $m_{12} = 371$.

Table (3) shows the iterations of the EM algorithm to the first device (see Sections (3) and 4) and the estimated values of π_{11} , for $p_{11} = 0.7$, $p_{12} = 0.3$, $m_{11} = 187$ and $m_{12} = 371$

Table (3): the iterations of the EM algorithm of π_{11} at $p_{11} = 0.7$, $p_{12} = 0.3$, $m_{11} = 187$ and $m_{12} = 371$

Iteration	k			$\hat{\pi}_{11}$
		$h = 1$	$h = 2$	
0				0.1
1	1	0.20588	0.79412	0.09922
	2	0.04545	0.95455	
2	1	0.20446	0.79554	0.09849
	2	0.04508	0.95492	
3	1	0.20313	0.79687	0.09781
	2	0.04473	0.95527	
...		...	...	...
...		...	...	...
10	1	0.19601	0.80399	0.09418
	2	0.04286	0.95714	
20	1	0.19019	0.80981	0.09123
	2	0.04135	0.95865	
∞	1	0.18347	0.81653	0.08783
	2	0.03964	0.96036	

$(0 \ 1 \ 0 \ 0)^/$, $(0 \ 0 \ 1 \ 0)^/$ and $(0 \ 0 \ 0 \ 1)^/$ denoting the respondent reports 1, 2, 3 and 4, respectively.

The transformation matrices in use are $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$, $\begin{pmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$,

$\begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{pmatrix}$ and $\begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix}$ with probabilities p_{31} , p_{32} , p_{33} and p_{34} , respectively. Corresponding to equation (3.1), the E step, for the first category, is

$$E[z_{i31} / \text{the } i \text{ th respondent reports 1}] = \frac{p_{31}\pi_{31}^{(t)}}{\lambda_{31}^{(t)}} = z_{i31}^*$$

$$E[z_{i32} / \text{the } i \text{ th respondent reports 2}] = \frac{p_{32}\pi_{31}^{(t)}}{\lambda_{32}^{(t)}} = z_{i312}^*$$

$$E[z_{i33} / \text{the } i \text{ th respondent reports 3}] = \frac{p_{33}\pi_{31}^{(t)}}{\lambda_{33}^{(t)}} = z_{i313}^*$$

$$E[z_{i34} / \text{the } i \text{ th respondent reports 4}] = \frac{p_{34}\pi_{31}^{(t)}}{\lambda_{34}^{(t)}} = z_{i314}^*$$

and corresponding to equation (3.2) the M step is

$$\hat{\pi}_{31}^{(t+1)} = \frac{1}{n} \sum_{i=1}^n z_{i3}^* \quad t = 1, 2, 3, \dots, \infty$$

$$\hat{\pi}_{32}^{(t+1)} = \hat{\pi}_{11} - \pi_{31}^{(t)}$$

$$\hat{\pi}_{33}^{(t+1)} = \hat{\pi}_{21} - \pi_{31}^{(t)}$$

$$\hat{\pi}_{34}^{(t+1)} = 1 - \pi_{31}^{(t)} - \hat{\pi}_{32}^{(t)} - \hat{\pi}_{33}^{(t)}$$

7. The Applied Study

We now apply the EM procedures presented in sections (3)-(6) to the case study of the three-stage randomized response model, suggested by Guirguis (2011) presented in section (2). This study aims to estimate the proportions of the informal marriage, as the first sensitive characteristic, and induced abortion, as the second sensitive characteristic, for the female students in the Faculty of Commerce, Benha University. It also aims to estimate the proportion of the female students having both sensitive characteristics. The selected sample size is $n = 558$. The sample size and

matrices in use are $W_{11} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ with probability p_{11} and $W_{12} = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ with probability p_{12} , respectively. Corresponding to equation (3.1) the E step, for the first category, is

$$E[z_{i11} / \text{the } i \text{ th respondent reports 1}] = \frac{p_{11}\pi_{11}^{(t)}}{\lambda_{11}^{(t)}} = z_{i11}^*$$

$$E[z_{i12} / \text{the } i \text{ th respondent reports 2}] = \frac{p_{12}\pi_{11}^{(t)}}{\lambda_{12}^{(t)}} = z_{i112}^*$$

and corresponding to equation (3.2) the M step is

$$\hat{\pi}_{11}^{(t+1)} = \frac{1}{n} \sum_{i=1}^n z_{i1}^* \quad t = 1, 2, 3, \dots, \infty$$

$$\hat{\pi}_{12}^{(t+1)} = 1 - \hat{\pi}_{11}^{(t+1)}$$

5. ML Estimation of the Parameters of the Second Device

In the second device we have $j = 2$; $c = 2$; $h = 1, 2$. The vector $\underline{y}_{i2}$ can only assume two distinct values namely $(1 \ 0)'$ and $(0 \ 1)'$ denoting the respondent reports 1 and 2, respectively. The transformation matrices in use are $W_{21} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ with probability p_{21} and $W_{22} = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ with probability p_{22} , respectively. Corresponding to equation (3.1) the E step, for the first category, is

$$E[z_{i21} / \text{the } i \text{ th respondent reports 1}] = \frac{p_{21}\pi_{21}^{(t)}}{\lambda_{21}^{(t)}} = z_{i21}^*$$

$$E[z_{i22} / \text{the } i \text{ th respondent reports 2}] = \frac{p_{22}\pi_{21}^{(t)}}{\lambda_{22}^{(t)}} = z_{i212}^*$$

and corresponding to equation (3.2) the M step is

$$\hat{\pi}_{21}^{(t+1)} = \frac{1}{n} \sum_{i=1}^n z_{i2}^* \quad t = 1, 2, 3, \dots, \infty$$

$$\hat{\pi}_{22}^{(t+1)} = 1 - \hat{\pi}_{21}^{(t+1)}$$

6. ML Estimation of the Parameters of the Third Device

In the third device we have $j = 3$; $c = 4$; $h = 1, 2, 3, 4$. The vector $\underline{y}_{i3}$ can only assume four distinct values namely $(1 \ 0 \ 0 \ 0)'$,

$$\begin{aligned}\therefore E[z_{ijh} / \underline{y}_{ij}, \underline{\pi}_j^{(t)}] &= Pr[z_{ijh} = 1 / \underline{y}_{ij}, \underline{\pi}_j^{(t)}] \\ &= \frac{Pr[z_{ijh}, \underline{y}_{ij} / \underline{\pi}_j^{(t)}]}{Pr[\underline{y}_{ij} / \underline{\pi}_j^{(t)}]}\end{aligned}$$

Then, for the first category at the j th device, the E step is

$$E[z_{ijh} / \text{the } i \text{ th respondent reports } h] = \frac{p_{jh}\pi_{j1}^{(t)}}{\lambda_{jh}^{(t)}} = z_{ij1h}^* \quad (3.1)$$

$h = 1, 2, \dots, c$

And the M step is

$$\hat{\pi}_{j1}^{(t+1)} = \frac{1}{n} \sum_{i=1}^n z_{ij1}^* \quad t = 1, 2, 3, \dots, \infty \quad (3.2)$$

The asymptotic sample variances of the estimators $\hat{\pi}_{jk}'s$; $k = 1, 2, \dots, c$ can be estimated by two ways;

1. Using the Louis' results (1982) as follows;

$$I_{j1} = \sum_{i=1}^n z_{ij}^* z_{ij}^{*'} /$$

where z_{ij}^* is the column vector of the elements

$$\left(\frac{z_{ijkh}^*}{\hat{\pi}_{jk}} - \frac{1 - z_{ijkh}^*}{1 - \hat{\pi}_{jk}} \right); \quad k, h = 1, 2, \dots, c$$

from the final iteration of the EM algorithm.

2. Using the Information matrix as follows;

The Log likelihood function may be expressed directly as

$$\text{Log } L(\underline{\pi}_j) = C + \sum_{h=1}^c m_{jh} \cdot \log \lambda_{jh}$$

where C is a constant. Thus, the Information matrix is

$$I_{j2} = -E \left[\frac{\partial^2 L(\underline{\pi}_j)}{\partial \pi_{jk} \partial \pi_{jl}} \right]; \quad k, l = 1, 2, \dots, c$$

4. ML Estimation of the Parameters of the First Device

In the first device we have $j = 1$; $c = 2$; $h = 1, 2$. The vector $\underline{y}_{i1}$ can only assume two distinct values namely $(1 \ 0)'$ and $(0 \ 1)'$ which means that the respondent reports 1 and 2, respectively. The transformation

the true response $\underline{x}_{ij}$ may be determined from the observed response $\underline{y}_{ij}$ by means of the transformation

$$\underline{x}_{ij} = W_{jh} \cdot \underline{y}_{ij} \quad h = 1, 2, \dots, c$$

where W_{jh} is one of a set of $(c \times c)$ transformation matrices. The actual transformations used are chosen according to the probability distribution p_{jh} , $\sum_{h=1}^c p_{jh} = 1$. The set of transformation matrices and their associated probabilities essentially define the particular randomized response in each device.

If $\underline{z}_{ij}$ is $(c \times 1)$ vector of similar structure to $\underline{x}_{ij}$ above indicating which transformation matrix is used by the i th respondent, then the actual response $\underline{x}_{ij}$ may be determined from vector $\underline{y}_{ij}$ by means of the transformation

$$\underline{x}_{ij} = \left[\sum_{h=1}^c z_{ijh} W_{jh} \right] \underline{y}_{ij}$$

In EM algorithm $\underline{z}_{ij}$ corresponds to the missing data on the sensitive characteristic level of the respondent. Then, we can represent the log likelihood function for $\underline{\pi}_j$ as

$$\begin{aligned} \text{Log } L(\underline{\pi}_j) &= \sum_{h=1}^c z_{ijh} \text{Log } p_{jh} + \sum_{k=1}^c \left(\sum_{h=1}^c z_{ijh} W_{jh} \right) \cdot \underline{y}_{ij} \text{Log } \pi_{jk} \\ &= C + \sum_{k=1}^c \left(\sum_{h=1}^c z_{ijh} W_{jh} \right) \cdot \underline{y}_{ij} \text{Log } \pi_{jk} \end{aligned}$$

Then, the complete data likelihood for the sample is

$$\text{Log } L(\underline{\pi}_j) = C + \sum_{i=1}^n \sum_{k=1}^c \left(\sum_{h=1}^c z_{ijh} W_{jh} \right) \cdot \underline{y}_{ij} \text{Log } \pi_{jk}$$

Then, the expected complete data likelihood at the t th iteration is

$$E \left[\text{Log } L(\underline{\pi}_j / \underline{\pi}_j^{(t)}) \right] = C + \sum_{i=1}^n \sum_{k=1}^c \left[\sum_{h=1}^c E(z_{ijh} / \underline{y}_{ij}, \underline{\pi}_j^{(t)}) \right] \text{Log } \pi_{jk}$$

Then, the E step consists of estimating the complete data sufficient statistics $\underline{z}_{ij}$ with its expectation $\underline{z}_{ij}^*$ conditional on $\underline{y}_{ij}$ and the current parameter $\underline{\pi}_j^{(t)}$

$\underline{\pi}_3 = (\pi_{31} \ \pi_{32} \ \pi_{33} \ \pi_{34})'$ by solving the Non-Linear programming problem

Max. $\chi_3 = \sum_{h=1}^4 m_{3h} \text{Log } \lambda_{3h}$
with respect to the π_{3k} 's, subject to

$$\pi_{31} + \pi_{32} = \pi_{11}$$

$$\pi_{31} + \pi_{33} = \pi_{21}$$

$$\sum_{k=1}^4 \pi_{3k} = 1$$

and the nonnegative constraints

$$\pi_{3k} \geq 0 \quad k = 1, 2, 3, 4$$

by using Lagrange Multipliers and Newton-Raphson techniques. In fact, estimating the parameters of the first and second randomization devices, by Maximum Likelihood method and Lagrange Multipliers with Newton-Raphson techniques, is simple and easy and give the same estimated values of the parameters of these devices. Estimating the parameters of the third randomization device, using Lagrange Multipliers and Newton-Raphson techniques, is very difficult (See Guirguis (2011)). This means that the estimation of the parameters, of the model, using the Lagrange Multipliers and Newton-Raphson techniques, is difficult if the number of categories of the sensitive characteristic, or the number of sensitive characteristics is more than one. Therefore, we suggest using the EM algorithm to find the ML estimates of the parameters of the model as presented in the following sections:

3. Estimation of the Parameters of the Suggested Model

Consider the sensitive characteristic, measured by the j th device; $= 1, 2, 3$, has c categories of which at most $c - 1$ are stigmatizing.

Let

the population proportion for category k be π_{jk} where $\sum_{k=1}^c \pi_{jk} = 1$ and our objective is to estimate the π_{jk} 's.

$\underline{x}_{ij}$ be the true response of the i th respondent in the j th device, where $\underline{x}_{ij}$ is a $(c \times 1)$ vector with all elements but one equal to zero, such that the k th element being unity identifies the i th respondent belongs to the k th category; $i = 1, 2, \dots, n$; $j = 1, 2, 3$; $k = 1, 2, \dots, c$.

In fact, the randomized response is one which employs a randomizing device to produce a reported response $\underline{y}_{ij}$ rather than the true response $\underline{x}_{ij}$. So, we assume that $\underline{y}_{ij}$ be a $(c \times 1)$ vector of similar structure to $\underline{x}_{ij}$. Then,

$$\text{Max.} \quad \chi_2 = \sum_{h=1}^2 m_{2h} \log \lambda_{2h}$$

with respect to the π_{2k} 's; $k = 1, 2$ subject to

$$\pi_{21} + \pi_{22} = 1 \text{ and } \pi_{21}, \pi_{22} \geq 0$$

2.3 The Third Randomization Device (Third Stage)

Suppose that every individual in the same study population belongs to one and only one of four related mutually exclusive groups; Group I: individuals having both related sensitive characteristics A_1 and B_1 at the same time; Group II: individuals having the first sensitive characteristic A_1 and not having the second sensitive characteristic B_2 ; Group III: individuals not having the first sensitive characteristic A_2 and having the second sensitive characteristic B_1 ; Group IV: individuals not having any of the two related sensitive characteristics A_2 and B_2 . Also, we assume that the true proportions of these groups are π_{31} , π_{32} , π_{33} and π_{34} , respectively. The device consists of four lists, and each list includes the following four statements; (1) I am a member of groups A_1 and B_1 , (A_1B_1); (2) I am a member of groups A_1 and B_2 , (A_1B_2); (3) I am a member of groups A_2 and B_1 , (A_2B_1); (4) I am a member of groups A_2 and B_2 , (A_2B_2), as shown in the following table

Table (1): The different lists used in the third randomization device

First List	Second List	Third List	Fourth List
1. A_1B_1			
2. A_1B_2			

The probabilities of selection of these lists are p_{31} , p_{32} , p_{33} and p_{34} , respectively. By using the same procedures of the first and second randomization devices, with

$$x_{i3} = h \text{ if the } i \text{th respondent reports a "h" answer } h = 1, 2, 3, 4$$

$$\therefore \Pr(x_{i3} = 1) = p_{31}\pi_{31} + p_{32}\pi_{32} + p_{33}\pi_{33} + p_{34}\pi_{34} = \lambda_{31} \quad i = 1, 2, \dots, m_{31},$$

$$\Pr(x_{i3} = 2) = p_{31}\pi_{32} + p_{32}\pi_{31} + p_{33}\pi_{34} + p_{34}\pi_{33} = \lambda_{32} \quad i = 1, 2, \dots, m_{32},$$

$$\Pr(x_{i3} = 3) = p_{31}\pi_{33} + p_{32}\pi_{34} + p_{33}\pi_{31} + p_{34}\pi_{32} = \lambda_{33} \quad i = 1, 2, \dots, m_{33},$$

$$\Pr(x_{i3} = 4) = p_{31}\pi_{34} + p_{32}\pi_{33} + p_{33}\pi_{32} + p_{34}\pi_{31} = \lambda_{34} \quad i = 1, 2, \dots, m_{34}.$$

