Performance, Gross Morphology, Histopathology and Morphometry of the Gut of Broilers as Influenced by Chitosan Derivatives and *Saccharomyces cerevisiae boulardii* at Different Inclusion Frequencies

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Abstract

The performance, gross morphology, histopathology and morphometry of the gut of broilers as influenced by chitosan derivatives and Saccharomyces cerevisiae boulardii (SCB) at different inclusion frequencies were described and compared in this study. After the feeding trial, gross morphology and tissue sections stained with hematoxylin and eosin (H & E) were evaluated. Morphometrics were measured (m) using Moticam®application. The type of feed supplement was assigned as Factor A (negative control, chitosan derivatives, S. cerevisiae boulardii and doxycycline hydroxide) and frequency of supplementation as Factor B (once a week, two times a week, three times a week and four times a week). Sixteen (16) groups were used having varying types of supplement and frequency of feed additive inclusion. Production performance, body weight, average daily gain and feed conversion efficiency, revealed highly significant differences among feed supplements given (p ¡ 0.05). Necropsy findings demonstrated that the small intestines were apparently normal. The gross morphological changes observed in some treatments include hyperemia, thinning and thickening of the gut wall. However, no significant lesions were noted. Histopathologically, no critical findings were noted in the gut. In terms of morphometry, there is a highly significant difference between treatments in terms of duodenal, jejunal and ileal villi height, depth of crypts and villi to crypt ratio (p ¡ 0.05). Moreover, providing SCB and DH two or three times a week may significantly improve the villi to crypt ratio of small intestines; depth of crypt of jejunum and ileum and villi height of ileum as reflected in the production performance indices.

Keywords: broilers, chitosan, gross morphology, histopathology, morphometry

Introduction

The gastrointestinal tract or gut of chickens is customarily the center of many research not only because it is the site of digestion and absorption, but also, it is the chief region that defines the improvement or failure of the animals immune system vis-a-vis production performance.

Current research studies are now focusing on means to assist the gut without using antibiotics and to get rid of its unwanted effects. An alternative is the use of natural growth promoters that work on eliminating pathogenic microbes in the gut through competitive exclusion and could potentially enhance the immune system (Hughes, 2005; Kabir, 2009).

A potential feed additive that may aid in improving gut health is chitosan. Chitosan is a non-toxic polyglucosamine which is, at varying levels, deacetylated form of chitin, a constituent of exoskeleton of shrimps, crabs and insects. Chitosan contains reactive functional groups, namely, amino acids and hydroxyl groups, which are noted to have antimicrobial, anti-inflammatory, antioxidative, immunostimulatory and hypocholesterolemic, among other properties (Swiatkiewicz et al., 2015).

Another equally potential feed additives used as antibiotic alternative are probiotics. A commercial probiotic containing concentrated live yeast of the strain *Saccharomyces cerevisiae boulardii* claims that it is specifically selected to enhance the nutrition and health of monogastrics such as swine and poultry (Ahmed et al., 2015).

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Therefore, the potential effects of *S. cerevisiae boulardii* and chitosan derivatives on the performance and gut integrity of broilers were tested in this study.

METHODOLOGY

Experimental Design

This study used 4 x 4 factorial in a completely randomized design (CRD). A total of 16 groups having four replicates each were used with 10 birds per replicate, for a total of 640 healthy Cobb broilers.

Factor A represents the feed and supplement given to broilers throughout the feeding trial following the standards for each particular supplement.

1. NC negative control group: basal diet
2. CD basal diet + chitosan derivatives (3 g/kg feed)
3. SCB basal diet + *S. cerevisiae boulardii* (0.1 g/kg feed)
4. DH basal diet + antibiotic: doxycycline hydrochloride (1 g/kg feed)

Factor B corresponds to the frequency of supplementation of broilers throughout the feeding trial.

1. Once a week
2. Twice a week

3. Thrice week
4. Four times a week

Feeding Trial

On day 15, right after brooding, chicks were segregated following the experimental design. Adequate welfare and sanitary conditions was strictly afforded to the birds at all times.

Feeds and standard feeding management practices was employed. Feed supplement provision was given as indicated in the treatment group of the birds. Aside from the condition and welfare of the birds, performance and livability were also checked, monitored, and recorded.

Determination of Performance

Birds were weighed at 15 (initial), 21, and 28 days of age. Average daily gain (ADG) and feed conversion efficiency (FCE) were calculated and recorded.

Gut Examination

Necropsy was conducted on day 28 of the feeding trial. First, the gut was evaluated in situ. Then, morphologic observation of the segments of the gut was done. Then, gross morphology evaluation of the duodenum, jejunum and ileum was conducted by experts using the following parameters: presence of ballooning, muscle tone, presence of abnormal content, presence of inflammation/hyperemia; integrity of mucosa, presence of undigested feeds and presence of parasites.

Next collection of tissue samples from the said segment of the gut for histopathological examination was done. Histopathological readings were done to further check the gut integrity using H&E stain at 100X magnification. Morphometry of the villi and crypts of the duodenum, jejunum and ieum was then taken. The intact, well-oriented, crypt and villi units were selected for each intestinal cross-section slides. Samples with relatively undamaged lamina propria were selected. The villus length was measured from the villus tip to the villus-crypt junction, while crypt depth was determined as the distance of the invagination between two villi. The measurement was done with software image-measuring device, Moticam.

Statistical Analysis

Results were analyzed and compared using Analysis of Variance (ANOVA) of CRD. Treatment means were compared using Duncans Multiple Range Test (DMRT). Gross morphology and histopathological readings were done by experts in a descriptive manner.

RESULTS AND DISCUSSION

Production Performance

The mean body weight (BW) of broilers at days 15 (initial weight), 21 and 28; average daily gain (ADG), and feed conversion efficiency (FCE) as affected by feed additives at different inclusion frequencies were taken. At day 15, no significant difference (p ¡0.05) was found since all birds had relatively the same weight during the start of the experiment. At day 21, the heaviest birds were found among the group supplemented with probiotic *S. cerevisiae boulardi* (SCB), followed by the groups supplemented with chitosan derivatives (CD), positive control doxycycline hydroxide (DH), and negative control, respectively (Table 1).

Highly significant differences (p ¡0.05) were noted on the ADG of broilers in terms of feed additives given. Birds fed with CD had the highest gain in weight of 53.98 g, followed by SCB group with 52.20 g, DH group with 49.70 g, and negative control with 46.05 g, respectively (Table 2). However, no significant interaction (p ¡0.05) were observed between feed supplements and supplementation frequencies.

Consistently, CD group exhibited the lowest feed conversion rate of 1.57. SCB gained the second rank with 1.62, SCB with 1.70, and NC group with 1.85, at third and fourth ranks, respectively (Table 3). However, no significant interaction effects (p ¡ 0.05) were observed between feed supplements and inclusion frequencies.

There was no mortality in the entire course of the experiment. Thus, 100% livability was noted in all of the treatments in the study.

Gut Integrity

Gross Morphological Finding

Gross morphological findings were based on the descriptive evaluation of experts (veterinary histologists). According to them, there were no significant pathological observations in situ in terms of gut positioning observed during the necropsy. It was also observed that all the organs were in their proper loci. In terms of gross morphologic condition of each of the segments of the small intestines (Table 4), the pathological bases used for evaluation were the following: presence of ballooning, muscle tone, presence of abnormal content, presence of inflammation/hyperemia, integrity of mucosa, presence of undigested feeds and presence of parasites.

In general, the segments of the small intestines, namely: duodenum (d), jejunum (j) and ileum (i) were apparently normal: absence of ballooning, good muscle tone, no abnormal content and absence of visible parasites. Although hyperemia, the thinning and thickening of the intestinal mucosa in some slides were also observed, these results were deemed incidental and did not affect the performance of birds as reflected in the production performance results.

Histopathological Findings

All slides examined have no significant pathological findings, with no evidence of any disease condition (Table 4). Some slides are severely autolytic: A1B1 jejunum (j) and ileum (i); A2B1 (j and i); A2B3 (j and i); A2B4 all slides; and A3B3 (j and i) with postmortem erosion/loss of surface epithelia. Nonetheless, histopathologic findings revealed essentially normal intestinal sections.

Table 1. Body weight (g) of birds supplemented with chitosan derivatives and *Saccharomyces cerevisiae boulardi* at different inclusion frequencies

Age of Birds	Factor A Feed Supplement	Factor B Frequency of Inclusion				A Mean
		Once a wk (B1)	2x a wk (B2)	3x a wk (B3)	4x a wk (B4)	
	A1 NC	449.43	449.08	448.71	448.95	**449.04**
	A2 CD	449.10	449.11	449.28	449.04	**449.30**
Day 15	A3 SCB	448.94	449. 32	449.28	449.28	**449.21**
	A4 DH	449.61	449.22	449.10	449.08	**449.25**
	B Mean	**449.27**	**449.18**	**449.09**	**449.26**	
	A1 NC	847.80	845.03	844.45	842.50	**844.94c**
	A2 CD	852.38	854.58	854.93	857.03	**854.73b**
Day 21	A3 SCB	862.93	862.20	863.08	859.77	**861.99a**
	A4 DH	844.88	850.33	845.35	846.88	**846.86c**
	B Mean	**851.99**	**853.03**	**851.95**	**851.54**	
	A1 NC	1090	1095	1105	1090	**1095.00d**
	A2 CD	1200	1190	1215	1210	**1203.75a**
Day 28	A3 SCB	1175	1180	1170	1195	**1180.00b**
	A4 DH	1140	1145	1140	1150	**1145.00c**
	B Mean	**1151.25**	**1152.5**	**1157.5**	**1162.5**	

NC negative control (basal diet);
CD basal diet + chitosan derivatives (3g/kg);
SCB basal diet + *Saccharomyces cerevisae boulardi* (0.10 g/kg);
DH basal diet + Doxycycline Hydroxide (1 g/kg)
Note: In a column, means followed by the same letter are not significantly different at 5% level of significance by DMRT.

Post mortem autolysis (Cabana, 2016; Manzano, 2016) and erosion of surface epithelia are just some of the changes usually found during necropsy. These result from degradation of tissues associated with the release of proteolytic lysosomal enzymes from the cells. These processes occur automatically after death of the animal. It also happens following death of a limited portion of an organ or tissues (necrosis).

Post mortem autolysis is predisposed by various factors. It is particularly heightened by the action of bacteria that form part of the microbial flora on the surface of mucosa particularly in the gut. Such bacteria may proliferate after death. This possibly occurs due to alterations in the environment, where the usual defense mechanism of the animal body ceases to operate (Cabana, 2016).

Morphometry of the Small Intestines

The morphological indices of the intestinal mucosa of broilers are described in Table 5. Modifications in the mucosal architecture in terms of villi height, crypt depth and villi height to crypt depth ratio were observed and measured.

Duodenum

Results revealed that birds supplemented with DH exhibited the tallest villi (1702.56), followed by CD (1690.29), SCB (1682.33) and NC (1532.19) groups, respectively. Highly significant results were found in terms of feed supplement given. Treatments given three times a week (1668.90) also exhibited the tallest villi, followed by the birds treated four times a week (1664.14), two times a week (1639.02) and once a week (1635.31), respectively. However, no significant differences were observed among inclusion frequencies. Meanwhile, that birds supplemented with DH exhibited the shortest crypts (280.61), followed by SCB (281.77), CD (284.36) and NC (360.13) groups, respectively. Highly significant differences were found among feed supplements given. On the other hand, treatments given four times a week also exhibited the shortest crypts (298.75), followed by the birds treated three times a week (303.69), two times a week (303.31) and once a week (302.13), respectively. Differences, however, were not statistically significant. The result of the villi to crypt ratio of duodenum () illustrates that birds supplemented with DH revealed the lengthiest villi to crypt ratio (6.07), followed by SCB (6.01), CD (5.95) and NC (4.24) groups, respectively. Differences exhibited highly significant among feed supplements given. Treatment groups given four times a week also exhibited the lengthiest villi to crypt ratio (5.68), followed by the groups treated three times a week (5.59), two times a week (5.49) and once a week (5.47), respectively. Also, results among interactions were significantly different from each other (p ¡0.05).

Jejunum

Broilers given DH exhibited the tallest villi (1237.65), followed by SCB (1226.70), CD (1215.84) and NC (1065.53)

Table 2. Average daily gain (g) of birds supplemented with chitosan derivatives and *Saccharomyces cerevisiae boulardi* at different inclusion frequencies

Factor A Feed Supplement	Factor B Frequency of Inclusion				A Mean
	Once a week (B1)	2x a week (B2)	3x a week (B3)	4x a week (B4)	
A1 NC	45.74	46.14	46.52	45.79	**46.05d**
A2 CD	53.64	53.28	54.69	54.31	**53.98a**
A3 SCB	51.86	52.19	51.48	53.26	**52.20b**
A4 DH	49.32	49.70	49.35	50.42	**49.70c**
B Mean	**50.14**	**50.33**	**50.51**	**50.95**	

NC negative control (basal diet);
CD basal diet + chitosan derivatives (3g/kg);
SCB basal diet + Saccharomyces cerevisae boulardi (0.10 g/kg);
DH basal diet + Doxycycline Hydroxide (1 g/kg)
Note: In a column, means followed by the same letter are not significantly different at 5% level of significance by DMRT.

Table 3. Feed conversion efficiency (FCE) of birds supplemented with chitosan derivatives and *Saccharomyces cerevisiae boulardi* at different inclusion frequencies.

Factor A Feed Supplement	Factor B Frequency of Inclusion				A Mean
	Once a week (B1)	2x a week (B2)	3x a week (B3)	4x a week (B4)	
A1 NC	1.86	1.84	1.84	1.85	**1.85 d**
A2 CD	1.58	1.59	1.55	1.56	**1.57 a**
A3 SCB	1.63	1.62	1.65	1.59	**1.62 b**
A4 DH	1.71	1.71	1.71	1.68	**1.70 c**
B Mean	**1.69**	**1.69**	**1.69**	**1.67**	

NC negative control (basal diet);
CD basal diet + chitosan derivatives (3g/kg);
SCB basal diet + *Saccharomyces cerevisae boulardi* (0.10 g/kg);
DH basal diet + Doxycycline Hydroxide (1 g/kg)
Note: In a column, means followed by the same letter are not significantly different at 5% level of significance by DMRT

Table 4. Necropsy findings of broilers at day 28 after feed supplementation with chitosan derivatives (CD) and *S. cerevisiae boulardii* (SCB) at different inclusion frequencies.