Guirguis (2011) found that the Maximum Likelihood method give inadmissible estimates of the parameters of this device, so he calculated the ML estimator for the vector $\underline{\pi}_3$, where

Guirguis (2011) used the Maximum Likelihood method to find the ML estimator for the vector $\underline{\pi}_1$. Also, he used the Lagrange Multipliers with Newton-Raphson techniques to solve the following problem

$$\text{Max.} \quad \chi_1 = \sum_{h=1}^2 m_{1h} \text{Log } \lambda_{1h}$$

with respect to the π_{1k} 's; $k = 1, 2$ subject to

$$\pi_{11} + \pi_{12} = 1 \text{ and } \pi_{11}, \pi_{12} \geq 0$$

2.2 The Second Randomization Device (Second Stage)

We assume that, for the same population of the previous case, a proportion, π_{21} , of some individuals of population possess a second sensitive characteristic, B_1 , while the remainder individuals of the population do not possess this characteristic, B_2 , with proportion $\pi_{22} = 1 - \pi_{21}$, and we want to estimate π_{21} . The second randomization device has the same procedures of the first randomization device. The first list includes the statements: (1) I am a member of group B_1 , (2) I am a member of group B_2 . The second list includes the statements: (1) I am a member of group B_2 , (2) I am a member of group B_1 . The probabilities of selection of these lists are p_{21} and p_{22} , respectively. The respondent is required to randomly select only one list and reads the selected list carefully then reports either "1" or "2" according to whether he (or she) has the second sensitive characteristic or not. Let

$$x_{i2} = h \text{ if the } i \text{th respondent reports a "h" answer, } h = 1, 2$$

Then, the probability that the i th respondent reports a "1" answer is

$$\text{Pr}(x_{i2} = 1) = p_{21}\pi_{21} + p_{22}\pi_{22} = \lambda_{21} \quad i = 1, 2, 3, \dots, m_{21}.$$

The probability that the i th respondent reports a "2" answer is

$$\text{Pr}(x_{i2} = 2) = p_{21}\pi_{22} + p_{22}\pi_{21} = \lambda_{22} \quad i = 1, 2, 3, \dots, m_{22}.$$

In matrix notation, we have

$$P_2 \underline{\pi}_2 = \underline{\lambda}_2$$

where $\underline{\pi}_2$ and $\underline{\lambda}_2$ are column vectors of π_{21} and π_{22} , and λ_{2h} ; $h = 1, 2$ respectively, and

$$P_2 = \begin{bmatrix} p_{21} & p_{22} \\ p_{22} & p_{21} \end{bmatrix}$$

Guirguis (2011) used the Maximum Likelihood method to find ML estimators for the vector $\underline{\pi}_2$. Also, he used the Lagrange Multipliers with Newton-Raphson techniques to solve the following problem

individuals having the sensitive characteristic B among those having the sensitive characteristic A and the population proportion of the individuals having the sensitive characteristic B among those not having the sensitive characteristic A . It is required to estimate, from a sample survey, these population proportions. Therefore, a simple random sample of size, say n , is drawn with replacement from that population. The respondents belonging to the sample are subject to perform three different randomization devices (each device represents a stage), and each randomization device has a different predetermined probabilities.

2.1 The First Randomization Device (First Stage)

Consider the case where a proportion, π_{11} , of some individuals of the population possess a first sensitive characteristic, A_1 , while the remainder individuals of the population do not possess this characteristic, A_2 , with proportion $\pi_{12} = 1 - \pi_{11}$, and we want to estimate π_{11} . With the aid of the randomization device, the respondent is invited to randomly select one of the following lists by chance. The first list includes the statements: (1) I am a member of group A_1 , (2) I am a member of group A_2 . The second list includes the statements: (1) I am a member of group A_2 , (2) I am a member of group A_1 . The probabilities of the selection of these lists are p_{11} and p_{12} , respectively. The respondent is required to randomly select only one list and reads the selected list carefully then reports either "1" or "2" according to whether he (or she) has the first sensitive characteristic or not. Let

$$x_{i1} = h \text{ if the } i \text{th respondent reports a "h" answer, } h = 1, 2$$

Then, the probability that the i th respondent reports a "1" answer is

$$Pr(x_{i1} = 1) = p_{11}\pi_{11} + p_{12}\pi_{12} = \lambda_{11} \quad i = 1, 2, 3, \dots, m_{11}.$$

The probability that the i th respondent reports a "2" answer is

$$Pr(x_{i1} = 2) = p_{11}\pi_{12} + p_{12}\pi_{11} = \lambda_{12} \quad i = 1, 2, 3, \dots, m_{12},$$

where

$$n = m_{11} + m_{12}$$

In matrix notation, we have

$$P_1 \underline{\pi}_1 = \underline{\lambda}_1$$

where $\underline{\pi}_1$ and $\underline{\lambda}_1$ are column vectors of π_{11} and π_{12} , and $\lambda_{1h}; h = 1, 2$ respectively, and

$$P_1 = \begin{bmatrix} p_{11} & p_{12} \\ p_{12} & p_{11} \end{bmatrix}$$

Proportions of the individuals having two related sensitive characteristics, such as informal marriage and induced abortion, the income and proneness to tax evasion, ... , etc. To avoid the estimation mentioned problem, he used the Non-Linear programming technique with Newton-Raphson method to estimate the parameters of the suggested model. Estimating the parameters of the model, using Non-linear programming technique with Newton-Raphson method, is very difficult, especially, when the number of categories of each sensitive characteristic, or the number of sensitive characteristics, is more than one. Therefore, we suggest using the EM algorithm, which was presented by Dempster et al. (1977), to find the ML estimates of the parameters of the model suggested by Guirguis (2011), since it is simpler and easier whatever the number of sensitive characteristics or the number of categories of each sensitive characteristic. Bourke and Moran (1984) and Guirguis (2007) used the EM Algorithm to find ML estimates of the parameters of Warner (1965) and Christofides (2003) models respectively.

The present research is directed towards introducing a numerical method to compute the ML estimates of the parameters of the Guirguis' model. So, the remainder of the present research is organized as follows: Section 2 presents the three-stage randomized response model suggested by Guirguis (2011). A general formulation of an EM algorithm procedures to estimate the parameters of the suggested model is presented in section 3. The EM algorithm procedures to estimate the parameter of the first device " first-stage " are constructed in section 4. The EM algorithm procedures to estimate the parameter of the second device " second-stage " are designed in section 5. The EM algorithm procedures to estimate the parameters of the third device " third-stage " are sketched in section 6. An application to the EM algorithm procedures, to the same case study in Guirguis (2011), of the informal marriage and induced abortion among the female students in the University level and a comparison between the Maximum Likelihood estimates of the parameters and their estimated variances of the model, using Maximum Likelihood, Non-Linear programming with Newton-Raphson and EM algorithm techniques, are given in section 7. Conclusions are drawn in section 8.

2. The Three-Stage Randomized Response Model

Suppose, some individuals, in a certain population, have two related sensitive characteristics A and B , and we want to estimate the population proportion of the individuals having the first sensitive characteristic A , the population proportion of the individuals having the second sensitive characteristic B , the population proportion of the individuals having both sensitive characteristics A and B , the population proportion of the

Estimating the Parameters of the Three-Stage Randomized Response Model Using the EM Algorithm

Farid Naguib Guirguis

Abstract

Maximum Likelihood (ML) estimates of the parameters of the three-stage randomized response model, suggested by Guirguis (2011), are presented. Since the Maximum Likelihood method may give inadmissible estimates of the parameters of the randomized response models, So Guirguis (2011) used the methods of Non-Linear programming with Newton-Raphson to estimate the parameters of the suggested model by him. Estimating the parameters of the model, using Lagrange Multipliers with Newton-Raphson methods, is very difficult, especially, when the number of parameters of a sensitive characteristic, or the number of sensitive characteristics, is more than one. So application of the EM algorithm is presented to find the Maximum Likelihood estimates of the parameters of the model. It is shown that one can apply the EM algorithm by viewing the observations from the model as incomplete data. A general formulation of EM algorithm is sketched for the model. An application to the EM algorithm procedures, to the same case study in Guirguis (2011), of the informal marriage and induced abortion among the female students in the University level is given. Comparison between the Maximum Likelihood estimates of the parameters and their estimated variances of the model, using Maximum Likelihood, Lagrange Multipliers with Newton-Raphson and EM algorithm techniques, is given.

Keywords: Randomized response; Latin square measurement design; Three-stage randomized response model; EM Algorithm

1. Introduction

Randomized response (RR) is a survey technique for reducing response bias arising from respondents concern over revealing sensitive information. Warner (1965) presented the first model, of the randomized response, for estimating the population proportion, π , of individuals having a sensitive characteristic in the given population. Other randomized response models were proposed by various other authors. These models either improve Warner's model, make an extension of the Warner's RR model, or provide alternative models (see Guirguis (2011)). In fact, many of the presented estimators for π in the RR models were claimed to be Maximum Likelihood (ML), although they may produce inadmissible estimates, as pointed out in Singh (1976) and Kim et al. (2006). Guirguis (2011) presented a three-stage randomized response model for estimating the

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$$(p_1^2 p_3 p_4 + p_1 p_2 p_3^2 + p_1 p_2 p_4^2 + p_2^2 p_3 p_4) \pi_{12}^3 + (p_1^2 p_2 p_4 + p_1 p_2^2 p_3 + p_1 p_3 p_4^2 + p_2 p_3^2 p_4) \pi_{21}^3 + (p_1^2 p_2 p_3 + p_1 p_2^2 p_4 + p_1 p_3^2 p_4 + p_2 p_3 p_4^2) \pi_{22}^3]$$

$$\begin{aligned} c_2 = & [n_1 p_1 (p_2 p_3^2 + p_2 p_4^2 + p_1 p_3 p_4) + n_2 p_2 (p_1 p_3^2 + p_1 p_4^2 + p_2 p_3 p_4) + n_3 p_3 \cdot \\ & (p_1^2 p_4 + p_2^2 p_4 + p_1 p_2 p_3) + n_4 p_4 (p_1^2 p_3 + p_2^2 p_3 + p_1 p_2 p_4)] \pi_{12} + \\ & [n_1 p_1 (p_2^2 p_3 + p_3 p_4^2 + p_1 p_2 p_4) + n_2 p_2 (p_1^2 p_4 + p_3^2 p_4 + p_1 p_2 p_3) + n_3 p_3 \cdot \\ & (p_1 p_2^2 + p_1 p_4^2 + p_2 p_3 p_4) + n_4 p_4 (p_1^2 p_2 + p_2 p_3^2 + p_1 p_3 p_4)] \pi_{21} + \\ & [n_1 p_1 (p_2^2 p_4 + p_3^2 p_4 + p_1 p_2 p_3) + n_2 p_2 (p_1^2 p_3 + p_3 p_4^2 + p_1 p_2 p_4) + n_3 p_3 \cdot \\ & (p_1^2 p_2 + p_2 p_4^2 + p_1 p_3 p_4) + n_4 p_4 (p_1 p_2^2 + p_1 p_3^2 + p_2 p_3 p_4)] \pi_{22} - \\ & (\gamma_1 + \gamma_2 + \gamma_3) [(p_1^3 p_4 + p_1 p_4^3 + p_2 p_3^3 + p_2^3 p_3 + 2 p_1^2 p_2 p_3 + 2 p_1 p_2^2 p_4 + \\ & 2 p_1 p_3^2 p_4 + 2 p_2 p_3 p_4^2) \pi_{12} \pi_{21} + (p_1^3 p_3 + p_1 p_3^3 + p_2^3 p_4 + p_2 p_4^3 + 2 p_1^2 p_2 p_4 + \\ & 2 p_1 p_3 p_4^2 + 2 p_1 p_2^2 p_3 + 2 p_2 p_3^2 p_4) \pi_{12} \pi_{22} + (p_1^3 p_2 + p_1 p_2^3 + p_3^3 p_4 + p_3 p_4^3 + \\ & 2 p_1^2 p_3 p_4 + 2 p_1 p_2 p_3^2 + 2 p_1 p_2 p_4^2 + 2 p_2^2 p_3 p_4) \pi_{21} \pi_{22} + \\ & (p_1^2 p_3^2 + p_1^2 p_4^2 + p_2^2 p_3^2 + p_2^2 p_4^2 + 2 p_1 p_2 p_3 p_4) \pi_{12}^2 + (p_1^2 p_2^2 + p_1^2 p_4^2 + p_2^2 p_3^2 \\ & + p_2^2 p_4^2 + 2 p_1 p_2 p_3 p_4) \pi_{21}^2 + (p_1^2 p_2^2 + p_1^2 p_3^2 + p_2^2 p_4^2 + p_3^2 p_4^2 + 2 p_1 p_2 p_3 p_4) \pi_{22}^2] \end{aligned}$$

$$\begin{aligned} c_3 = & n p_1 p_2 p_3 p_4 - (\gamma_1 + \gamma_2 + \gamma_3) [(p_1^2 p_3 p_4 + p_1 p_2 p_3^2 + p_1 p_2 p_4^2 + p_2^2 p_3 p_4) \pi_{12} \\ & + (p_1^2 p_2 p_4 + p_1 p_2^2 p_3 + p_2 p_3^2 p_4 + p_1 p_3 p_4^2) \pi_{21} + (p_1^2 p_2 p_3 + p_1 p_2^2 p_4 + p_1 p_3^2 p_4 \\ & + p_2 p_3 p_4^2) \pi_{22}] \end{aligned}$$