Treatment		Duodenum	Jejunum	Ileum
NC	**A1B1**	NSL	hyperemic at the distal half	NSL
	A1B2	Hyperemic	No significant lesion	NSL
	A1B3	Hyperemic	hyperemic at the proximal third	NSL
	A1B4	Hyperemic; thickened	Hyperemic and slightly thickened at the proximal third	thinning of mucosa
CD	**A2B1**	Hyperemic	Hyperemic at the proximal half	thinning of mucosa
	A2B2	NSL	Presence of undigested feed in the mid half; hyperemic at the distal half	NSL
	A2B3	NSL	thinning of mucosa at the proximal and distal aspects	NSL
	A2B4	NSL	hyperemic at the proximal third	Presence of undigested feeds; poor muscle tone
SCB	**A3B1**	Entire length is hyperemic; slightly thickened	Proximal part and some focal areas are slightly hyperemic; slightly thickened	Thinning of the proximal part of the mucosa
	A3B2	Entire length is thickened	Distal fourth of the segment is thickened	NSL
	A3B3	NSL	Entire length is hyperemic; thinning of the distal fourth	Hyperemic; thinning of mucosa; poor muscle tone
	A3B4	Entire length is hyperemic and thickened	Slight thickening of the proximal third; slightly thickened; pasty ingesta	NSL
DH	**A4B1**	NSL	NSL	NSL
	A4B2	Slightly hyperemic	Slightly hyperemic	Slightly thickened proximal fourth
	A4B3	NSL	Slightly thickened	Slightly thickened
	A4B4	NSL	Slightly hyperemic distal part	Slightly hyperemic

A Feed supplement; B Inclusion Frequency; 1,2,3,4 Replication number
NC negative control (basal diet); CD basal diet + chitosan derivatives (3g/kg);
SCB basal diet + *Saccharomyces cerevisae boulardii* (0.10 g/kg);
DH basal diet + Doxycycline Hydroxide (1 g/kg)
*NSL no significant lesion

Table 5. Histopathological findings of broilers at day 28 after feed supplementation with chitosan derivatives (CD) and *S. cerevisiae boulardii* (SCB) at different inclusion frequencies.

Treatment		Duodenum	Jejunum	Ileum
NC	**A1B1**	NSF	Severely autolytic	Severely autolytic
	A1B2	NSF	NSF	NSF
	A1B3	NSF	NSF	NSF
	A1B4	NSF	NSF	NSF
CD	**A2B1**	NSF	Severely autolytic	Severely autolytic
	A2B2	NSF	NSF	NSF
	A2B3	NSF	Severely autolytic	Severely autolytic
	A2B4	NSF	NSF	NSF
SCB	**A3B1**	NSF	NSF	NSF
	A3B2	NSF	NSF	NSF
	A3B3	NSF	postmortem erosion/loss of surface epithelia	postmortem erosion/loss of surface epithelia
	A3B4	NSF	NSF	NSF
DH	**A4B1**	NSF	NSF	NSF
	A4B2	NSF	NSF	NSF
	A4B3	NSF	NSF	NSF
	A4B4	NSF	NSF	NSF

NC negative control (basal diet);
CD basal diet + chitosan derivatives (3g/kg);
SCB basal diet + *Saccharomyces cerevisae boulardii* (0.10 g/kg);
DH basal diet + Doxycycline Hydroxide (1 g/kg)
*Histopathologic Diagnosis: Essentially normal intestinal sections. No significant findings (NSF).

groups, respectively. Results demonstrated by the treated birds were significantly different from the control group. Treatment groups given four times a week also maintained the tallest villi (5.68); followed by the birds treated three times a week (5.54), then by the groups treated two times a week (5.51), and once a week (5.47), respectively. However, no significant differences were observed among inclusion frequencies. Meanwhile, birds supplemented with DH exhibited the shortest crypts (183.76), followed by SCB (184.43), CD (189.87), and NC (192.07) groups, respectively. Highly significant differences were found among groups given feed supplements. Birds treated four times a week (184.23) also demonstrated the shortest crypts, followed by the birds treated three times a week (186.67), two times a week (189.81), and once a week (189.43), respectively. Also, highly significant differences were observed among inclusion frequencies. Result also displays that birds supplemented with DH revealed the highest villi to crypt ratio (6.74) tied with SCB (6.66), followed by CD (6.40), and NC (5.55) groups, respectively. Still, treatments given four times a week (6.57) also measured the highest villi to crypt ratio, followed by the birds treated three times a week (6.37), two times a week (6.23), and once a week (6.20), respectively. Highly significant differences were observed among treatments and among inclusion frequencies (p¡0.05).

Ileum

Result showed that birds supplemented with DH had the tallest villi (602.30), followed by SCB (600.78), CD (596.58), and NC (530.40) groups, respectively. The results were highly significant. Birds given four times a week also maintained the tallest villi (601.34) tied with those treated three times a week (600.94), followed by those treated two times a week (588.02), and once a week (539.77), respectively. Also, highly significant differences were observed among inclusion frequencies. Birds supplemented with DH showed the shortest crypts (164.97), followed by SCB (167.18), CD (169.88), and NC (173.28) groups, respectively. Highly significant differences were found among treatments. Again, treatments given four times a week (166.68) also demonstrated the shortest crypts, tied with birds treated three times a week (168.45), and followed by those treated once a week (168.11) and twice a week (171.46), respectively. Highly significant results were found among inclusion frequencies. Also, result indicates that birds supplemented with DH exhibited the lengthiest villi to crypt ratio (3.66), followed by SCB (3.60), DH (3.51) and NC (3.06). Highly significant differences among treatments were observed (p ¡0.05). Consistently, birds treated four times gained the greatest villi to crypt ratio (3.62) tied with birds given treatment three times a week (3.57), and followed by those treated twice a week (3.43) and once a week respectively. Highly significant results were noted among interactions.

Absorption entirely depends on the mechanisms that happen in the intestinal epithelium, particularly the mucosa which include the villi and the crypts. In this study, DH, SCB and CD significantly improved the intestinal villi of the birds and possibly because of the energetic efficiency of the intestines.

The action of CD, SCB and DH can be expounded by some

Table 6. Morphometry (μ) of gut of birds supplemented with chitosan derivatives and *S. cerevisiae boulardii* at different inclusion frequencies

Gut Segment		Factor A Feed Supplement	Factor B Frequency of Inclusion				A Mean
			Once a week (B1)	2x a week (B2)	3x a week (B3)	4x a week (B4)	
Duodenum	Villi Height	A1 NC	1561.70	1548.50	1522.53	1496.05	**1532.19b**
		A2 CD	1661.45	1666.32	1714.15	1719.22	**1690.29a**
		A3 SCB	1657.70	1664.62	1716.45	1690.55	**1682.33a**
		A4 DH	1660.40	1676.62	1722.47	1750.75	**1702.56a**
		B Mean	**1635.31**	**1639.02**	**1668.90**	**1664.14**	
	Depth of Crypt	A1 NC	362.20	362.92	361.52	361.87	**362.13a**
		A2 CD	290.12	285.90	290.02	271.50	**284.36b**
		A3 SCB	280.85	282.07	282.12	282.02	**281.77b**
		A4 DH	280.07	281.65	281.12	279.60	**280.61b**
		B Mean	**303.13**	**303.31**	**303.69**	**298.75**	
	Villi to Crypt Ratio	A1 NC	4.32	4.67	4.22	4.14	**4.24b**
		A2 CD	5.73	5.83	5.91	6.33	**5.95a**
		A3 SCB	5.90	5.90	6.08	5.99	**5.97a**
		A4 DH	5.93	5.95	6.13	6.26	**6.07a**
		B Mean	**5.47b**	**5.49b**	**5.59ab**	**5.68a**	
Jejunum	Villi Height	A1 NC	1069.72	1064.97	1063.60	1063.82	**1065.53b**
		A2 CD	1213.75	1209.80	1215.62	1224.17	**1215.84a**
		A3 SCB	1216.90	1208.50	1233.92	1247.47	**1226.70a**
		A4 DH	1221.40	1210.07	1234.27	1284.85	**1237.65a**
		B Mean	**1180.44**	**1173.34**	**1186.85**	**1205.08**	
	Crypt Depth	A1 NC	193.25	190.10	191.90	193.00	**192.07a**
		A2 CD	190.60	191.65	189.12	188.12	**189.87a**
		A3 SCB	188.12	188.12	182.80	178.70	**184.43b**
		A4 DH	187.25	187.85	182.85	177.10	**183.76b**
		B Mean	**189.81a**	**189.43a**	**186.67ab**	**184.23**b	
	Villi to Crypt Ratio	A1 NC	5.54	5.62	5.54	5.51	**5.55c**
		A2 CD	6.37	6.31	6.43	6.51	**6.40b**
		A3 SCB	6.47	6.43	6.75	6.98	**6.66a**
		A4 DH	6.52	6.44	6.75	7.26	**6.74a**
		B Mean	**6.23b**	**6.20b**	**6.37b**	**6.57a**	
Ileum	Villi Height	A1 NC	537.10	529.75	529.70	525.07	**530.40b**
		A2 CD	536.50	609.22	617.80	622.82	**596.58a**
		A3 SCB	541.80	608.17	625.52	627.62	**600.78a**
		A4 DH	543.67	604.95	630.72	629.87	**602.30a**
		B Mean	**539.77b**	**588.02b**	**600.94a**	**601.34a**	
	Crypt Depth	A1 NC	171.20	172.72	172.17	177.00	**173.28a**
		A2 CD	168.95	170.87	172.35	167.32	**169.88b**
		A3 SCB	168.42	171.62	165.60	163.07	**167.18bc**
		A4 DH	166.25	170.62	163.67	159.32	**164.97c**
		B Mean	**168.71b**	**171.46a**	**168.45b**	**166.68b**	
	Villi to Crypt Ratio	A1 NC	3.14	3.06	3.07	2.97	**3.06b**
		A2 CD	3.18	3.57	3.58	3.72	**3.51a**
		A3 SCB	3.22	3.55	3.78	3.85	**3.60a**
		A4 DH	3.27	3.55	3.85	3.96	**3.66a**
		B Mean	**3.20b**	**3.43ab**	**3.57a**	**3.62a**	

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SCB basal diet + *Saccharomyces cerevisae boulardii* (0.10 g/kg);
DH basal diet + Doxycycline Hydroxide (1 g/kg)
Note: In a column, means followed by the same letter are not significantly different at 5% level of significance by DMRT.

mechanisms such as the protection of the villi and absorptive surfaces against pathogens, as well as the stimulation of the immune system and the production of antimicrobial substances, organic acids, and enzymes. With these perceived effects, there is a very low incidence or chance of infectious and inflammatory processes in the treated groups to occur.

Crypt depth and villous height are useful indicators of the size of proliferate and absorptive compartments in the intestinal mucosa. It is presumed that an increased villus height is paralleled by an improved digestive and absorptive function of the intestine due to increased absorptive surface area, expression of brush border enzymes, and nutrient transport systems (Sharma and Schumacher, 2001). Hence, a taller villus increases the intestinal absorptive capacity which can lead to improved nutrient absorption and assimilation, which consequently results in better performance. Moreover, greater crypt depth is indicative of better proliferative cellular activity to guarantee a satisfactory epithelium turnover rate, and compensating for the shorter villi height as observed in control group. Furthermore, reduction in crypt depth as realized for broilers fed with supplements is suggestive of lower secretory activity such as lower mucus production which means lower tendencies and incidences of inflammation and pathogenic infection. With the modification in the depth of the crypt, the secretion, digestion, absorption and assimilation of nutrients can be appropriately performed by the epithelium of the animals in the treated groups. Hence, the improved production performance of the broilers given feed supplements, SCB, CD and DH.

Results of this study are in agreement with the findings of Samanya and Yamauchi (2002) who found longer villi in small intestines of adult layer with slight improvement in feed efficiency after dietary addition of probiotics in layer diet and broiler diets. Moreover, reduction in crypt depth as manifested by broilers fed with supplements, DH, CD and SCB is suggestive of lower secretory activity such as lower mucus production which could be linked with reduced intestinal microbial population (Engberg et al., 2004). Drop in intestinal bacteria population may be attributed to the antimicrobial activity of DH and the competitive exclusion activity of CD and SCB.

Thus, for optimum broiler performance, maintaining gut integrity is an essential step. When the gut is intact, it absorbs nutrients more efficiently and limits or eliminates the adhesion and replication of unwanted microbes. It also prevents gut diseases and subsequently improves productivity (Kabir, 2009; Khan and Naz, 2013). Antimicrobial additives are used to control agents that may damage intestinal integrity, thereby significantly improving animal performance. Moreover, it also decreases incidence of diseases, mortality and thereby maximizing animal performances (Edens, 2003; Hughes, 2005).

Conclusions

Based on the results of the study, the following conclusions were drawn: Supplementation with SCB and CD improves the performance indices of broilers, BW, ADG and FCE. SCB and CD supplementation has no significant gross and histopathological effects in the gut. Also, SCB and CD demonstrate significant improvement in gut integrity as exhibited in the production performance results.

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Do International Remittances Alleviate or Aggravate Poverty in Developing Countries?: A Panel Data Analysis

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Abstract

This study investigated the effect of the surging increase in international remittances on poverty level in developing countries controlling for income, inequality, and other sources of external funding. Using the newly-suggested remittance variable, panel data analysis was applied across 66 developing countries for nine panel years from 1981 to 2005. With the use of pooled ordinary least square (OLS) method, results showed that international remittances may have helped in alleviating poverty in developing countries as manifested by the significant negative relationship of remittances on dimensions of poverty such as level, depth and severity of poverty. However, the significance of this alleviating effect of remittances disappeared when using panel data approach which implies that the alleviating effect of remittances on poverty is less apparent in developing countries when controlling for individual country-specific effect.