$$c_4 = -(\gamma_1 + \gamma_2 + \gamma_3) p_1 p_2 p_3 p_4$$

$$\begin{aligned}
 & + p_1 p_3^2 + p_2 p_3 p_4) + n_4 p_4 (p_1^2 p_2 + p_2 p_4^2 + p_1 p_3 p_4)] \pi_{12}^2 \pi_{21} + \\
 & [n_1 p_1 (p_1^2 p_2 + p_2 p_4^2 + p_1 p_3 p_4) + n_2 p_2 (p_1 p_2^2 + p_1 p_3^2 + p_2 p_3 p_4) + n_3 p_3 (p_2^2 p_4 \\
 & + p_3^2 p_4 + p_1 p_2 p_3) + n_4 p_4 (p_1^2 p_3 + p_3 p_4^2 + p_1 p_2 p_4)] \pi_{12} \pi_{21}^2 + \\
 & [n_1 p_1 (p_1^2 p_4 + p_2^2 p_4 + p_1 p_2 p_3) + n_2 p_2 (p_1^2 p_3 + p_2^2 p_3 + p_1 p_2 p_4) + n_3 p_3 (p_2 p_3^2 \\
 & + p_2 p_4^2 + p_1 p_3 p_4) + n_4 p_4 (p_1 p_3^2 + p_1 p_4^2 + p_2 p_3 p_4)] \pi_{21}^2 \pi_{22} + \\
 & [n_1 p_1 (p_1^2 p_3 + p_2^2 p_3 + p_1 p_2 p_4) + n_2 p_2 (p_1^2 p_4 + p_2^2 p_4 + p_1 p_2 p_3) + n_3 p_3 (p_1 p_3^2 \\
 & + p_1 p_4^2 + p_2 p_3 p_4) + n_4 p_4 (p_2 p_3^2 + p_2 p_4^2 + p_1 p_3 p_4)] \pi_{21} \pi_{22}^2 + \\
 & [n_1 p_1 (p_1^2 p_4 + p_3^2 p_4 + p_1 p_2 p_3) + n_2 p_2 (p_2^2 p_3 + p_3 p_4^2 + p_1 p_2 p_4) + n_3 p_3 (p_1^2 p_2 \\
 & + p_2 p_3^2 + p_1 p_3 p_4) + n_4 p_4 (p_1 p_2^2 + p_1 p_4^2 + p_2 p_3 p_4)] \pi_{12}^2 \pi_{22} + \\
 & [n_1 p_1 (p_1^2 p_2 + p_2 p_3^2 + p_1 p_3 p_4) + n_2 p_2 (p_1 p_2^2 + p_1 p_4^2 + p_2 p_3 p_4) + n_3 p_3 (p_1^2 p_4 \\
 & + p_3^2 p_4 + p_1 p_2 p_3) + n_4 p_4 (p_2^2 p_3 + p_3 p_4^2 + p_1 p_2 p_4)] \pi_{12} \pi_{22}^2 + \\
 & [n_1 p_1^2 p_3 p_4 + n_2 p_2^2 p_3 p_4 + n_3 p_1 p_2 p_3^2 + n_4 p_1 p_2 p_4^2] \pi_{12}^3 + [n_1 p_1^2 p_2 p_4 + \\
 & n_2 p_1 p_2^2 p_3 + n_3 p_2 p_3^2 p_4 + n_4 p_1 p_3 p_4^2] \pi_{21}^3 + [n_1 p_1^2 p_2 p_3 + n_2 p_1 p_2^2 p_4 + \\
 & n_3 p_1 p_3^2 p_4 + n_4 p_2 p_3 p_4^2] \pi_{22}^3 - \\
 & (\gamma_1 + \gamma_2 + \gamma_3) [(p_1^3 p_2 + p_1 p_2^3 + p_3^3 p_4 + p_3 p_4^3 + 2 p_1^2 p_3 p_4 + 2 p_1 p_2 p_3^2 + \\
 & 2 p_1 p_2 p_4^2 + 2 p_2^2 p_3 p_4) \pi_{12}^2 \pi_{21} \pi_{22} + (p_1^3 p_3 + p_1 p_3^3 + p_2^3 p_4 + p_2 p_4^3 + 2 p_1^2 p_2 p_4 \\
 & + 2 p_1 p_2^2 p_3 + 2 p_1 p_3 p_4^2 + 2 p_2 p_3^2 p_4) \pi_{12} \pi_{21}^2 \pi_{22} + (p_1^3 p_4 + p_1 p_4^3 + p_2^3 p_3 + \\
 & p_2 p_3^3 + 2 p_1^2 p_2 p_3 + 2 p_1 p_2^2 p_4 + 2 p_1 p_3^2 p_4 + 2 p_2 p_3 p_4^2) \pi_{12} \pi_{21} \pi_{22}^2 + \\
 & (p_1^2 p_2^2 + p_1^2 p_3^2 + p_2^2 p_4^2 + p_3^2 p_4^2 + 2 p_1 p_2 p_3 p_4) \pi_{12}^2 \pi_{21}^2 + (p_1^2 p_2^2 + p_1^2 p_4^2 + \\
 & p_2^2 p_3^2 + p_3^2 p_4^2 + 2 p_1 p_2 p_3 p_4) \pi_{12}^2 \pi_{22}^2 + (p_1^2 p_3^2 + p_1^2 p_4^2 + p_2^2 p_3^2 + p_2^2 p_4^2 + \\
 & 2 p_1 p_2 p_3 p_4) \pi_{21}^2 \pi_{22}^2 + \\
 & (p_1^2 p_2 p_3 + p_1 p_2^2 p_4 + p_1 p_3^2 p_4 + p_2 p_3 p_4^2) (\pi_{12} \pi_{21}^3 + \pi_{12}^3 \pi_{21}) + (p_1^2 p_2 p_4 + \\
 & p_1 p_2^2 p_3 + p_1 p_3 p_4^2 + p_2 p_3^2 p_4) (\pi_{12} \pi_{22}^3 + \pi_{12}^3 \pi_{22}) + \\
 & (p_1^2 p_3 p_4 + p_2^2 p_3 p_4 + p_1 p_2 p_3^2 + p_1 p_2 p_4^2) (\pi_{21} \pi_{22}^3 + \pi_{21}^3 \pi_{22}) + \\
 & (p_1 p_2 p_3 p_4) (\pi_{12}^4 + \pi_{21}^4 + \pi_{22}^4)] \\
 c_1 = & [(p_3^3 + p_1^2 p_3 + p_2^2 p_3 + p_3 p_4^2 + 2 p_1 p_2 p_4) (n_1 p_1 \pi_{12} \pi_{22} + n_2 p_2 \pi_{12} \pi_{21} + \\
 & n_4 p_4 \pi_{21} \pi_{22})] + [(p_4^3 + p_1^2 p_4 + p_2^2 p_4 + p_3^2 p_4 + 2 p_1 p_2 p_3) (n_1 p_1 \pi_{12} \pi_{21} + \\
 & n_2 p_2 \pi_{12} \pi_{22} + n_3 p_3 \pi_{21} \pi_{22})] + [(p_2^3 + p_1^2 p_2 + p_2 p_3^2 + p_2 p_4^2 + 2 p_1 p_3 p_4) \cdot \\
 & (n_1 p_1 \pi_{21} \pi_{22} + n_3 p_3 \pi_{12} \pi_{21} + n_4 p_4 \pi_{12} \pi_{22})] + [(p_1^3 + p_1 p_2^2 + p_1 p_3^2 + p_1 p_4^2 \\
 & + 2 p_2 p_3 p_4) (n_2 p_2 \pi_{21} \pi_{22} + n_3 p_3 \pi_{12} \pi_{22} + n_4 p_4 \pi_{12} \pi_{21})] + \\
 & [n_1 p_1 (p_1 p_3^2 + p_1 p_4^2 + p_2 p_3 p_4) + n_2 p_2 (p_2 p_3^2 + p_2 p_4^2 + p_1 p_3 p_4) + n_3 p_3 (p_1^2 p_3 \\
 & p_2^2 p_3 + p_1 p_2 p_4) + n_4 p_4 (p_1^2 p_4 + p_2^2 p_4 + p_1 p_2 p_3)] \pi_{12}^2 + \\
 & [n_1 p_1 (p_1 p_2^2 + p_1 p_4^2 + p_2 p_3 p_4) + n_2 p_2 (p_1^2 p_2 + p_2 p_3^2 + p_1 p_3 p_4) + n_3 p_3 (p_2^2 p_3 \\
 & p_3 p_4^2 + p_1 p_2 p_4) + n_4 p_4 (p_1^2 p_4 + p_3^2 p_4 + p_1 p_2 p_3)] \pi_{21}^2 + \\
 & [n_1 p_1 (p_1 p_2^2 + p_1 p_3^2 + p_2 p_3 p_4) + n_2 p_2 (p_1^2 p_2 + p_2 p_4^2 + p_1 p_3 p_4) + n_3 p_3 (p_1^2 p_3 \\
 & p_3 p_4^2 + p_1 p_2 p_4) + n_4 p_4 (p_2^2 p_4 + p_3^2 p_4 + p_1 p_2 p_3)] \pi_{22}^2 - \\
 & (\gamma_1 + \gamma_2 + \gamma_3) [(p_1^4 + p_2^4 + p_3^4 + p_4^4 + 2 p_1^2 p_2^2 + 2 p_1^2 p_3^2 + 2 p_1^2 p_4^2 + 2 p_2^2 p_3^2 + \\
 & 2 p_2^2 p_4^2 + 2 p_3^2 p_4^2 + 8 p_1 p_2 p_3 p_4) \pi_{12} \pi_{21} \pi_{22} + \\
 & (p_1^3 p_4 + p_1 p_4^3 + p_2^3 p_3 + p_2 p_3^3 + 2 p_1^2 p_2 p_3 + 2 p_1 p_2^2 p_4 + 2 p_1 p_3^2 p_4 + 2 p_2 p_3 p_4^2) \cdot \\
 & (\pi_{12}^2 \pi_{22} + \pi_{21}^2 \pi_{22}) + (p_1^3 p_3 + p_1 p_3^3 + p_2^3 p_4 + p_2 p_4^3 + 2 p_1^2 p_2 p_4 + 2 p_1 p_2^2 p_3 + \\
 & 2 p_1 p_3 p_4^2 + 2 p_2 p_3^2 p_4) (\pi_{12}^2 \pi_{21} + \pi_{21}^2 \pi_{22}) + (p_1^3 p_2 + p_1 p_2^3 + p_3^3 p_4 + p_3 p_4^3 + \\
 & 2 p_1^2 p_3 p_4 + 2 p_2^2 p_3 p_4 + 2 p_1 p_2 p_3^2 + 2 p_1 p_2 p_4^2) (\pi_{12} \pi_{21}^2 + \pi_{12}^2 \pi_{22}) +
 \end{aligned}$$

$$\frac{\partial g_3}{\partial \pi_{12}} = \frac{n_1 p_2}{\lambda_1} + \frac{n_2 p_1}{\lambda_2} + \frac{n_3 p_4}{\lambda_3} + \frac{n_4 p_3}{\lambda_4} - \gamma_1 - \gamma_2$$

$$\frac{\partial g_3}{\partial \pi_{21}} = \frac{n_1 p_3}{\lambda_1} + \frac{n_2 p_4}{\lambda_2} + \frac{n_3 p_1}{\lambda_3} + \frac{n_4 p_2}{\lambda_4} - \gamma_1 - \gamma_3$$

$$\frac{\partial g_3}{\partial \pi_{22}} = \frac{n_1 p_4}{\lambda_1} + \frac{n_2 p_3}{\lambda_2} + \frac{n_3 p_2}{\lambda_3} + \frac{n_4 p_1}{\lambda_4} - \gamma_1$$

$$\frac{\partial g_3}{\partial \gamma_1} = -(\pi_{11} + \pi_{12} - \pi_{A_1})$$

$$\frac{\partial g_3}{\partial \gamma_2} = -(\pi_{11} + \pi_{21} - \pi_{B_1})$$

$$\frac{\partial g_3}{\partial \gamma_3} = -(\pi_{11} + \pi_{12} + \pi_{21} + \pi_{22} - 1)$$

$$\frac{\partial^2 g_3}{\partial \pi_{11}^2} = -\frac{n_1 p_1^2}{\lambda_1^2} - \frac{n_2 p_2^2}{\lambda_2^2} - \frac{n_3 p_3^2}{\lambda_3^2} - \frac{n_4 p_4^2}{\lambda_4^2}$$

$$\frac{\partial^2 g_3}{\partial \pi_{12}^2} = -\frac{n_1 p_2^2}{\lambda_1^2} - \frac{n_2 p_1^2}{\lambda_2^2} - \frac{n_3 p_4^2}{\lambda_3^2} - \frac{n_4 p_3^2}{\lambda_4^2}$$

$$\frac{\partial^2 g_3}{\partial \pi_{21}^2} = -\frac{n_1 p_3^2}{\lambda_1^2} - \frac{n_2 p_4^2}{\lambda_2^2} - \frac{n_3 p_1^2}{\lambda_3^2} - \frac{n_4 p_2^2}{\lambda_4^2}$$

$$\frac{\partial^2 g_3}{\partial \pi_{22}^2} = -\frac{n_1 p_4^2}{\lambda_1^2} - \frac{n_2 p_3^2}{\lambda_2^2} - \frac{n_3 p_2^2}{\lambda_3^2} - \frac{n_4 p_1^2}{\lambda_4^2}$$

$$\frac{\partial^2 g_3}{\partial \pi_{11} \partial \pi_{12}} = \frac{\partial^2 g_3}{\partial \pi_{12} \partial \pi_{11}} = -\frac{n_1 p_1 p_2}{\lambda_1^2} - \frac{n_2 p_1 p_2}{\lambda_2^2} - \frac{n_3 p_3 p_4}{\lambda_3^2} - \frac{n_4 p_3 p_4}{\lambda_4^2}$$

$$\frac{\partial^2 g_3}{\partial \pi_{11} \partial \pi_{21}} = \frac{\partial^2 g_3}{\partial \pi_{21} \partial \pi_{11}} = -\frac{n_1 p_1 p_3}{\lambda_1^2} - \frac{n_2 p_2 p_4}{\lambda_2^2} - \frac{n_3 p_1 p_3}{\lambda_3^2} - \frac{n_4 p_2 p_4}{\lambda_4^2}$$

$$\frac{\partial^2 g_3}{\partial \pi_{11} \partial \pi_{22}} = \frac{\partial^2 g_3}{\partial \pi_{22} \partial \pi_{11}} = -\frac{n_1 p_1 p_4}{\lambda_1^2} - \frac{n_2 p_2 p_3}{\lambda_2^2} - \frac{n_3 p_2 p_3}{\lambda_3^2} - \frac{n_4 p_1 p_4}{\lambda_4^2}$$

$$\frac{\partial^2 g_3}{\partial \pi_{12} \partial \pi_{21}} = \frac{\partial^2 g_3}{\partial \pi_{21} \partial \pi_{12}} = -\frac{n_1 p_2 p_3}{\lambda_1^2} - \frac{n_2 p_1 p_4}{\lambda_2^2} - \frac{n_3 p_1 p_4}{\lambda_3^2} - \frac{n_4 p_2 p_3}{\lambda_4^2}$$

$$\frac{\partial^2 g_3}{\partial \pi_{12} \partial \pi_{22}} = \frac{\partial^2 g_3}{\partial \pi_{22} \partial \pi_{12}} = -\frac{n_1 p_2 p_4}{\lambda_1^2} - \frac{n_2 p_1 p_3}{\lambda_2^2} - \frac{n_3 p_2 p_4}{\lambda_3^2} - \frac{n_4 p_1 p_3}{\lambda_4^2}$$

$$\frac{\partial^2 g_3}{\partial \pi_{21} \partial \pi_{22}} = \frac{\partial^2 g_3}{\partial \pi_{22} \partial \pi_{21}} = -\frac{n_1 p_3 p_4}{\lambda_1^2} - \frac{n_2 p_3 p_4}{\lambda_2^2} - \frac{n_3 p_1 p_2}{\lambda_3^2} - \frac{n_4 p_1 p_2}{\lambda_4^2}$$

The terms of c_0, c_1, c_2, c_3 and c_4 of equation (5.11) are

$$\begin{aligned} c_0 = & [n_1 p_1 (p_1^3 + p_1 p_2^2 + p_1 p_3^2 + p_1 p_4^2 + 2 p_2 p_3 p_4) + n_2 p_2 (p_2^3 + p_1^2 p_2 + p_2 p_3^2 + \\ & p_2 p_4^2 + 2 p_1 p_3 p_4) + n_3 p_3 (p_3^3 + p_1^2 p_3 + p_2^2 p_3 + p_3 p_4^2 + 2 p_1 p_2 p_4) + n_4 p_4 (p_4^3 \\ & + p_1^2 p_4 + p_2^2 p_4 + p_3^2 p_4 + 2 p_1 p_2 p_3)] \pi_{12} \pi_{21} \pi_{22} + \\ & [n_1 p_1 (p_1^2 p_3 + p_3 p_4^2 + p_1 p_2 p_4) + n_2 p_2 (p_2^2 p_4 + p_3^2 p_4 + p_1 p_2 p_3) + n_3 p_3 (p_1 p_2^2 \end{aligned}$$

$$\frac{\partial g_1}{\partial \pi_{A_1}} = \frac{n'_1 r_1}{\eta_1} + \frac{n'_2 r_2}{\eta_2} - \alpha$$

$$\frac{\partial g_1}{\partial \pi_{A_2}} = \frac{n'_1 r_2}{\eta_1} + \frac{n'_2 r_1}{\eta_2} - \alpha$$

$$\frac{\partial g_1}{\partial \alpha} = -(\pi_{A_1} + \pi_{A_2} - 1)$$

$$\frac{\partial^2 g_1}{\partial \pi_{A_1}^2} = -\frac{n'_1 r_1^2}{\eta_1^2} - \frac{n'_2 r_2^2}{\eta_2^2}$$

$$\frac{\partial^2 g_1}{\partial \pi_{A_2}^2} = -\frac{n'_1 r_2^2}{\eta_1^2} - \frac{n'_2 r_1^2}{\eta_2^2}$$

$$\frac{\partial^2 g_1}{\partial \pi_{A_1} \partial \pi_{A_2}} = \frac{\partial^2 g_1}{\partial \pi_{A_2} \partial \pi_{A_1}} = -\frac{n'_1 r_1 r_2}{\eta_1^2} - \frac{n'_2 r_1 r_2}{\eta_2^2}$$

The terms of a_0 , a_1 and a_2 of equation (3.9) are

$$a_0 = n'_1 r_1^2 \pi_{A_2} + n'_2 r_2^2 \pi_{A_2} - \alpha r_1 r_2 \pi_{A_2}^2$$

$$a_1 = n'_1 r_1 r_2 + n'_2 r_1 r_2 - \alpha r_1^2 \pi_{A_2} - \alpha r_2^2 \pi_{A_2}$$

$$a_2 = -\alpha r_1 r_2$$

Appendix 2

The first and second partial derivatives of equation (4.6) are

$$\frac{\partial g_2}{\partial \pi_{B_1}} = \frac{n''_1 q_1}{\delta_1} + \frac{n''_2 q_2}{\delta_2} - \beta$$

$$\frac{\partial g_2}{\partial \pi_{B_2}} = \frac{n''_1 q_2}{\delta_1} + \frac{n''_2 q_1}{\delta_2} - \beta$$

$$\frac{\partial g_2}{\partial \beta} = -(\pi_{B_1} + \pi_{B_2} - 1)$$

$$\frac{\partial^2 g_2}{\partial \pi_{B_1}^2} = -\frac{n''_1 q_1^2}{\delta_1^2} - \frac{n''_2 q_2^2}{\delta_2^2}$$

$$\frac{\partial^2 g_2}{\partial \pi_{B_2}^2} = -\frac{n''_1 q_2^2}{\delta_1^2} - \frac{n''_2 q_1^2}{\delta_2^2}$$

$$\frac{\partial^2 g_2}{\partial \pi_{B_1} \partial \pi_{B_2}} = \frac{\partial^2 g_2}{\partial \pi_{B_2} \partial \pi_{B_1}} = -\frac{n''_1 q_1 q_2}{\delta_1^2} - \frac{n''_2 q_1 q_2}{\delta_2^2}$$

The terms of b_0 , b_1 and b_2 of equation (4.9) are

$$b_0 = n''_1 q_1^2 \pi_{B_2} + n''_2 q_2^2 \pi_{B_2} - \beta q_1 q_2 \pi_{B_2}^2$$

$$b_1 = n''_1 q_1 q_2 + n''_2 q_1 q_2 - \beta q_1^2 \pi_{B_2} - \beta q_2^2 \pi_{B_2}$$

$$b_2 = -\beta q_1 q_2$$

Appendix 3

The first and second partial derivatives of equation (5.4) are

$$\frac{\partial g_3}{\partial \pi_{11}} = \frac{n_1 p_1}{\lambda_1} + \frac{n_2 p_2}{\lambda_2} + \frac{n_3 p_3}{\lambda_3} + \frac{n_4 p_4}{\lambda_4} - \gamma_1 - \gamma_2 - \gamma_3$$

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Applying equations (6.1) – (6.3) the estimated value of π_{B_1/A_1} , its bias and its variance are

$$\begin{aligned}\hat{\pi}_{B_1/A_1} &= 0.05317, \\ E(\hat{\pi}_{B_1/A_1} - \pi_{B_1/A_1}) &= -0.089325, \\ Var(\hat{\pi}_{B_1/A_1}) &= 0.175836\end{aligned}$$

Similarly, applying equations (6.5) – (6.7) the estimated value of π_{B_1/A_2} , its bias and its variance are

$$\begin{aligned}\hat{\pi}_{B_1/A_2} &= 0.01782, \\ E(\hat{\pi}_{B_1/A_2} - \pi_{B_1/A_2}) &= -0.000791, \\ Var(\hat{\pi}_{B_1/A_2}) &= 0.002018\end{aligned}$$

9. Conclusions

This article presents a three-stages randomized response model. The first randomized device, the first-stage, is constructed for measuring the proportion of the individuals having the first sensitive characteristic. The second randomized device, the second-stage, is designed for measuring the proportion of the individuals having the second sensitive characteristic. The third randomized device, the third-stage, is sketched for measuring the proportion of the individuals having both two related sensitive characteristics. The method of Maximum Likelihood is used to estimate the parameters of the suggested model. Also, the Non-Linear programming with Newton-Raphson techniques are applied to estimate the parameters of the suggested model. This article presents the conditional proportions of the individuals having the second sensitive characteristic among those having or not having the first sensitive characteristic, their biases and their variances. An application is presented, for the suggested model, to estimate the proportions of the informal marriage and induced abortion phenomena among the female students in the University level. The study showed that the Maximum Likelihood and Non-Linear programming with Newton-Raphson methods give the same estimates of the parameters of the first and second randomized devices. The Maximum Likelihood method gives inadmissible estimates of the parameters of the third randomized device, and the Non-Linear programming with Newton-Raphson methods are used to manipulate this problem. The Bootstrap technique is used to calculate the expected values of the estimators of the parameters, the biases and variances of the conditional proportions.

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values of π'_A s, and $Var(\hat{\pi}_{A_1}) = 0.001122$ and $Var(\hat{\pi}_{A_2}) = 0.001782$, respectively.

8.2 The Second Device

The second device is performed to measure the proportion π_{B_1} of the female students induced abortion, in the Faculty of Commerce, Benha University. Putting $q_1 = 0.65$ and $q_2 = 0.35$, we found that $n_1'' = 199$ and $n_2'' = 359$. Applying equations (4.4) and (4.5), the results are

$$\hat{\pi}_{B_1} = 0.02210 \text{ and } Var(\hat{\pi}_{B_1}) = 0.002490$$

Also, by applying the equations (4.7) – (4.9) with Newton-Raphson method and initial value $\pi_{B_1} = 0.04$, and using equation (4.10), we get the same estimated value of π_{B_1} , and $Var(\hat{\pi}_{B_1}) = 0.001303$, respectively.

8.3 The Third Device

The third device is performed to measure the proportion π_{11} of the female students, in the Faculty of Commerce, Benha University, having both two related sensitive characteristics, informal marriage and induced abortion. This device is also used to estimate the proportion π_{B_1/A_1} of the female students who had induced abortion among those having informal marriage and the proportion π_{B_1/A_2} of the female students who had induced abortion among those not having informal marriage. Putting $p_1 = 0.35$, $p_2 = 0.30$, $p_3 = 0.20$ and $p_4 = 0.15$, we found that; $n_1 = 103$, $n_2 = 95$, $n_3 = 168$ and $n_4 = 192$. Applying equation (5.2) the estimated values of the proportions (parameters) are

$$\hat{\pi}_{11} = 0.10260, \hat{\pi}_{12} = 0.13351, \hat{\pi}_{21} = 0.26389 \text{ and } \hat{\pi}_{22} = 0.29480$$

These estimates are inadmissible because $\sum_{j=1}^2 \sum_{k=1}^2 \hat{\pi}_{jk} < 1$.

Applying equations (5.5) – (5.11), with Newton-Raphson method and initial value $\pi_{11} = 0.01$, and using equation (5.12), the estimates of these proportions and their variances are

$$\begin{array}{ll} \hat{\pi}_{11} = 0.00467 & \hat{\pi}_{12} = 0.08316 \\ Var(\hat{\pi}_{11}) = 0.001302 & Var(\hat{\pi}_{12}) = 0.001355 \\ \hat{\pi}_{21} = 0.01743 & \hat{\pi}_{22} = 0.89474 \\ Var(\hat{\pi}_{21}) = 0.001718 & Var(\hat{\pi}_{22}) = 0.001787 \end{array}$$

The Bootstrap Technique is used to calculate the estimated expected values of the proportions of the two related sensitive characteristics. The number of runs was 50 times. The size of the samples was 0.9 from the original sample. SPSS program is used to draw these samples. The estimated expected values of the proportions are

$$\begin{array}{ll} E(\hat{\pi}_{A_1}) = 0.08395, & E(\hat{\pi}_{A_2}) = 0.91605, \\ E(\hat{\pi}_{11}) = 0.00397, & E(\hat{\pi}_{21}) = 0.01642 \end{array}$$

Applying equations (6.4) and (6.8), we found that;

$$Cov(\pi_{A_1}, \pi_{11}) = 0.000698, \quad Cov(\pi_{A_2}, \pi_{21}) = 0.000690$$

d is the precision of estimating of π_{A_1}

2. Similarly, Calculating the sample size using $Var(\hat{\pi}_{B_1})$

$$n^{**} = \frac{Z^2(q_1^2 + q_2^2)\delta_1\delta_2}{d^2(q_1 - q_2)^2} \quad (7.2)$$

3. Choosing the sample size as follows

$$n = \text{Max.}[n^*, n^{**}] \quad (7.3)$$

Since η_1 and δ_1 are unknown, they would be estimated by using preliminary random sample, or replaced by either a suitable suggested values or by 0.5 if no information is available.

8. The Applied Study

This study aims to estimate the proportions of the informal marriage, as a first sensitive characteristic, and abortion, as a second sensitive characteristic, for female students in the Faculty of Commerce, Benha University, and estimate the proportion of the female students having both sensitive characteristics. This study also aims to estimate the proportion of the female students who had induced abortion among those having informal marriage, and the proportion of the female students who had induced abortion among those not having informal marriage. A preliminary random sample of size 100 female students, from the study population, is selected, and by using $r_1 = 0.7$ and $q_1 = 0.65$, we found that;

$$\hat{\eta}_1 = 0.34 \text{ and } \hat{\delta}_1 = 0.36$$

Applying equations(7.1) and (7.2), we found that

$$n^* = 325 \text{ and } n^{**} = 558$$

Then, the sample size to be selected is $n = 558$.

The proportional allocation is used to allocate the sample size to the different strata of the study population. The sizes of the study population in each stratum, and the allocation of n to different strata are shown in table (2).

Table (2): The sizes of study population in each stratum and allocation of n to the different strata

Classes	First	Second	Third	Fourth	Total
Female Students	375	1386	1160	1668	4589
Sample	46	168	141	203	558

8.1 The First Device

The first device is performed to measure the proportion π_{A_1} of the informal marriage for the female students, in the Faculty of Commerce, Benha University. Putting $r_1 = 0.7$ and $r_2 = 0.3$, we found that $n'_1 = 187$ and $n'_2 = 371$. Applying equations (3.4) and (3.5), the results are

$$\hat{\pi}_{A_1} = 0.08783, \quad \hat{\pi}_{A_2} = 0.91217$$

$$Var(\hat{\pi}_{A_1}) = Var(\hat{\pi}_{A_2}) = 0.001448$$

And by applying the equations (3.7) – (3.9) with Newton-Raphson method and initial value $\pi_{A_1} = 0.10$, and using equation (3.10), we obtain the same estimated

the true conditional proportion of the individuals having the second sensitive characteristic among those not having the first sensitive characteristic.

Then, the natural estimator of π_{B_1/A_1} is the estimator

$$\hat{\pi}_{B_1/A_1} = \frac{\pi_{11}}{\pi_{A_1}} \quad (6.1)$$

In fact, $\hat{\pi}_{B_1/A_1}$ is a ratio estimator. As a ratio estimator $\hat{\pi}_{B_1/A_1}$ is in general biased. The approximating term of its bias (See Mood et al. (1974)) is given by

$$E(\hat{\pi}_{B_1/A_1} - \pi_{B_1/A_1}) \cong \frac{E(\pi_{11})}{[E(\pi_{A_1})]^3} \text{Var}(\pi_{A_1}) - \frac{\text{Cov}(\pi_{A_1}, \pi_{11})}{[E(\pi_{A_1})]^2} \quad (6.2)$$

and

$$\text{Var}(\hat{\pi}_{B_1/A_1}) \cong \left(\frac{E(\pi_{11})}{E(\pi_{A_1})} \right)^2 \left[\frac{\text{Var}(\pi_{A_1})}{[E(\pi_{A_1})]^2} + \frac{\text{Var}(\pi_{11})}{[E(\pi_{11})]^2} - \frac{2\text{Cov}(\pi_{A_1}, \pi_{11})}{[E(\pi_{A_1})][E(\pi_{11})]} \right] \quad (6.3)$$

where

$$\text{Cov}(\pi_{A_1}, \pi_{11}) = \frac{1}{2} [\text{Var}(\pi_{A_1}) + \text{Var}(\pi_{11}) - \text{Var}(\pi_{12})] \quad (6.4)$$

Similarly

$$\hat{\pi}_{B_1/A_2} = \frac{\pi_{21}}{\pi_{A_2}} \quad (6.5)$$

The approximating term of its bias is given by

$$E(\hat{\pi}_{B_1/A_2} - \pi_{B_1/A_2}) \cong \frac{E(\pi_{21})}{[E(\pi_{A_2})]^3} \text{Var}(\pi_{A_2}) - \frac{\text{Cov}(\pi_{A_2}, \pi_{21})}{[E(\pi_{A_2})]^2} \quad (6.6)$$

and

$$\text{Var}(\hat{\pi}_{B_1/A_2}) \cong \left(\frac{E(\pi_{21})}{E(\pi_{A_2})} \right)^2 \left[\frac{\text{Var}(\pi_{A_2})}{[E(\pi_{A_2})]^2} + \frac{\text{Var}(\pi_{21})}{[E(\pi_{21})]^2} - \frac{2\text{Cov}(\pi_{A_2}, \pi_{21})}{[E(\pi_{A_2})][E(\pi_{21})]} \right] \quad (6.7)$$

where

$$\text{Cov}(\pi_{A_2}, \pi_{21}) = \frac{1}{2} [\text{Var}(\pi_{A_2}) + \text{Var}(\pi_{21}) - \text{Var}(\pi_{22})] \quad (6.8)$$

In the application study, the Bootstrap technique is used to calculate the expected values of the estimators of all parameters of the suggested model. SPSS program is used to draw the Bootstrapped samples from the original sample.