Keywords: Remittances, Poverty, Developing Countries, Panel Data

Introduction

Migration is an old-age phenomenon. For centuries, people have migrated in search for better economic and social opportunities. According to the International Organization for Migration (2006), the global estimates show that there are more than 200 million estimated international migrants in the world today representing 3% of the worlds global population. Migration with economic motives is increasingly being perceived as a force that can contribute to development because it has become one of the main sources of capital for developing countries (2006, 2006).

Over the past three decades, a new trend of migration issue has attracted significant attentions from government, academes, and media because this phenomenon depicts a continuous and robust growth. This trend refers to one of the interesting consequences of international migration, the remittances. Remittances refer to the unrequited monetary transfer usually from international migrant workers in developed countries to their families in developing countries. This unrequited transfer has begun to significantly exceed the official development aid (ODA) and is now reputed as the second highest source of external funding next to foreign direct investment (FDI) (Maimbo and Ratha, 2005). In 2007, remittances sent to developing countries accounted to almost 75% of the worlds total remittances. However, during the recession, Ratha and Mohapatra (2009) forecasted a sharp decline in remittances ranging from 5% to 8% in 2009 . But this decline was small relative to the projected fall in private capital flows or official aid to developing countries.

The number one target under the first goal of Millennium Development Goal of eradicating extreme poverty and hunger is to halve the proportion of people living in extreme poverty whose income is less than or equal to US$1.00 dollar a day between 1990 and 2015 (Nations, 2009). To address this goal, one of the potential ways to lift people out from poverty is to increase their income level. Despite the argument that poverty alleviation could not just happen in an instant as it is rooted from various and complex factors with varying dimensions, remittances proved to dispel this by increasing the income level of families left behind by migrant workers (Serino and Kim, 2011). However, major issue remains- does the poor really benefit from these remittances? Though remittances significantly increase the income level of households left in home countries, this does not necessarily mean that the poor directly receives this financial flow.

On a macro perspective, most of the worlds remittances were received mostly by developing countries, thus several studies have explored the impact of such income transfers on poverty level in developing countries. But hardly a clear consensus of views can be achieved. On the positive side, remittances could be used by recipient households to either fund current consumption or finance asset accumulation (Chami et al., 2008) or as insurance against income shocks (Yang and Choi, 2007). Remittances were also argued to fuel economic development, promote poverty alleviation by lifting people out of poverty (Acosta et al., 2008), smoothen consumption, and have a multiplier effect through increased household spending (Wagh and Pattillo, 2007). However, argument continues that poor households are actually not benefitting from remittances since they do not have the capacity to migrate, thus increasing income inequality (Lipton, 1980; Stahl, 1982; Adams Jr, 1989). Also, the potential moral hazard by migrants households (Chami et al., 2003; Naiditch and Vranceanu, 2009; for Economic Co-operation and Development, 2008) and the Dutch disease, which could retard the whole economy (Chami et al., 2008), and that which point out the negative implication of remittances, could not be disregarded.

Region-specific or country-specific studies conducted to evaluate the effect of remittances on poverty are common in some literature. However, studies covering a wide range of developing countries are very limited. Thus, this study may fill that gap by covering broad range of developing countries with the main objective of evaluating whether remittances alleviate or aggravate poverty in developing countries. Results of the study

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may add to the literature of macroeconomic implications of remittances on poverty issues by highlighting two major points. First, this study used a concise and representative account of remittances. In the past, there has been no clear definition of remittance variable. Until recently, Chami et al. (2008) suggested using a specific series in the World Development Indicator (WDI) capturing the behavior of remittances. Common practice is to aggregate the three subcomponents of remittances and represent it as remittance measure. Such practice could result in misleading conclusions (Chami et al., 2008). Based on their suggestion, this study only utilized workers remittance in the World Development Indicator as measure of remittances. Second, this study used a more heterogeneous sample of developing countries. And aside from the conventional ordinary least square regression, this study employed the methods of panel data analysis to control for time invariant country-specific characteristics.

Remittances and Poverty in Developing Countries

This study sought to describe the performance of the teacher education graduates of Tarlac College of Agriculture in the licensure examination for teachers from 2010-2014. Specifically, it sought to answer the following questions:

A handful of earlier studies evaluating the effect of remittances on poverty showed that remittances tend to worsen income inequality and eventually increase poverty level (Lipton, 1980; Stahl, 1982). These studies imply that better-off households are more capable of migrating and sending remittances than poor households. Clearly, the better-off households reap the benefits from remittances and not the poor. Study on workers remittances and inequality in rural Egypt by Adams Jr (1989) indicated that remittances from abroad worsened rural household income distribution, both in terms of gross and per capita, because they were earned mainly by upper income villagers. This shows that households that are on top of the income quantile benefit the most from remittances which leads to an increase in income inequality between households. The rich becomes richer and eventually the poor becomes poorer. Estudillo (1997) in her study about the income inequality in the Philippines from 1961 1991, found that income from remittances is one of the inequality-increasing factors in the Philippines. Similarly, Rodriguez (1998) concludes that while remittances increase household income, it also suggests a rise in income inequality. He also stated that further emigration could slow down any gains in economic welfare by worsening the income distribution in the Philippines where progress toward equality has been sluggish.

In another strand, remittances seem to show consistent and positive impact in reducing poverty in several regions and country-specific studies. However, current literature has limited study which covers a broad and wide range of developing countries. Adams Jr and Page (2005) conducted a cross-section analysis using new data set on international migration, remittances, inequality, and poverty across 71 developing countries and analyzed the effect of migration and remittances on poverty in developing world. Their results showed that both international migration and remittances significantly reduced the level, depth, and severity of poverty in the developing world. Further, it showed that a 10% increase in per capita official international remittances may lead to a 3.5% decline in the share of people living in poverty. Meanwhile, another study using a large cross-country panel dataset suggested that remittances in Latin American and Caribbean (LAC) countries reduced inequality and poverty. However, corresponding changes are generally small in magnitude. Thus, reductions in poverty are achieved mostly through the higher levels of income of migrant-sending households Acosta et al. (2008). In Sub-Sahara Africa (SSA), Wagh and Pattillo (2007) assessed the impact of the steadily growing remittance flows on poverty and inequality. Though the region received only a small portion of the total recorded remittances to developing countries, and the volume of aid flows to SSA swamps remittances, they found that remittances, which were stable and privately transferred, had a direct poverty-mitigating effect and could promote financial development. Moreover, Jongwanich et al. (2007) examined the impact of workers remittances on growth and poverty reduction in developing 17 Asia-Pacific countries using panel data over the period 1993-2003. It was found out that remittances had a direct impact on poverty reduction through increasing income, smoothing consumption and easing capital constraints of the poor. Results also suggested that a one-percent increase in remittance reduced poverty by 0.43 percent.