7. The Determination of the Sample Size n

The sample size is determined as follows

1. Calculating the sample size using $\text{Var}(\hat{\pi}_{A_1})$ (See Yamane (1967))

$$n^* = \frac{Z^2(r_1^2 + r_2^2)\eta_1\eta_2}{d^2(r_1 - r_2)^2} \quad (7.1)$$

where

Z is the reliability

$$\text{Max.} \quad \chi_3 = \sum_{h=1}^4 n_h \text{Log } \lambda_h$$

with respect to each of the π_{jk} 's, subject to the constraints

$$\sum_{k=1}^2 \pi_{1k} = \pi_{A_1}, \quad \sum_{j=1}^2 \pi_{j1} = \pi_{B_1} \text{ and } \sum_{j=1}^2 \sum_{k=1}^2 \pi_{jk} = 1$$

And the non negative constraints; $\pi_{jk} \geq 0$; $j, k = 1, 2$

By using the Lagrange Multipliers method, then

$$\begin{aligned} \text{Max.} \quad g_3(\pi_{11}, \pi_{12}, \pi_{21}, \pi_{22}, \gamma_1, \gamma_2, \gamma_3) = & \sum_{h=1}^4 n_h \text{Log } \lambda_h - \\ & \gamma_1 [\pi_{11} + \pi_{12} - \pi_{A_1}] - \gamma_2 [\pi_{11} + \pi_{21} - \pi_{B_1}] - \\ & \gamma_3 [\pi_{11} + \pi_{12} + \pi_{21} + \pi_{22} - 1] \end{aligned} \quad (5.4)$$

Performing the same procedure of the previous section, the ML estimator for the vector $\underline{\pi}_3$ is obtained by solving the following system of equations

$$\pi_{12} = \pi_{A_1} - \pi_{11} \quad (5.5)$$

$$\pi_{21} = \pi_{B_1} - \pi_{11} \quad (5.6)$$

$$\pi_{22} = 1 - \pi_{11} - \pi_{12} - \pi_{21} \quad (5.7)$$

$$\gamma_1 = \frac{n_1 p_4 \lambda_2 \lambda_3 \lambda_4 + n_2 p_3 \lambda_1 \lambda_3 \lambda_4 + n_3 p_2 \lambda_1 \lambda_2 \lambda_4 + n_4 p_1 \lambda_1 \lambda_2 \lambda_3}{\lambda_1 \lambda_2 \lambda_3 \lambda_4} \quad (5.8)$$

$$\gamma_2 = \frac{n_1 p_2 \lambda_2 \lambda_3 \lambda_4 + n_2 p_1 \lambda_1 \lambda_3 \lambda_4 + n_3 p_4 \lambda_1 \lambda_2 \lambda_4 + n_4 p_3 \lambda_1 \lambda_2 \lambda_3}{\lambda_1 \lambda_2 \lambda_3 \lambda_4} - \gamma_1 \quad (5.9)$$

$$\gamma_3 = \frac{n_1 p_3 \lambda_2 \lambda_3 \lambda_4 + n_2 p_4 \lambda_1 \lambda_3 \lambda_4 + n_3 p_1 \lambda_1 \lambda_2 \lambda_4 + n_4 p_2 \lambda_1 \lambda_2 \lambda_3}{\lambda_1 \lambda_2 \lambda_3 \lambda_4} - \gamma_1 \quad (5.10)$$

$$c_0 + c_1 \pi_{11} + c_2 \pi_{11}^2 + c_3 \pi_{11}^3 + c_4 \pi_{11}^4 = 0 \quad (5.11)$$

with Newton-Raphson method and initial value of π_{11} . The first and second partial derivatives of equation (5.4) and the terms of c_0, c_1, c_2, c_3 and c_4 of equation (5.11) are given in the appendix 3. Since the Log likelihood function may be expressed directly as

$$\text{Log } L(\underline{\pi}_3) = C_3 + \sum_{h=1}^4 n_h \cdot \log \lambda_h$$

where, C_3 is a constant. Thus, the sample variances of the estimated values of the π_{jk} 's can be estimated by using the Information matrix

$$I_3 = -E \left[\frac{\partial^2 L(\underline{\pi}_3)}{\partial \pi_{jk} \partial \pi_{lu}} \right] ; j, k, l, u = 1, 2 \quad (5.12)$$

6. The Conditional Proportions

Let π_{B_1/A_1} be the true conditional proportion of the individuals having the second sensitive characteristic among those having the first sensitive characteristic, π_{B_1/A_2} be

am a member of groups A_2 and B_2 , (A_2B_2), as shown in table (1). The probabilities of the selection of these lists are p_1, p_2, p_3 and p_4 respectively.

Table (1): The different lists used in the Third randomized device

First List	Second List	Third List	Four List
1. A_1B_1	1. A_1B_2	1. A_2B_1	1. A_2B_2
2. A_1B_2	2. A_1B_1	2. A_2B_2	2. A_2B_1
3. A_2B_1	3. A_2B_2	3. A_1B_1	3. A_1B_2
4. A_2B_2	4. A_2B_1	4. A_1B_2	4. A_1B_1

Performing the same procedure of the previous randomization devices, with

$x_{i3} = h$ if the i th respondent reports an "h" answer $h = 1, 2, 3, 4$

$$\therefore \Pr(x_{i3} = 1) = p_1\pi_{11} + p_2\pi_{12} + p_3\pi_{21} + p_4\pi_{22} = \lambda_1 \quad i = 1, 2, \dots, n_1,$$

$$\Pr(x_{i3} = 2) = p_1\pi_{12} + p_2\pi_{11} + p_3\pi_{22} + p_4\pi_{21} = \lambda_2 \quad i = 1, 2, \dots, n_2,$$

$$\Pr(x_{i3} = 3) = p_1\pi_{21} + p_2\pi_{22} + p_3\pi_{11} + p_4\pi_{12} = \lambda_3 \quad i = 1, 2, \dots, n_3,$$

$$\Pr(x_{i3} = 4) = p_1\pi_{22} + p_2\pi_{21} + p_3\pi_{12} + p_4\pi_{11} = \lambda_4 \quad i = 1, 2, \dots, n_4.$$

In matrix notation, we have

$$P \underline{\pi}_3 = \underline{\lambda} \quad (5.1)$$

where $\underline{\pi}_3$ and $\underline{\lambda}$ are column vectors of $\pi_{jk}; j, k = 1, 2$ and $\lambda_h; h = 1, 2, 3, 4$ respectively, and

$$P = \begin{bmatrix} p_1 & p_2 & p_3 & p_4 \\ p_2 & p_1 & p_4 & p_3 \\ p_3 & p_4 & p_1 & p_2 \\ p_4 & p_3 & p_2 & p_1 \end{bmatrix}$$

The ML estimator for the vector $\underline{\pi}_3$ is given by

$$\hat{\underline{\pi}}_3 = P^{-1} \hat{\underline{\lambda}} \quad |P| \neq 0 \quad (5.2)$$

where $\hat{\underline{\lambda}}$ is a vector of elements $\hat{\lambda}_h = n_h/n; h = 1, 2, 3, 4$. It is easy to prove that

$$E(\hat{\underline{\pi}}_3) = E(P^{-1} \hat{\underline{\lambda}}) = \underline{\pi}_3$$

and

$$Var(\hat{\underline{\pi}}_3) = Var(P^{-1} \hat{\underline{\lambda}}) = P^{-1} \Phi (P^{-1})/ \quad (5.3)$$

Where

$$\Phi = \begin{bmatrix} \frac{\lambda_1(1-\lambda_1)}{n} & 0 & 0 & 0 \\ 0 & \frac{\lambda_2(1-\lambda_2)}{n} & 0 & 0 \\ 0 & 0 & \frac{\lambda_3(1-\lambda_3)}{n} & 0 \\ 0 & 0 & 0 & \frac{\lambda_4(1-\lambda_4)}{n} \end{bmatrix}$$

Also, the ML estimator for the vector $\underline{\pi}_3$ is obtained by solving the Non-Linear programming problem

$$E(\hat{\pi}_2) = E(Q^{-1}\hat{\delta}) = \pi_2$$

and

$$Var(\hat{\pi}_2) = Var(Q^{-1}\hat{\delta}) = Q^{-1} W (Q^{-1})'$$

where

$$W = \begin{bmatrix} \frac{\delta_1 \delta_2}{n} & 0 \\ 0 & \frac{\delta_1 \delta_2}{n} \end{bmatrix}$$

By using the Lagrange Multipliers method, then

$$Max. \quad g_2(\pi_{B_1}, \pi_{B_2}, \beta) = \sum_{k=1}^2 n_k'' Log \delta_k - \beta[\pi_{B_1} + \pi_{B_2} - 1] \quad (4.6)$$

Performing the same procedure of the previous section, the ML estimator for the vector π_2 is obtained by solving the following system of equations

$$\pi_{B_2} = 1 - \pi_{B_1} \quad (4.7)$$

$$\beta = \frac{n_1'' q_2}{\delta_1} + \frac{n_2'' q_1}{\delta_2} \quad (4.8)$$

$$b_0 + b_1 \pi_{B_1} + b_2 \pi_{B_1}^2 = 0 \quad (4.9)$$

with Newton-Raphson method and initial value of π_{B_1} . The first and second partial derivatives of equation (4.6) and the terms of b_0 , b_1 and b_2 of equation (4.9) are given in the appendix 2. Since the *Log* likelihood function may be expressed directly as

$$Log L(\pi_2) = C_2 + \sum_{k=1}^2 n_k'' . log \delta_k$$

where C_2 is a constant. Thus the sample variances of the estimated values of the π_B 's can be estimated by using the Information matrix

$$I_2 = -E \left[\frac{\partial^2 L(\pi_2)}{\partial \pi_{B_k} \partial \pi_{B_u}} \right] \quad k, u = 1, 2 \quad (4.10)$$

5. The Third Randomization Device (Third Stage)

Suppose that every individual in the same study population belongs to one and only one of four related mutually exclusive groups; Group I: persons having both sensitive characteristics A_1 and B_1 at the same time; Group II: persons having the first sensitive characteristic A_1 and not having the second sensitive characteristic B_2 ; Group III: persons not having the first sensitive characteristic A_2 and having the second sensitive characteristic B_1 ; Group IV: persons not having any of the two sensitive characteristics A_2 and B_2 . Also, we assume that the true proportions of these groups are π_{11} , π_{12} , π_{21} and π_{22} , respectively. The device consists of four lists, and each list includes the following four statements; I am a member of groups A_1 and B_1 , ($A_1 B_1$); I am a member of groups A_1 and B_2 , ($A_1 B_2$); I am a member of groups A_2 and B_1 , ($A_2 B_1$); I

Newton-Raphson method. Since the *Log* likelihood function may be expressed directly as

$$\text{Log } L(\underline{\pi}_1) = C_1 + \sum_{j=1}^2 n_j' \cdot \log \eta_j$$

where, C_1 is a constant. Thus, the sample variances of the estimated values of the π_A 's can be estimated by using the Information matrix

$$I_1 = -E \left[\frac{\partial^2 L(\underline{\pi}_1)}{\partial \pi_{A_j} \partial \pi_{A_l}} \right] ; j, l = 1, 2 \quad (3.10)$$

4. The Second Randomization Device (Second Stage)

We assume that, for the same population of the previous case, a proportion, π_{B_1} , of some individuals of population possess a second sensitive characteristic, B_1 , while the remainder individuals of the population do not possess this characteristic, B_2 , with proportion $\pi_{B_2} = 1 - \pi_{B_1}$, and we want to estimate π_{B_1} . The second randomized device has the same procedure of the first randomized device. The first list includes the statements: (1) I am a member of group B_1 , (2) I am a member of group B_2 . The second list includes the statements: (1) I am a member of group B_2 , (2) I am a member of group B_1 . The probabilities of the selection of these lists are q_1 and q_2 , respectively. The respondent is required to randomly select only one list and reads the selected list carefully then reports either "1" or "2" according to whether he (or she) has the second sensitive characteristic or not.

Let

$$x_{i2} = k \text{ if the } i \text{ th respondent reports a "k" answer, } k = 1, 2$$

$$\therefore \Pr(x_{i2} = 1) = q_1 \pi_{B_1} + q_2 \pi_{B_2} = \delta_1 \quad i = 1, 2, 3, \dots, n_1'' \quad (4.1)$$

and

$$\Pr(x_{i2} = 2) = q_1 \pi_{B_2} + q_2 \pi_{B_1} = \delta_2 \quad i = 1, 2, 3, \dots, n_2'' \quad (4.2)$$

where

$$n = n_1'' + n_2''$$

In matrix notation, we have

$$Q \underline{\pi}_2 = \underline{\delta} \quad (4.3)$$

where $\underline{\pi}_2$ and $\underline{\delta}$ are column vectors of π_{B_1} and π_{B_2} , and δ_k ; $k = 1, 2$ respectively, and

$$Q = \begin{bmatrix} q_1 & q_2 \\ q_2 & q_1 \end{bmatrix}$$

The Maximum Likelihood (ML) estimator for the vector $\underline{\pi}_2$ is given by

$$\hat{\underline{\pi}}_2 = Q^{-1} \hat{\underline{\delta}} \quad |Q| \neq 0 \quad (4.4)$$

where $\hat{\underline{\delta}}$ is a vector of elements $\hat{\delta}_k = n_k''/n$; $k = 1, 2$. It is easy to prove that

The Maximum Likelihood (ML) estimator for the vector $\underline{\pi}_1$ is given by

$$\hat{\underline{\pi}}_1 = R^{-1} \hat{\underline{\eta}} \quad |R| \neq 0 \quad (3.4)$$

where $\hat{\underline{\eta}}$ is a vector of elements $\hat{\eta}_j = n'_j/n$; $j = 1, 2$. It is easy to prove that

$$E(\hat{\underline{\pi}}_1) = E(R^{-1} \hat{\underline{\eta}}) = \underline{\pi}_1$$

and

$$Var(\hat{\underline{\pi}}_1) = Var(R^{-1} \hat{\underline{\eta}}) = R^{-1} V (R^{-1})' \quad (3.5)$$

where

$$V = \begin{bmatrix} \frac{\eta_1 \eta_2}{n} & 0 \\ 0 & \frac{\eta_1 \eta_2}{n} \end{bmatrix}$$

The resulting vector $\hat{\underline{\pi}}_1$ of elements $\hat{\pi}_{A_1}$ and $\hat{\pi}_{A_2}$ may be inadmissible, *i.e.* does not satisfy

$$\pi_{A_1}, \pi_{A_2} \geq 0 \quad \text{and} \quad \pi_{A_1} + \pi_{A_2} = 1$$

So it is necessary to find the ML estimator for the vector $\underline{\pi}_1$ by solving the Non-Linear programming problem

$$\text{Max.} \quad \chi_1 = \sum_{j=1}^2 n'_j \text{Log } \eta_j$$

with respect to the π_{A_i} 's, subject to the constraints

$$\pi_{A_1} + \pi_{A_2} = 1 \quad \text{and} \quad \pi_{A_1}, \pi_{A_2} \geq 0$$

By using the Lagrange Multipliers method, then

$$\text{Max.} \quad g_1(\pi_{A_1}, \pi_{A_2}, \alpha) = \sum_{j=1}^2 n'_j \text{Log } \eta_j - \alpha [\pi_{A_1} + \pi_{A_2} - 1] \quad (3.6)$$

Differentiating equation (3.6) with respect to each of the parameters π_{A_1} , π_{A_2} and α . Equating the resulting partial derivatives to zero and solving the resulting equations for π_{A_1} , π_{A_2} and α respectively, we get

$$\pi_{A_2} = 1 - \pi_{A_1} \quad (3.7)$$

$$\alpha = \frac{n'_1 r_2}{\eta_1} + \frac{n'_2 r_1}{\eta_2} \quad (3.8)$$

$$a_0 + a_1 \pi_{A_1} + a_2 \pi_{A_1}^2 = 0 \quad (3.9)$$

The ML estimator for the vector $\underline{\pi}_{A_1}$ is obtained by solving the system of equations (3.7) – (3.9) with Newton-Raphson method (See Carnahan et al. (1969)) and initial value of π_{A_1} . The first and second partial derivatives of equation (3.6) and the terms of a_0, a_1 and a_2 of equation (3.9) are given in the appendix 1. The MathCAD program is used to solve the system of equations (3.7) – (3.9) and to apply

2. The Proposed Three-Stages Randomized Response Model

Suppose, some individuals, in a certain population, have two related sensitive characteristics A and B , and we want to estimate the population proportion of the individuals having the first sensitive characteristic A , the population proportion of the individuals having the second sensitive characteristic B , the population proportion of the individuals having both sensitive characteristics A and B , the population proportion of the individuals having the sensitive characteristic B among those having the sensitive characteristic A and the population proportion of the individuals having the sensitive characteristic B among those not having the sensitive characteristic A . It is required to estimate, from a sample survey, these population proportions. Therefore, a simple random sample of size, say n , is drawn with replacement from that population. The respondents belonging to the sample are subject to perform three different randomization devices (each device represents a stage), and each randomization device has a different predetermined probabilities.