Country-specific studies also showed that remittances negatively affect poverty. This means that remittances tend to lower down the poverty level. Adams (2006) concludes that international remittances reduce the level, depth, and severity of poverty in Ghana. In addition, Brown and Jimenez (2008), in their comparative study between Fiji and Tonga, conclude that the estimated effects of remittances on poverty alleviation are strong and remittances have a substantial effect in alleviating poverty. In the Philippines, Yang and Martinez (2006) and Pernia (2008) found that an increase in remittances would lead to a reduction in poverty because of its spill-over effect.

Methodology

Empirical Model

To capture the effect of remittances on poverty, this study utilized the empirical model developed by Ravallion (1997) and Ravallion (1997). It states that poverty can be expressed as a function of mean income, measures of income distribution, the variable of interest, and international remittances. The model used in this study was similar to what Adams Jr and Page (2005), Jongwanich et al. (2007), Wagh and Pattillo (2007), and Seriño (2014) employed. The poverty equation is postulated as follows:

$$P_{it} = \alpha_{it} + \beta_1 \log(Gini_{it}) + \beta_2 \log(GDP_{it}) + \beta_3 \log(Remit_{it}) + \beta_4 \log(X_{it}) + \partial_i + \varepsilon_{it} \quad (1)$$

where Pit represents the measures of poverty such as headcount ratio, poverty gap and squared poverty gap; Gini is an index of income inequality; GDP refers to the per capita gross domestic product at 2000 constant prices; Remit is the main variable of interest representing the total amount of remittances

coursed through banks measured as ratio to gross domestic product. Moreover, X is a set of control variables; i is the country-specific effect; and it is the error term. The subscript t refers to year and i denotes the individual country. The control variables considered were other main sources of external funding in developing countries such as foreign direct investment (FDI) and level of official aid. The foreign direct investment refers to the private transfer of companies or private firms to other countries or any form of investment that earns interest in enterprises which function outside of the domestic territory of the investor while official aid are monetary transfers granted by developed countries (OECD members) to developing countries with the main objective of promoting economic welfare and development (for Economic Co-operation and Development, 2008).

The main concern of this study was 3. Based on the existing studies, β 3 could either be positive or negative. If 3¿0, then remittances would tend to worsen poverty but if 3¡0, then remittances tend to reduce poverty. Controlling for inequality, countrys income, and external funding, this study estimated the magnitude and sign of 3 which relates to the extent of how poverty in developing countries is affected with the surging increase of international remittances. Since independent variables is expressed in logarithmic form while dependent variable is in level form, then 3 is expressed as 3/100. This is interpreted as the change associated with a percentage increase in remittances (Adams, 2006).

For the other estimates, 1 is expected to be positive since higher poverty is associated with higher inequality; 2 is expected to be negative since it is evident that poverty will reduce as countrys income increases. Other control variables are expected to be negative as it is assumed to positively contribute to economic growth thereby having the tendency to reduce poverty.

In this study, it was assumed that all specified variables were exogenous. That is, reverse causality is not working. Hence, the relationship captured in this analysis was not causal in nature but correlational. Although it can be argued for the case of remittances, poverty might fuel remittances through migration. However, it should be noted that an increase in migration does not guarantee an increase in remittances since it is suspected that substantial number of migrant workers do not remit especially those on long term migration. In addition, people living in extreme poverty do not have the capacity to migrate. Thus, it was assumed that remittance was an exogenous variable since migration has already taken place (Acosta et al. (2008) as cited by Özden and Schiff (2007)) and remittances flow regardless of poverty level. Nevertheless, this study recognized that potential endogeneity might be possible. Table 1 shows the summary of variables used in the analysis and their hypothesized relationships.

Data Used

This study utilized panel data for 115 developing countries covering nine panel years from 1981 to 2005. Due to missing observations, the total number of countries included was 66 developing countries, making the panel set-up unbalanced. Data were retrieved from different online databases such as World Development Indicator (WDI), World Banks PovcalNet (2008) (2008) and OECD database.

Measures of poverty were taken from World Banks PovcalNet database. The interactive PovcalNet database allows researchers to set the poverty line. Headcount ratio, poverty gap squared and squared poverty gap are the poverty measures used to represent different dimensions of poverty such as level, depth, and severity of poverty. These measures are expressed in percentages. Headcount ratio means the percentage of population living below the poverty line. Poverty gap, which captures the depth of poverty, measures in percentage in terms of how far the average expenditures (income) of the poor fall short of the poverty line. For instance, a poverty gap of 10% means that the average poor persons expenditure (income) is 90% of the poverty line. The squared poverty gap indicates the severity of poverty. Squared poverty gap is the mean of the squared distance below the poverty line expressed as a proportion of the poverty line. It is more sensitive to the distribution of the poor. In other words, while a transfer of income from poor to poor will not change the headcount or the poverty gap, it will decrease the squared poverty gap since distribution among poor would tend to be equitable (Adams Jr and Page, 2005; Wagh and Pattillo, 2007). The poverty line used in this study was the international poverty threshold set at US$ 1.00 a day by the World Bank. This poverty threshold is used to account the number people living in extreme poverty.

The Gini index which measures income inequality was also sourced out from PovcalNet database. Per capita gross domestic product (GDP) at 2000 constant prices, and foreign direct investment (FDI) data were retrieved from the World Development Indicator (WDI) while the official development assistance was taken from OECD database although this data set could also be retrieved from WDI. Workers remittances (US dollars) in WDI were used to represent the level of remittances sent to developing countries. Other components of remittances were not used in this study considering the arguments raised by Chami et al. (2008). However, it should be noted that the remittances measured here were only those transfers coursed through banks and other formal channels.

Estimation Procedure

Before estimating the panel model postulated in equation 1, the model was first analyzed using pooled OLS estimation with time and regional dummies included. To check for presence of heteroskedasticity, Breusch-Pagan (BP) test was employed. If the null hypothesis of homoskedasticity was rejected, robust standard errors were used.

After conducting pooled OLS and checking for presence of heteroskedasticity, the panel regression analysis was employed. In the estimation of panel data regression models, two approaches are available: the random effects and the fixed effects approach. In the fixed effect model, unobserved country specific term, i, is assumed to be correlated with the independent variables specified while for the random effects model, i term

Table 1. Summary of the variables used in the analysis and their hypothesized relationship with poverty.

Variable	Description	Data source	Hypothesize relationship with Poverty
Poverty	Measures of poverty include headcount ratio, poverty gap and squared poverty gap	World Banks Povcal-Net Database	not applicable
Gini index	Index on income inequality. A value closer to 1 means higher inequality and a value closer to zero means more equitable income distribution	World Banks Povcal-Net Database	Positive. A worsening income distribution is associated with higher levels of poverty
GDP per capita	Measures the average income per person in a country. This measures national income or national output divided by the population.	World Development Indicator	Negative. Improvement in national income will reduce poverty
Foreign direct investment	Refers to cross-border investment measuring the equity flows in the reporting economy. It is the sum of equity capital, reinvestment of earnings, and other capital made by a company or individual in one country in business interests in another country	World Development Indicator	Negative. Higher investments translate to more job opportunities hence it will be bring down incidence of poverty
Development aid	It consists of disbursements of loan or financial assistance usually given by governments of developed economies to support the economic, political, social and environmental development of developing countries.	World Development Indicator	Negative. More assistance will facilitate economic development.
Remittances	It consists of current unrequited transfers in cash or in kind received by resident households from workers who are employed in an economy where they are not resident.	World Development Indicator	Negative / Positive. The effect of remittances could be positive or negative

is assumed uncorrelated with the rest of independent variables. The random effects approach is appropriate if it is found that i is uncorrelated with each explanatory variable (Wooldridge, 2006) while fixed effects model best control for omitted variable problem as it takes into account the unobserved country-specific characteristics.