3. The First Randomization Device (First Stage)

Consider the case where a proportion, π_{A_1} of some individuals of the population possess a first sensitive characteristic, A_1 , while the remainder individuals of the population do not possess this characteristic, A_2 , with proportion $\pi_{A_2} = 1 - \pi_{A_1}$, and we want to estimate π_{A_1} . With the aid of the randomization device, the respondent is invited to randomly select only one of the following lists. The first list includes the statements: (1) I am a member of group A_1 , (2) I am a member of group A_2 . The second list includes the statements: (1) I am a member of group A_2 , (2) I am a member of group A_1 . The probabilities of the selection of these lists are r_1 and r_2 , respectively. The respondent is required to randomly select only one list and reads the selected list carefully then reports either "1" or "2" according to whether he (or she) has the first sensitive characteristic or not. Let

$$x_{i1} = j \text{ if the } i \text{ th respondent reports a "j" answer, } j = 1, 2$$

Then, the probability that the i th respondent reports a "1" answer is

$$Pr(x_{i1} = 1) = r_1\pi_{A_1} + r_2\pi_{A_2} = \eta_1 \quad i = 1, 2, 3, \dots, n'_1 \quad (3.1)$$

The probability that the i th respondent reports a "2" answer is

$$Pr(x_{i1} = 2) = r_1\pi_{A_2} + r_2\pi_{A_1} = \eta_2 \quad i = 1, 2, 3, \dots, n'_2 \quad (3.2)$$

where

$$n = n'_1 + n'_2$$

In matrix notation, we have

$$R \underline{\pi}_1 = \underline{\eta} \quad (3.3)$$

where $\underline{\pi}_1$ and $\underline{\eta}$ are column vectors of π_{A_1} and π_{A_2} , and η_j ; $j = 1, 2$ respectively, and

$$R = \begin{bmatrix} r_1 & r_2 \\ r_2 & r_1 \end{bmatrix}$$

Following Warner's model many authors presented other randomized response (RR) models. These models either improve Warner's model, make an extension of the Warner's RR model, or provide alternative models such as: Greenberg et al. (1969), Singh et al. (2000), Chang and Huang (2001), Huang (2001), Bhargava and Singh (2002), Singh (2002), Biswas, (2003), Chang et al. (2004), Chaudhuri (2004), Kim and Elam (2005), Kim and Warde (2005), Kim and Warde (2005), Padmawar (2006), Van Den Hout and Kooiman (2006), Gjestvang and Singh (2007), Van Den Hout et al. (2007), Barabesi (2008), Chaudhuri and Pal (2008), Yu et al. (2008), Jia and McDonald (2009), Odumade and Singh (2009), Barabesi and Marcheselli (2010), Gupta et al. (2010), Christofides (2010), Son et al. (2010), Bandyopadhyay (2011), Saha (2011), Singh et al. (2011).

Cheng and Singh (2009) presented a model to measure the proportions of the population having two non related sensitive characteristics. But in many cases, it is important to estimate the proportion of the population having two related sensitive characteristics at the same time, and to estimate the proportion of the population having any of these two sensitive characteristics among those having or not having another sensitive characteristic. These two related sensitive characteristics such as addiction to drugs and history of past involvement in crimes, informal marriage and induced abortion, earnings of head of household and tax evasion, ... , etc. Christofides (2005) presented a model for estimating these proportions. This model depends on the model suggested by him in (2003). In fact, many of the estimators for the proportions of the population having sensitive characteristics presented in the early randomized response models were claimed to be Maximum Likelihood estimators. These estimators and estimators of Christofides models may produce inadmissible estimates, as pointed out in Singh (1976) and Kim et al. (2006).

To avoid this problem we present a three-stages randomized response model to estimate the proportions of two related sensitive characteristics, and use the Non-Linear programming technique with Newton-Raphson method to obtain the Maximum Likelihood estimates of the parameters of the suggested model, especially, when the Maximum Likelihood method give inadmissible estimates. The Latin square measurement design, presented by Bourke and Dalenius (1973), is used to construct the devices of the model. So, the remainder of the present research is organized as follows: Section 2 introduces the proposed three-stages randomized response model. The first-stage " the first randomization device " for measuring the proportion of the individuals having the first sensitive characteristic is constructed in section 3. The second-stage " the second randomization device " for measuring the proportion of the individuals having the second sensitive characteristic is designed in section 4. The third-stage " the third randomization device " for measuring the proportion of the individuals having both sensitive characteristics is sketched in section 5. The conditional proportions *i.e.* the proportions of the individuals having the second sensitive characteristic among those having or not having the first sensitive characteristic are presented in section 6. The sample size of the application study is determined in section 7. An application of the suggested model to the study of informal marriage and induced abortion phenomena among female students in the University level is given in section 8. Section 9 is devoted for conclusions.

Three-Stage Randomized Response Model For Measuring Two Related Sensitive Characteristics

Farid Naguib Guirguis*

Abstract

A Three-Stage randomized response model is proposed to estimate the proportions of the individuals having two related sensitive characteristics. The first-stage is constructed to include the first device to estimate the proportion of the individuals having the first sensitive characteristic. The second-stage is designed to include the second device to estimate the proportion of the individuals having the second sensitive characteristic. The third-stage is sketched to include the third device to estimate the proportion of the individuals having both related sensitive characteristics at the same time. Estimates of the parameters of the suggested model are obtained by using Maximum Likelihood method and Non-Linear programming with Newton-Raphson methods. Since the Maximum Likelihood method may give inadmissible estimates of the parameters of randomized response models, so the Non-Linear programming with Newton-Raphson methods are used to manipulate this problem. The conditional proportions, *i.e.* the proportions of the individuals having the second sensitive characteristic among those having or not having the first sensitive characteristic, their biases and variances are derived. MathCAD program is used to solve equations of the Non-Linear programming and to apply Newton-Raphson method. An application to the informal marriage and induced abortion among the female students in the University level is given. The Bootstrap technique is used to calculate the estimated expected values of the estimators of all parameters of the suggested models. SPSS program is used to draw the Bootstrapped samples from the original sample. The study showed that the Maximum Likelihood method and Non-Linear programming with Newton-Raphson methods gave the same estimates of the parameters of the first and second devices. Maximum Likelihood method gave inadmissible estimates of the parameters of the third device.

Keywords: Randomized response; Maximum Likelihood; Latin square measurement design; Non-Linear programming; Newton-Raphson method; Ratio estimator; Bootstrap technique.

1. Introduction

In survey sampling in human population, a major source of biased results due to refusal of individuals to respond to certain questions of sensitive or highly personal characteristics, such as addiction to drugs and other intoxicants, induced abortions, proneness to tax evasion, gambling habits, history of past involvement in crimes, ... , etc. In addition, some of those respondents provide untruthful answers. Thus, it is difficult to make inference about these topics based on human survey sampling in which sensitive questions are asked directly. Warner (1965) suggested an interviewing procedure designed to reduce or eliminate this bias. He named this procedure "Randomized Response Model" because the respondent answers "yes" or "no" to question which he or she selects at random from two questions and does so in such a manner that the interviewer does not know which of the two questions was answered.

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4. Conclusions

In this paper, the analysis has sought to extend the understanding of poverty in Mauritania by going beyond the bivariate analysis of the poverty profile and visual analysis of the poverty maps. It studied the spatial determinants of poverty, that is, the relationship between poverty and the environment, the effect of including spatial analysis in poverty and environment links and to explore the impact of spatial variables on poverty in Mauritania.

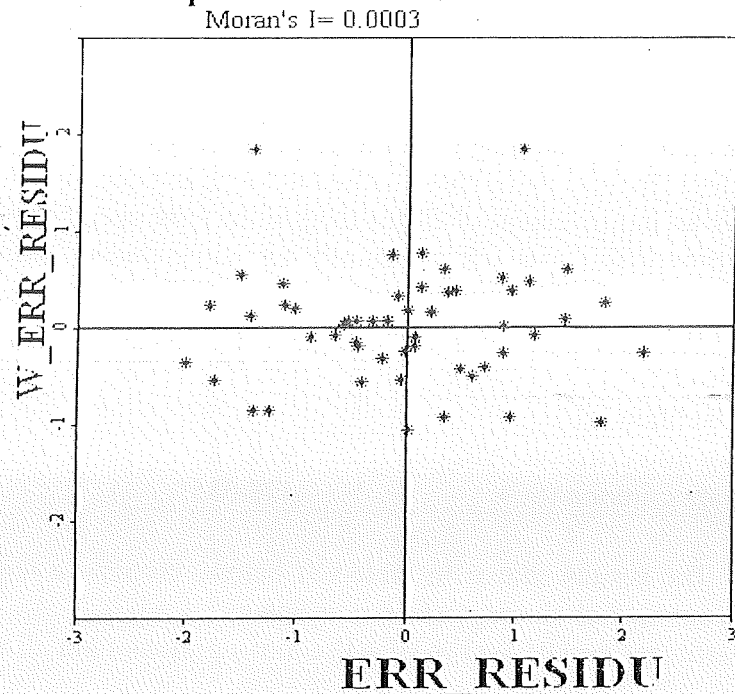
Spatial explanatory data analyses showed the existence of spatial clustering and spatial correlation between locations. Spatial Error model added the average of the error terms in the neighboring counties to the predictor variables. The spatial error model was better than the ordinary least square model with respect to the information criterion.

It can be noticed that agriculture was positively associated with poverty and it is not serving as an effective means of reducing food insecurity. On the role of access to services and infrastructure as a spatial determinant of the poverty head count, the most important determinant was the distance to the nearest public transport station.

The spatial error model produced that the determinants of poverty prevalence vary spatially in their effects across counties in Mauritania. The results might most easily be employed to guide quite local action to reduce poverty by examining the local model of the prevalence of poverty for a specific locale. The implication is that poverty reduction efforts in Mauritanian's counties will need to be targeted at the counties levels. A national, relatively inflexible approach to poverty reduction is unlikely to enjoy broad success.

weighted residuals (W_ERR-RESIDU) by using the weighted file. So, a Moran scatter plot has been constructed as shown in figure (3).

Figure (3): Moran scatter plot for ERR-RESIDU



According to Moran's I test statistic it indicates that the spatially autoregressive error term in the model has eliminated all spatial autocorrelation, as it should.

Robus LM (lag)	1	0.013	0.908
Lagrange Multiplier (error)	1	8.436	0.004
Robus LM (error)	1	3.942	0.047
Lagrange Multiplier (SARMA)	2	8.45	0.015

3.2.2 Spatial Error Model

The ML estimation of the spatial error model is introduced in table (7) and in table (8). The proper measures of fit L, AIC and SC are given in Table (7) below. By comparing these values to those in table (4), it can be seen that there is an improvement of fit for the spatial error specification (compensating the improved fit for the added spatially lagged dependent variable).

Table (7)

Pseudo- R^2	0.749
Log likelihood (L)	-204.392
Akaike info criterion (AIC)	418.783
Schwarz criterion (SC)	428.635

The results shown in table (8) below, confirm a strong positive and significant spatial autoregressive coefficient ($\lambda = 0.42$). As in the OLS case, the coefficient for HH-WOM-HEAD is not significant but all the others are.

Table (8)

Variables	Coefficients	S. E	Z-value	P-value
Constant	-7.946	7.91	-1.005	0.315
HH-WOM-HEAD	0.16	0.193	0.83	0.406
HH-AGRLAN	0.258	0.107	2.419	0.016
HH-MOUTCHE	0.536	0.143	3.758	0.000
DIS-P-TR500	0.35	0.103	3.394	0.001
LAMDA	0.423	0.155	2.722	0.006

Spatial error diagnostics are provided in table (9) below. The results indicated that, there is no problem of heteroskedasticity and the likelihood ratio test which comparing the null model (the classic regression specification) to the alternative (spatial lag model) confirms the strong significance of the spatial autoregressive coefficient.

Table (9): Spatial Error Diagnostics

Test	d.f	Value	P-value
Diagnostics for Heteroskedasticity			
Breusch-Pagan test	4	4.272	0.37
Diagnostics for Spatial Dependence			
Likelihood Ratio test	1	6.788	0.009

In the spatial error model a distinction has to be done between the model residuals (ERR-RESIDU) used in further diagnostic checks and the

Table (3)

Variables	Coefficients	S.E	T-stat	P-value
Constant	-7.44	7.33	-1.015	0.315
HH-WOM-HEAD	0.105	0.198	0.529	0.599
HH-AGRLAN	0.221	0.099	2.235	0.030
HH-MOUTCHÈ	0.572	0.138	4.143	0.000
DIS-P-TR500	0.347	0.12	2.887	0.005

Finally, table (4) contains three measures that are included to maintain comparability with the fit of the spatial regression models.

Table (4)

Log likelihood (L)	-207.786
Alkire info criterion (AIC)	425.571
Schwarz criterion (SC)	435.423

The results of table (5) below, showed that either multicollinearity, non-normality of the errors or heteroskedasticity is not significant in the model and it does not assume a specific functional form for the heteroskedasticity .

Table (5): Regression Diagnostics

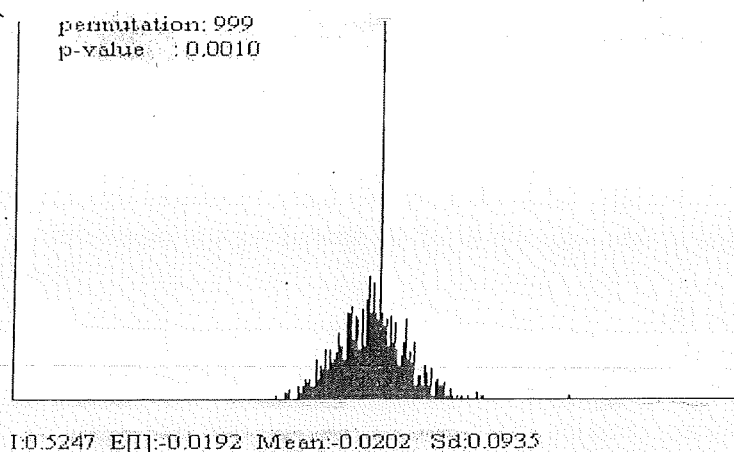
Multicollinearity condition number		12.667	
Test	d.f	Value	P-value
Test on Normality of Errors			
Jarque-Bera	2	0.739	0.691
Diagnostics for Heteroskedasticity			
Breusch-Pagan test	4	6.133	0.189
Koenker-Bassett test	4	8.630	0.071
Specification Robust Test			
White test	14	17.809	0.126

In Table (6) below a six test statistics are reported to diagnostic the spatial autocorrelation. The Moran statistic is highly significant, suggesting a problem with spatial autocorrelation. Since, Moran's I statistic has great power in detecting misspecifications in the model and not only spatial autocorrelation then it is less helpful in suggesting which alternative specification should be used. Also, five Lagrange Multiplier (LM) test statistics are considered in the diagnostic. Since, LM-Lag, LM-Error and the Robust LM Error statistic are significant while the Robust LM-Lag statistic is not then the spatial error model is the proper alternative one.

Table (6): Diagnostics of Spatial Dependence

Test	MI / d.f	Value	P-value
Moran's I (MI)	0.277	3.864	0.000
Lagrange Multiplier (lag)	1	4.508	0.034

Figure (2): Permutation empirical distribution for Moran's I



3.2 Regression Analysis

When conducting regression analyses with data aggregated to geographic areas such as counties, it is commonly find that the residuals usually spatially positively auto-correlated so, high residuals tend to cluster in space and low-valued residuals similarly tend to show geographic clustering (Paul, et al., 2005).

To model the prevalence of poverty as a function of spatial variables two different analyses were carried out: First, Ordinary Least Squares (OLS), second, Estimation by means of maximum likelihood (ML) of a spatial regression model that includes a spatially lagged dependent variable

3.2.1 Ordinary Least Squares (OLS)

The OLS method was applied by using PL as the dependent variable while HH-WOM-HEAD, HH-AGRLAN, HH-MOUTCHE and HH-P-TR500 as the explanatory variables (spatially variables). The results of OLS introduced in Table (2) to table (4).