To determine if country-specific term (∂ i) is correlated with explanatory variables, Hausman test was employed. Under the hypothesis of no correlation, estimates of both random and fixed effect are consistent, but estimates from fixed effect are inefficient. While under the alternative, fixed effect is consistent but random effect is not. Therefore, under the null hypothesis, the two estimates should not differ systematically (Wooldridge, 2006).

Results and Discussion

The logarithmic transformation of the independent variables with dependent variables on level form allows to interpret the coefficients as the change associated with a percentage increase in the independent variable. In other words, for the remittance estimate, β 3/100 is the unit change in poverty measures when the ratio of remittance to GDP increases by 1%.

Before estimating the postulated models, test for heteroskedasticity using Bruesch-Pagan (BP) test was conducted. Results showed that there was a strong evidence indicating that data set suffers from heteroskedasticity problem. The F- value of heteroskedasticity test with headcount ratio, poverty gap, and squared poverty gap as dependent variable were 6.0, 6.02, and 3.98 respectively (with P-values = 0.0). In all three estimations, presence of heteroskedasticity was detected. This necessitates the use of robust standard errors throughout the estimation procedure. In addition, Hausman test was employed to determine which of the two panel methods (random effects and fixed effects method) would be appropriate to use. Results showed that Hausman test failed to judge which of the two panel methods would be appropriate to use. But even if Hausman test was inconclusive, it was suspected that the unobserved country-specific effect was correlated with independent variables and so fixed effects was a good option of analysis over random effects.

Pooled OLS estimation results

The estimation results using headcount ratio as dependent variable are presented in Table 1. In pooled OLS, time and regional dummies were included to control for time and regional effects with year 1981 as base year and Europe and Central Asia (ECA) as control regional group. Results showed that in the years 1984 and 1987, headcount ratio was higher than its 1981 level. But starting from the year 1990 onwards, headcount ratio was observed to be lower than the base year. However, estimates of time dummies were insignificant. Nevertheless, the negative effect of time dummies relative to headcount ratio since 1990 is in line with the Millennium Development Goals (MDG) of halving extreme poverty from 1990 to 2015. With respect to the regional dummies, East Asia and Pacific (ESP), Latin America and Caribbean (LAC), South Asia (SA) and Sub-Sahara Africa (SSA) were observed to have higher incidence of poverty as compared to Europe and Central Asia (ECA). Sub-Sahara Africa (SSA) was observed to display the highest level of headcount ratio followed by East Asia and Pacific (ESP). Among the regional aggregates considered, only the Middle East and North African Countries (MENA) was observed to have highly significant lower estimate of headcount ratio compared to ECA. In terms of significance, LAC was insignificant while SA was significant at 10% and the rest of the regional dummies were highly significant. This implies that changes in headcount ratio are strongly influenced by the regional aggregations.

Looking at the other variables, Gini coefficient, GDP per capita, AID, FDI, and remittances showed the expected signs with only FDI estimate being insignificant. Interpreting the estimates, Gini coefficient shows that a percentage increase in Gini index is associated with an increase in headcount ratio by 0.13 holding other factors constant. Meanwhile, a one-percentage increase in GDP per capita is associated with a reduction in poverty measured by headcount ratio by 0.17. And a percentage increase in official ODA is associated with 0.01 reduction in headcount ratio, respectively, holding other factors constant.

Turning to the main variable which is the remittances, the result showed a significant negative association with headcount ratio. This implies that an increase in remittances sent by migrant workers to developing countries is associated with the reduction of headcount ratio. Holding other factors constant, a percentage increase in remittance is associated with a reduction in headcount ratio by 0.012. Pooled OLS estimate is a good fit with an R2 close to 80%. However, the fact that there may be unobserved country-specific factors affecting the dependent variable (i), which may be correlated or uncorrelated with the independent variables, could not be disregarded. Hence, the regression results under pooled OLS may not actually yield the reducing effect of remittances towards poverty since the generated estimates might be biased and inconsistent. Thus, estimation using random effects or fixed effects method is deemed necessary.

Estimation results using panel data analysis

Random effects estimation assumes that the country-specific effect i is uncorrelated with each independent variable across time periods considered. Under random effects assumption, estimators are said to be consistent but eliminating i would result to an inefficient estimators (Wooldridge, 2006). Results showed that estimates of time dummies were consistent with previous estimation result. Headcount ratio was observed to be relatively higher in 1984 and 1987 compared to its 1981 level. But starting from year 1990 up to 2005, time dummies displayed a negative association with headcount ratio, implying that headcount ratio from these years has been lower compared to 1981 level. Regional aggregates showed that MENA had a headcount ratio significantly lower than ECA, while SSA posted higher headcount ratio compared to ECA. Random effects estimation showed that the variables considered had the expected sign. Aside from the intercept, only Gini and GDP per capita displayed significant results. An increase in Gini index tends to increase the level of

headcount ratio which appears to be logical since an increase in income inequality would worsen poverty level. The GDP per capita showed the largest poverty reducing effect with 0.15 reductions in headcount ratio holding other factors constant. This result is expected since an increase in income would lift people out of poverty.

Moreover, results showed that remittance had a reducing effect on headcount ratio as manifested by its negative sign. However, estimate was not statistically significant. Now, compared to pooled OLS result with significant estimate, random effects estimation reported lesser reducing effect in terms of magnitude. This means that level of remittances has a weak mitigating effect in reducing headcount ratio as manifested by its insignificant estimate. However, the fact that remittance is negatively associated with headcount ratio shows inclination in alleviating poverty. Further, results of random effect might suffer from omitted variable problem as well as result from pooled OLS estimation. Thus, estimation using fixed effects method which single-handedly took care of omitted variable problem was carried out.

Fixed effects estimation assumes that ∂_i is correlated with the rest of explanatory variables. If the unobserved effect is not eliminated, this would cause bias to the estimates. Using fixed effects estimation, the i term is eliminated in order to make the estimate unbiased and consistent (Wooldridge, 2006). In addition, fixed effects take care of possible bias from omitted variable problem. Table 1 also reports the results from fixed effects estimation. Results of the time dummies showed the same behavior observed with pooled OLS and random effects method. With regard to other variables, results showed that Gini coefficient, GDP per capita, and FDI presented the expected sign but surprisingly ODA and remittances showed otherwise. The result for ODA is unexpected since this would mean that an increase in aid would tend to increase poverty. The result is somehow counter-intuitive and contrary to the objectives of the official aid in improving the welfare of developing countries. However, this unexpected sign probably captures the behavior of increasing humanitarian aid or development aid when a country experiences negative shocks such as natural disasters, political chaos, and economic turmoil. With regard to remittances, positive association was observed but the effect was very marginal. This suggests that increasing the level of remittances may worsen headcount ratio implying that poverty worsens as remittances increase. This result gives an interesting view regarding the impact of remittances in developing countries since it contradicts the results from previous estimation. Even though this result implies the worsening effect of remittance on headcount ratio, this piece of evidence is weak since estimate is insignificant and its effect is very minimal judging from its magnitude. Other estimates showed that Gini coefficient and GDP per capita had a highly significant effect on headcount ratio.