Table (2): Summary of the Model

Number of Observations	53
Number of Variables	5
Degree of Freedom	48
R-squared	0.701416
Adjusted R-squared	0.676534
F-statistic	28.1897
Prob (F-statistic)	4.49626E-12

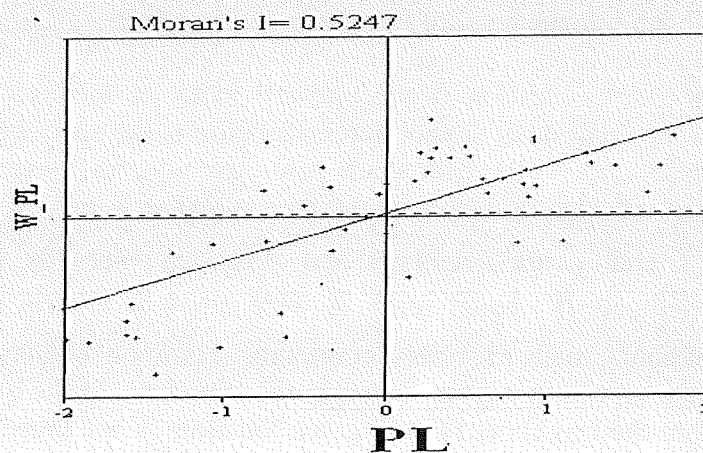
Table (3) shows that all independent variables, except HH-WOM-HEAD are significant.

autocorrelation (clustering), while negative values suggest spatial outliers (Anselin, 1992).

3.1 Global Moran's I Statistic

Moran's Scatterplot (figure (1)) illustrate the relation between the standardized value of the poverty for a county (PL) represented by the horizontal axis and the standardized value of the average poverty rates for that county's neighbors as defined by the weighted matrix (W_PL) represented by the vertical axis. Neighbors are defined under the first-order queen convention. The upper right quadrant showed counties with above average poverty which also share boundaries with neighboring counties that have above average values on the same variable (high-high). The lower left quadrant showed counties with below average poverty values and neighbors also with below average values (low-low). The lower right quadrant displays counties with above average poverty surrounded by counties with below average values (high-low), and the upper left quadrant contains the reverse (low-high).

Figure (1): Moran's Scatterplot of poverty rate in Mauritanian' Counties.



The large positive Moran I value (0.5247) suggest a clustered spatial pattern in distribution of county poverty rate data. Inference for Moran's I is based on a random permutation procedure, which recalculates the statistic many times to generate a reference distribution. The obtained statistic is then compared to this reference distribution and a pseudo significance level is computed (Anselin, 2005). The following figure (2) shows the number of permutations and the pseudo significance level.

This paper is based on theoretically informed expectation that certain aggregate socio-economic characteristics of where household or individual lives can be important determinants of whether those residents will attain an adequate level of welfare to get their needs. Such a local-scale understanding of the significant spatial determinants of local welfare, if coupled with knowledge of how individual or household-specific, broader national and sub-national factors affect household welfare will contribute to the success of poverty reduction efforts.

Welfare is defined as the level of expenditure of a household or an individual (Deaton et al., 2002). The welfare and poverty content of this analysis is based on the expenditure as a welfare measure for each household or individual in OSLC. The welfare measure was evaluated against the poverty line to determine if the person is poor or non-poor.

There are four independent variables have been selected for the analysis: household headed by woman (HH-WOM-HEAD), household headed agriculture land (HH-AGRLAN), household headed ownership of sheep and goats (HH-MOUTCHE) and household headed nearest public transport station 500 meters at least (HH-P-TR500). They are categorized by their nature and their relationship to the level of poverty in the counties.

The discussion of spatial autocorrelation has dealt with situations where the points and its location is the primary focus of interest. A fundamental concept in the analysis of spatial autocorrelation is the spatial weighted matrix (in this case, 53×53) with each row and column corresponding to an observation. Also, an element W_{ij} of the weighted matrix W is non-zero if locations i and j are neighbors and zero otherwise (by convention, the diagonal elements W_{ii} equal zero). A wide range of criteria may be used to define neighbors, such as binary contiguity (common boundary) or distance bands (locations within a given distance of each other), or the queen contiguity, meaning that the neighbors for any given location 'A' are those other locations that share a common boundary (or single point of contact) with 'A' in any direction. A spatial weighted matrix of the queen first order was used to formalize a notion of locational similarity and is central to every test statistic.

The presence or absence of pattern is indicated by the concept of spatial autocorrelation or the co-incidence of similarity in value with similarity in location. In contrast, if high values at a location were surrounded by nearby low values, or vice versa, negative spatial autocorrelation is present in the form of spatial outliers. The point of reference in the analysis of spatial autocorrelation is spatial randomness or the lack of any structure (Anselin, et al., 2000).

The most commonly used measure for spatial autocorrelation is Moran's I statistic. This test indicates the degree of spatial association as reflected in the data set as a whole. It necessitates the choice of a spatial weights matrix. Moran's I is based on cross products to measure value association. Positive values for Moran's I indicate positive spatial

statistical methods for describing and analyzing the patterns of spatially distributed phenomenon (Anselin, 1995, 2006).

2. Source of Data

The National Office of Statistics (NOS) under the Ministry of Planning in Mauritania is the organization mandated by law to collect, compile and disseminate statistics of importance. The NOS has conducted the Ongoing Survey of Living Conditions (OSLC) since 1988. OSLC survey conducted in two steps, the first from August to November 2008, while the second from December 2008 to February 2009. A two-stage stratified random sampling technique has been applied in drawing the sample of OSLC 2008 under the framework of the basis of the population and housing Census 2000. The sample consists of 13705 households, divided into rural and urban areas. The questionnaire contains all information about household and socio-economic characteristics including education, assets, employment and household consumption expenditure (NOS, 2008).

3. Methods of Analysis

Data on county poverty head count ratios were computed and digital data layers of agriculture land, ownership of sheep and goats, and percentage of households who are away from the nearest public transport station 500 meters at least along with digitized administrative boundary layers produced by National Office of Statistics were used as inputs for the study. Spatial weight matrix was computed internally by GeaDa,0.9.5 as the queen first order contiguity. To describe the spatial autocorrelation and spatial pattern in county poverty ratio, statistical measures such as Moran I statistic and univariate LISA were computed,(Anselin, 1995, 2003). First a classical regression was performed to model the functional relationship between county level poverty and the selected spatial variables. The diagnostics for spatial dependence were examined to determine the type of spatial dependence (spatial lag dependence or spatial error dependence).

The poverty line that used for the OSLC is US\$1 per person per day. The extreme poverty line corresponds to a consumption level of US\$270 per person per year (table (1), below shows the values in Ouguiyas).

Table (1): Poverty Lines and Extreme Poverty Lines, 1988-2008.

Year	Poverty Line	Extreme Poverty Line
1988	32800	24400
1996	58400	43450
2000	72600	54000
2004	94600	70400
2008	129600	96400

Source: Poverty Profile, National Office of Statistics (NOS), Mauritania, 2008.

Spatial Analysis of Poverty in Mauritania

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Abstract

In this paper, the concept of poverty in Mauritania has been improved by studying the spatial factors that are related to poverty and how this factors varies across Mauritanian's counties? Also, how much the variation in poverty incidence can be explained by these factors? An approach based on the spatial regression model, for mapping poverty rate in Mauritania has been investigated. The county level poverty head count ratios of Mauritania and spatial variables were analyzed using spatial regression models.

Key words: poverty measures – expenditure - Maran I Statistic - spatial analysis – Geoda, 0.9.5. - NOS, 2008.

1. Introduction

Poverty is a multidimensional phenomenon which manifests itself primarily in three forms: (i) income poverty; (ii) poverty in terms of living conditions and (iii) poverty in terms of potentials. Income poverty is measured by means of Foster-Greer-Thorbecke indexes, which refer in particular to the incidence of poverty, the depth of poverty and the severity of poverty.

Consumption is theoretically a better indicator of longer-term living standards than current income. Also, from a practical perspective, survey respondents tend to reveal their consumption pattern more accurately than their income (Hentschel et al., 1996).

The variability in spatial distribution of poverty is related to its geographic determinants such as differences in geographic conditions, infrastructure, access to public facilities, the presence or absence of natural resources (Petrucchi, et al., 2003, Monot et al., 2006, Okwi et al., 2007). A poverty map increases the visibility and perceptibility in spatial heterogeneity of poverty at a higher disaggregated level. However, it does not provide an estimate of the relationship between spatial patterns of poverty and spatial variables that influence it (Petrucchi, et al., 2003). Lack of information on geographic determinants of poverty hampers the efforts to reduce poverty and geographic targeting of resources. Geostatistical methods provide a set of spatial

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4-Using the quality indicator q_{i4} given by (2.16) to measure the quality of any observation in the data set.

There is a need for investigating the performance of the proposed indicator for several real applications. Further research could introduce much modification to the proposed indicator as well as investigating its performance for other forms of data sets and distributions.

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Table (9) :Average *MSE* of *the quality indicator* for different quality indicators for the method (distance <40% percentile of distances) under model 2, $n=25, r=2000$.

	<i>Manhattan</i>	<i>Euclidean</i>	<i>Chebyshev</i>
q_{i1}	0.2020425	0.1927604	0.4409465
q_{i2}	0.217401	0.2111933	0.1980929
q_{i3}	0.2324943	0.2308685	0.2170209
q_{i4}	0.06898758	0.05082359	0.08310548
q_{i5}	0.1687197	0.1518726	0.1584818

Table (10): Average *MSE* of q_{i4} for different distances for the method (distance <40% percentile of distances) under model 2, $n=25, r=2000$.

	<i>Manhattan</i>	<i>Euclidean</i>
D_{ij1}	0.200051	0.1976012
D_{ij2}	0.2349765	0.2354078
D_{ij3}	0.152416	0.1330891

The performance of q_{i4} was not enhanced any further so the best performance was for q_{i4} with the method (distance<40% percentile of distances) and distance D_{ij} and Euclidean distance. The *MSE* of q_{i4} for $n=100$ was 0.04617199 so this applies for large sample size also.

4. A recommended indicator for the quality of MVN data

Based on the results of section 3, it can be recommended that the best indicator of quality for MVN data among the proposed indicators can be found using the following algorithmic approach:

1-Using the Euclidean distance given by (2.4) to measure the distance between different observations in the data set.

2-Using the method (distance<40% percentile of distances) to find the nearest neighbors of any observation in the data set.

3-Using the distance D_{ij} given by (2. 7) to measure the distance between any observation and its nearest neighbors.

Table (6) :Average MSE of q_{i*} for different distances for the method (distance < median of distances) under model 2, $n=25, r=2000$.

	<i>Manhattan</i>	<i>Euclidean</i>	<i>Chebyshev</i>
D_{ij1}	0.2348656	0.23342	0.2345979
D_{ij2}	0.2354926	0.2356403	0.2360121
D_{ij3}	0.2128696	0.2046886	0.2766526

Table (7) :Average MSE of *the quality indicator* for different quality indicators for the method (distance < median of distances) under model 2, $n=25, r=2000$.

	<i>Manhattan</i>	<i>Euclidean</i>	<i>Chebyshev</i>
q_{i1}	0.2024979	0.1936358	0.467549
q_{i2}	0.2081561	0.2011548	0.1897319
q_{i3}	0.2292204	0.2271319	0.2129621
q_{i4}	0.06922832	0.05744453	0.08677776
q_{i5}	0.1558576	0.140076	0.1483533

Table (8) :Average MSE of q_{i*} for different distances for the method (distance < 40% percentile of distances) under model 2, $n=25, r=2000$.

	<i>Manhattan</i>	<i>Euclidean</i>	<i>Chebyshev</i>
D_{ij1}	0.2351933	0.2352913	0.2348812
D_{ij2}	0.2362015	0.2361687	0.2359246
D_{ij3}	0.2143886	0.205275	0.2567144

4. The fourth part of the document discusses the implications of the findings and the potential applications of the research.

5. The fifth part of the document provides a summary of the key points and a final conclusion.

6. The sixth part of the document contains the references and the list of sources used in the study.

method (distance < median of distances) while Tables (8) and (9) show the results for the method (distance < 40% percentile of distances).

It is noted that the performance of the quality indicator was greatly enhanced when using the indicator q_{i4} with the method (distance < 40% percentile) with the Manhattan and Euclidean distances so the performance of this quality indicator was investigated more to see if there is any enhancement when using it with the distances D_{ij1} , D_{ij2} or D_{ij3} . Results are shown in Table (10).

Table (5) :Average MSE of q_{i*} for different distances and methods to find nearest neighbors under model 2, $n=25$, $r=2000$.

	<i>Manhattan</i>	<i>Euclidean</i>	<i>Chebyshev</i>
distance < mean of distances	0.1571564	0.1663518	0.2043588
distance < median of distances	0.123727	0.1063142	0.1703396
distance < (median-s.d) of distances	0.2350323	0.2345035	0.235732
distance < 30% percentile of distances	0.1422933	0.1168047	0.163964
distance < 40% percentile of distances	0.1307172	0.1086657	0.1695414
distance < 60% percentile of distances	0.1225087	0.1116929	0.1774601
distance < 20% percentile of distances	0.1655419	0.1424759	0.1677398
distance < (median-0.5s.d) of distances	0.2296412	0.2301242	0.2358792
distance < (median-2s.d) of distances	0.2366464	0.2361483	0.2362151

Table (2) :Average MSE of q_{i*} for different distances for the method (distance <40% percentile of distances) under model 1, $n=25, r=2000$.

	<i>Euclidean</i>
D_{ij1}	0.5599393
D_{ij2}	0.5694687
D_{ij3}	0.1158264

Table (3) :Average MSE of *the quality indicator* for different quality indicators for the method (distance <40% percentile of distances) under model 1, $n=25, r=2000$.

	<i>Euclidean</i>
q_{i1}	0.100565
q_{i2}	0.2815847
q_{i3}	0.412242
q_{i4}	0.008305907
q_{i5}	0.212143

Table (4) :Average MSE of q_{i4} for different distances for the method (distance <40% percentile of distances) under model 1, $n=25, r=2000$.

	<i>Euclidean</i>
D_{ij1}	0.4543263
D_{ij2}	0.5624983
D_{ij3}	0.01697887

Results are given by Table (5). Among the different methods to find the nn , the methods with the least MSE were distance < median of distances and distance < 40% percentile of distances so these two methods were investigated more to see if their performance would be enhanced by changing the distance measure given by (2.7) to one of the distance measures given by (2.8), (2.9), and (2.10). Also these two methods were investigated to see if their performance would be enhanced by changing the quality indicator given by (2.12) to one of the quality indicators given by equations (2.13) till (2.17). Tables (6) and (7) show the results for the

Table (1) :Average MSE of q_{i*} for different distances and methods to find nearest neighbors under model 1, $n=25, r=2000$.

	<i>Manhattan</i>	<i>Euclidean</i>	<i>Chebyshev</i>
distance<mean of distances	0.1511384	0.1334708	15.12786
distance<median of distances	0.1083642	0.0533716	13.52241
distance<(median-s.d) of distances	0.4144564	0.3929098	2.825768
distance<30% percentile of distances	0.1487853	0.08149871	7.302385
distance<40% percentile of distances	0.07452742	0.01473317	10.74774
distance<60% percentile of distances	0.7106853	0.6668251	17.63232
distance<20% percentile of distances	0.3037025	0.2538365	4.93655
distance<(median-0.5s.d) of distances	0.201758	0.1569697	6.849639
distance<(median-2s.d) of distances	0.5431635	0.5263513	0.6153321

investigated to see if its performance would be enhanced by changing the quality indicator given by (2.12) to one of the quality indicators given by equations (2.13) till (2.17). Tables (2) and (3) show the results.

It is noted that the performance of the quality indicator was greatly enhanced when using the indicator q_{i4} with the method (distance <40% percentile) with the *Euclidean* distance so the performance of this quality indicator was investigated more to see if there is any enhancement when using it with the distances D_{ij1} , D_{ij2} or D_{ij3} . Results are shown in Table (4).

The performance of q_{i4} was not enhanced any further so the best performance was for q_{i4} with the method (distance <40% percentile of distances) and distance D_{ij} and *Euclidean* distance. The average *MSE* of q_{i4} for $n=100$ was 0.008463937 so this applies for large sample size also.

Model 2

$(X_1, X_2, X_3, X_4, X_5, X_6) \sim MVN(\mu, \Sigma)$ where

$$\mu = (205, 0.56, 3, 1050, 78, 6.9)$$

$$\Sigma = \begin{bmatrix} 223.34 & 2032.51 & -1198.1 & -96.73 & -9.45 & -277.16 \\ 2032.51 & 41452.09 & -7669.97 & -991.91 & -833.11 & -2511.91 \\ -1198.1 & -7669.97 & 41606.31 & -744.4 & -552.01 & 781.16 \\ -96.73 & -991.91 & -744.4 & 187.92 & -57.17 & 476.54 \\ -9.45 & -833.11 & -552.01 & -57.17 & 260.45 & -209.58 \\ -277.16 & -2511.91 & 781.16 & 476.54 & -209.58 & 1458.30 \end{bmatrix}$$

Observed values are given by $X_i^* = X_i + U_i$,

$$X^* = (x_1, x_2, x_3, x_4, x_5, x_6)$$

where

$$\begin{aligned} U_1 &\sim \text{lognormal}(5, 3), U_2 \sim \text{lognormal}(3, 1), U_3 \sim \text{lognormal}(4, 0.5), \\ U_4 &\sim \text{lognormal}(1.6, 1), U_5 \sim \text{lognormal}(7, 0.9), U_6 \sim \text{lognormal}(2, 0.4) \end{aligned} \quad (3.2)$$

3. Investigating the proposed data quality indicator

For data sets where the variables have a MVN distribution, two models were considered.

Model 1

$(X_1, X_2, X_3, X_4, X_5, X_6) \sim MVN(\mu, \Sigma)$ where

$$\mu = (35, 65, 650, 200, 430, 150)$$

$$\Sigma = \begin{bmatrix} 7.48 & -11.99 & 10.37 & 13.33 & -0.91 & 4.86 \\ -11.99 & 81.78 & 12.67 & -26.46 & 26.31 & -10.18 \\ 10.37 & 12.67 & 66.19 & 46.06 & -10.56 & 5.84 \\ 13.33 & -26.46 & 46.06 & 57.92 & -26.33 & 2.58 \\ -0.91 & 26.31 & -10.56 & -26.33 & 25.82 & 1.29 \\ 4.86 & -10.18 & 5.84 & 2.58 & 1.29 & 9.15 \end{bmatrix}$$

Observed values are given by $X_i^* = X_i + U_i$,

$$X^* = (x_1, x_2, x_3, x_4, x_5, x_6)$$

where $U_1 \sim N(0,7)$, $U_2 \sim N(0,15)$, $U_3 \sim N(0,25)$, $U_4 \sim N(0,20)$,

$$U_5 \sim N(0,37), \sim U_6 \sim (0,40) \quad (3.1)$$

Using D_{ij} as given by (2.7) and q_{i*} as given by (2.12), the MSE of q_{i*} was calculated for the three different distances given by (2.4), (2.5), and (2.6), and using different methods to find the nearest neighbors. Sample size used was $n=25$, number of replications used was $r=2000$. The average of the MSE over the replications was calculated. The program R version 2.13.0 (R Development Core Team, 2011), was used in simulating data sets and calculating all the measures. Results are shown by Table (1).

Among the different methods to find the nn , the method with the least MSE was (distance < 40% percentile of distances) with the *Euclidean* distance so this method was investigated more to see if its performance would be enhanced by changing the distance measure given by (2.7) to one of the distance measures given by (2.8), (2.9), and (2.10). Also this method was

$$D_{ij1} = | (X_{ij} - \bar{X}_{ij(nn)}) | \quad (2.8)$$

$$D_{ij2} = (X_{ij} - \bar{X}_{ij(nn)})^2 \quad (2.9)$$

$$D_{ij3} = ((X_{ij} - \bar{X}_{ij(nn)}) / \bar{X}_{ij(nn)})^2 \quad (2.10)$$

Finally, for each observation i , there will be a set of p measures of distances $(D_{i1}, D_{i2}, \dots, D_{ip})$ available. Let $\bar{D}_i$ denote the mean of these p distance measures for observation i then :

$$\bar{D}_i = \frac{\sum_j D_{ij}}{p} \quad (2.11)$$

A quality indicator can be proposed based on the distance given by (2.11). The following indicators were considered:

$$q_{i*} = 1/\bar{D}_i \quad (2.12)$$

$$q_{i1} = 1/\bar{D}_i^2 \quad (2.13)$$

$$q_{i2} = \exp(-\bar{D}_i) \quad (2.14)$$

$$q_{i3} = \exp(-\bar{D}_i^2) \quad (2.15)$$

$$q_{i4} = 1/\sqrt{\bar{D}_i} \quad (2.16)$$

$$q_{i5} = \exp(-\sqrt{\bar{D}_i}) \quad (2.17)$$

The performance of any of the previous indicators can be judged based on its mean square error (MSE). For example, the MSE of q_{i*} given by (2.12) can be defined as follows:

$$MSE q_{i*} = \frac{\sum_{i=1}^n (q_{i*} - \bar{q}_{i*})^2}{n} \quad (2.18)$$

where q_i is given by (2.3) and q_{i*} is given by (2.12).

Using simulated data sets from MVN distribution, the MSE of the proposed indicators can be calculated and compared.

$$[(x_1 - x_2)^2 + (y_1 - y_2)^2]^{1/2} \quad (2.4)$$

The *Chebyshev distance* (Cantrell, 2000), is given by:

$$\text{Max}(|x_1 - x_2|, |y_1 - y_2|) \quad (2.5)$$

And the *Manhattan distance* (Krause, 1987), given by

$$|x_1 - x_2| + |y_1 - y_2| \quad (2.6)$$

Several methods to find the nearest neighbors to any observation were considered depending on the distance between the observations as follows:

1-Nearest neighbors to observation i are the observations which their distance to observation i is less than the mean of the distances between observation i and all other observations.

2-Nearest neighbors to observation i are the observations which their distance to observation i is less than the median of the distances between observation i and all other observations.

3-Nearest neighbors to observation i are the observations which their distance to observation i is less than (median- k *s.d) of the distances between observation i and all other observations, where s.d is the standard deviation of distances and $k = 0.5, 1, \text{and } 2$.

4-Nearest neighbors to observation i are the observations which their distance to observation i is less than the p percentile of the distances between observation i and all other observations where $p=20\%, 30\%, 40\%, \text{and } 60\%$.

Now after locating the nearest neighbors to observation i excluding variable j , there is a need to calculate a distance measure between X_{ij} and $\bar{X}_{ij(nn)}$ where $\bar{X}_{ij(nn)}$ indicates the mean of variable j for the nearest neighbors of observation i excluding variable j .

The following distance measures were considered:

$$D_{ij} = |(X_{ij} - \bar{X}_{ij(nn)}) / \bar{X}_{ij(nn)}| \quad (2.7)$$

$$\text{Quality of } X_{ij}^* = \exp \left\{ - \left| \frac{(x_{ij} - x_{ij}^*)}{x_{ij}} \right| \right\} \quad (2.2)$$

where $i=1,2,\dots,n$ and $j=1,2,\dots,p$. If the quality of any observation is taken to be the average quality of values of this observation on all variables then the overall quality of every observation in the data set can be calculated.

Let q_i denote the overall quality of observation i and q_{ij} denote the quality of X_{ij} as given by (2.2) then:

$$q_i = \frac{\sum_j q_{ij}}{p} \quad (2.3)$$

Now with q_i known, the performance of any proposed quality indicator can be evaluated where the performance is judged by the ability to estimate q_i with minimum errors.

It makes sense that in a typical data set, observations tend to fall into clusters depending on the relation between the variables so that observations in the same cluster will have a similar type of relations between variables (Mirkin, 2005). For any observation i , in order to study the quality of say, X_{i1} , suppose that all the observations in the entire data set are searched to find those most similar to the combination $(X_{i2}, X_{i3}, \dots, X_{ip})$. In other words, to find the *nearest neighbors*(nn) of observation i regarding all values of observation i except the value of X_{i1} . It would be expected now that the value of X_{i1} be somewhat close to the average of the values of the first variable for the nearest neighbors of observation i .

There is a need for a measure of dissimilarity or distance between the combination $(X_{i2}, X_{i3}, \dots, X_{ip})$ and every other combination on the same variables in the data set. The distance between two points, with coordinates (x_1, y_1) and (x_2, y_2) , respectively, could be measured using several measures of distance.

Three distances were considered. The Euclidean *distance* (Cantrell, 2000), is given by:

1. The first part of the paper is devoted to a general discussion of the problem of the existence of a solution of the system of equations (1) for arbitrary values of the parameters α and β . It is shown that the system has a solution for arbitrary values of the parameters α and β if and only if the condition

$$\alpha + \beta > 0 \quad (2)$$

is satisfied. If this condition is not satisfied, then the system has no solution for arbitrary values of the parameters α and β .

2. In the second part of the paper the problem of the existence of a solution of the system of equations (1) for arbitrary values of the parameters α and β is solved. It is shown that the system has a solution for arbitrary values of the parameters α and β if and only if the condition

$$\alpha + \beta > 0 \quad (3)$$

is satisfied. If this condition is not satisfied, then the system has no solution for arbitrary values of the parameters α and β .

1. The first part of the paper is a review of the literature on the topic of the paper. It starts with a general overview of the field and then moves on to a more detailed discussion of the specific issues that are being addressed in the paper.

2. The second part of the paper is a description of the methodology that was used in the study. This includes a discussion of the data sources, the sample, and the statistical methods that were used to analyze the data.

3. The third part of the paper is a presentation of the results of the study. This includes a discussion of the findings of the study and a comparison of these findings with the results of previous studies. The results are presented in a clear and concise manner, using tables and figures where appropriate.

4. The fourth part of the paper is a discussion of the implications of the study. This includes a discussion of the theoretical implications of the findings and a discussion of the practical implications of the findings.

5. The fifth part of the paper is a conclusion. This includes a summary of the main findings of the study and a statement of the author's conclusions.

6. The sixth part of the paper is a list of references. This includes a list of all the sources that were cited in the paper.

7. The seventh part of the paper is an appendix. This includes any additional information that is relevant to the study.

8. The eighth part of the paper is a glossary. This includes a list of all the terms that are used in the paper and their definitions.

already gathered, with no chance to re-measure the same observations again. In such cases, it seems more practical to study the quality of the available data set based only on this very data set, without auxiliary information.

It is the importance of studying the quality of data as well as the limited use of statistical tools in addressing the problem, which greatly motivated the current research.

The current paper presented an indicator of data quality which depends only on the observed values of the observations without any auxiliary information. In the following section, the proposed quality indicator will be presented in detail.

2. A proposed indicator of data quality

For a random sample of n observations drawn from a p -multivariate normal (MVN) population, values on p variables, $(X_1, X_2, \dots, X_p)$ will be available for n observations. If the data set described above is measured with error, then the observed variables will not be $X_i = (X_1, X_2, \dots, X_p)$ but will rather be $X_i^* = (X_1^*, X_2^*, \dots, X_p^*)$ where

$$X_i^* = X_i + U_i \quad (2.1)$$

$$\text{where } U_i \sim N[0, \Sigma_U] \text{ and } \Sigma_U = \begin{bmatrix} \sigma_{U_1}^2 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sigma_{U_p}^2 \end{bmatrix}$$

A typical measure of quality or accuracy of any observation measures the relation between the values of X_{ij} and X_{ij}^* for this observation, $i=1, 2, \dots, n$ and $j=1, 2, \dots, p$, such that the greater the difference between these two values, the less the quality of the observation.

Let the quality of observation i for the variable j be defined as follows:

Data quality refers to the degree of excellence exhibited by the data in relation to the portrayal of the actual phenomena. Also data quality has been defined as the state of completeness, validity, consistency, timeliness and accuracy that makes data appropriate for a specific use (Olsen, 2003).

Researchers realized how much data with poor quality can cost organizations and governments. The great importance of data quality has been emphasized by many researchers (see for example, Fisher and Kingma, 2001 and Olsen, 2003).As Olsen (2003), points out, accurate data is a fundamental requirement of good information systems. The lack of accurate data costs organizations dearly in correction activities, lost customers, missed opportunities and incorrect decisions.

There have been several attempts in the literature for methods or measures to study and judge the accuracy and preciseness of data, or study the quality of data in general. Data accuracy in some fields, especially the medical one, is calculated using the measure of correctness. It is usually measured using *validation data* on some sample items, where the *gold standard*, which is the true aspect that the data represent, is known. Reliability of any measurement in general refers to the consistency of a number of measurements taken using the same measurement method on the same subject (Kan, 2007).

Cook's distance is an influence statistic. Cook's distance measures the effect of deleting a given observation on the regression model (Cook, 1979). Also, *Mahalanobis distance*, is often used to detect influential observations in the development of linear models (Mahalanobis, 1936). As discussed by Olsen (2003), the data profiling approach, is a set of procedures to check the consistency of the data items in relation to each other. For example the data rule analysis puts rules to check the value of a certain variable in relation to other variable(s).

Statistical tools used to study the problem of data quality are not enough. Obtaining validation data and repeated measures for some observations could be quite costly and time consuming especially with large data sets. Besides, usually in applications, researchers are confronted with data

A Proposed Indicator for Quality of Multivariate Normal Data

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Abstract: Correctness and precision of data are very crucial in applications for reliable results. However, not much statistical tools have been used to deal with the problem of data quality. Statistical methods for studying data quality have focused on detecting outliers and influential observations. In this paper, an indicator for data quality is proposed, which depends on the relations between observations in multivariate normal data sets without the need for auxiliary information, where several distances are proposed in the developing of the indicator. The performance of the proposed indicator for multivariate normal data is tested by its mean square error as calculated from simulated data sets.

Keywords: Data quality-Multivariate normal-Measures of quality-Distance measures-Nearest neighbors-Indicators-Euclidean distance

1. Introduction

The main core of statistics in general is analyzing data to make decisions. If the data is not precise or accurate then the results of the statistical analysis would not be reliable and it will be misleading. The concept of *Data Quality* had lots of attention over the past decade and has been a subject of interest to a decent number of researchers in different fields.

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1. The first part of the document is a letter from the President of the United States to the Congress, dated January 1, 1861. It is a very important document, as it sets out the President's policy for the new year. The letter is written in a very formal and dignified style, and it is a very good example of the President's power and authority.

2. The second part of the document is a report from the Secretary of the Treasury, dated January 1, 1861. It is a very important document, as it sets out the Secretary's policy for the new year. The report is written in a very formal and dignified style, and it is a very good example of the Secretary's power and authority.

3. The third part of the document is a report from the Secretary of the Interior, dated January 1, 1861. It is a very important document, as it sets out the Secretary's policy for the new year. The report is written in a very formal and dignified style, and it is a very good example of the Secretary's power and authority.

Index

APPLIED STATISTICS

1	A Proposed Indicator for Quality of Multivariate Normal Data Y.M, Ibrahim , S.K, El Attar	1-15
2	Spatial Analysis of Poverty in Mauritania Ahmed A El-Sheikh , Dina H. Abdel-Hady, Mohamed ould Aly Oumar	16-25
3	Three-Stage Randomized Response Model For Measuring Two Related Sensitive characteristics, Farid Naguib Guirguis	26-43
4	Estimating the Parameters of the Three- Stage Randomized Response Model Using the EM Algorithm Farid Naguib Guirguis	44-60
5	Optimal Allocation for Fiscal Stimulus Package Across Sectors in Egypt (2009/2010):A Simulation Analysis Auda H , Zakareya E.	61-77
6	Methods of Pooling Time Series – Cross section (PTSCS) Data: A Comparative Study Abeer Zidan	78-91



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