Comparing the results of the three regression presented in Table 1 and focusing on the main variable; the remittances, results showed that the estimate of remittance in pooled OLS was relatively higher compared to random effects and fixed effects in absolute terms. The difference could be attributed to the possible bias encountered with pooled OLS estimation. Somehow, there is an agreement in the result of pooled OLS and random effects showing that remittances could have contributed to the decrease in headcount ratio. However, the result from fixed effects method showed otherwise. This tendency to worsen poverty is possibly due to the increasing income inequality.

Table 2 shows the estimation results using poverty gap as dependent variable with robust standard errors reported. Poverty gap measures the depth of poverty while headcount ratio measures the level of poverty. Results showed that poverty gap in developing countries was reduced with time. The same observation that is depicted in Table 1. With regard to regional dummies, only Sub-Sahara Africa (SSA) posted a significant and higher level of poverty gap compared to control region (ECA). This relates to the observation that poverty gap in SSA is not getting better.

The rest of the variables considered bore the expected sign. Focusing on remittances, results showed a significant effect on poverty gap. Holding other factors constant, one-percent increase in the inflow of remittances sent to developing countries is associated with 0.008 reduction in poverty gap. But as mentioned earlier, results from pooled OLS estimation might be bias and inconsistent and should be interpreted with caution. Thus, the model was analyzed further using the methods of panel data regression.

Random effects estimation result showed a negative relationship of remittance towards poverty gap. The inverse relationship claimed to alleviate poverty level. However, the estimate was not statistically significant. Other estimates of random effects estimation bore the expected. Only Gini and GDP per capita were reported to have highly significant estimates affirming their strong impact on poverty. On the other hand, estimates of time dummies showed similar results from Table 1. The effect of time towards poverty gap was found to be important since in terms of magnitude of estimates, time dummies were higher than the three major sources of external funding.

Results from fixed effects estimation showed that remittance had a negative relationship with poverty gap. This negative relationship signals that the potential capacity of remittance to reduce poverty does exist. However, estimates could not be confidently interpreted since it was insignificant. On the other hand, official aid was observed to be worsening the level of poverty gap since it posted unexpected sign: positive relationship with poverty. The same argument for official aid could be held in this case, that humanitarian aid increases when developing countries experience huge negative economic shock. Time dummies were reported to behave similarly with the previous results and the rest of the estimates showed the expected sign.

With poverty gap as the measure of poverty, estimation results showed that remittances had a negative relationship with poverty. This may imply that remittances alleviate the level of poverty gap in developing countries. The piece of evidence was strong in pooled OLS at 5% significance level but the pieces of evidence from random effects and fixed effects were weak since estimates were insignificant (Table 2).

Comparing the magnitude of remittance estimates, pooled OLS estimate was higher in magnitude relative to random and fixed effects estimate, with fixed effects estimate reporting the

Table 2. Estimation results with headcount ratio as dependent variable.

Variables	OLS		Random Effects		Fixed Effects	
	Coef	se	Coef	se	coef	se
lnGINI	13.171**	5.988	20.651***	6.751	26.880**	12.443
lnGDP per capita	-16.872***	1.409	-15.493***	2.142	-17.974***	4.428
lnFDI (ratio to GDP)	-0.421	0.419	-0.294	0.314	-0.279	0.484
lnAID (ratio to GDP)	-1.100***	0.299	-0.250	0.501	0.638	0.565
lnREMIT (ratio to GDP)	-1.185**	0.533	-0.203	0.555	0.095	0.980
y84	1.469	4.288	1.651	2.584	1.628	1.348
y87	2.073	4.352	0.628	2.750	0.186	1.970
y90	-1.168	3.855	-2.050	2.457	-2.434	2.050
y93	-4.317	3.397	-4.090*	2.342	-3.830	2.951
y96	-3.245	3.511	-4.599**	2.306	-4.614	2.808
y99	-3.012	3.455	-4.573*	2.402	-4.353	3.327
y02	-2.739	3.500	-4.778**	2.380	-4.360	3.145
y05	-1.736	3.648	-4.820*	2.588	-4.202	3.584
ESP	8.336***	2.603	7.555	6.318		
LAC	3.605	2.726	-1.808	4.557		
MENA	-6.812***	2.081	-11.107***	4.113		
SA	6.107*	3.268	5.871	7.888		
SSA	17.754***	3.152	15.265**	6.347		
Constant	86.925***	24.507	64.201**	29.470	70.409	50.766
N	295		295		295	
No. of countries			66		66	
R2	0.8017		0.7792		0.6391	
F-statistics	78.54					

Note: *** p<0.01, ** p<0.05, * p<0.1

least in magnitude. This could be attributed to the fact that pooled OLS and random effects do not take into account the bias resulting from omitted variable problem. Though, random effects take into account this unobserved effect, it is assumed as uncorrelated with the rest of explanatory variables which is suspected to be correlated. Thus, fixed effects could better reflect the effect of remittances on poverty gap since bias from omitted variable problem is being considered. It is worth noting that the negative relationship of time dummies with poverty is in accordance with the scope year of Millennium Development Goals. The same observation was drawn from Table 1 and SSA which reported to have a significant higher incidence of poverty gap.

The third measure of poverty is squared poverty gap. It measures the severity of poverty and this measure is more sensitive to the distribution of the poor. Result is reported in Table 3. Pooled OLS estimation and random effects displayed similar results in comparison to the previous estimations with pooled OLS being significant while random effects estimate was insignificant. In this estimation (Table 3) most regional dummies were lower than the control group and insignificant except only for SSA. Considering the results from pooled OLS, remittance showed a negative association with squared poverty gap and was significant at 5% level. The negative sign of remittance shows the tendency of remittances to reduce squared poverty gap. Holding other factors constant, a 1% increase in the bulk of remittances sent to developing countries coursed through banks was associated with 0.005 reduction in squared poverty gap. This implies that this monetary transfer contributes to the improvement of poverty distribution in developing countries, ceteris paribus.

On the other hand, results from random effects showed that remittances displayed a negative relationship with squared poverty gap while controlling for time and regional dummies, Gini coefficient, GDP per capita, and other sources of external funding. The expected negative sign gives the signal on the capacity of remittance to ease the severity of poverty in developing countries even though the estimate is insignificant.

With fixed effects estimation, remittance showed the expected negative sign but somehow the estimate was insignificant. The same result was observed from regressing remittances on poverty gap. The negative association of remittance on squared poverty gap tends to ease severity of poverty. This would translate to a better distribution among poor people in developing countries. But the effect of remittances is not that strong since estimates are not significantly different from zero. Other variables considered showed the expected sign with only Gini coefficient and GDP per capita reported to have a significant effect on squared poverty gap. Gini coefficient and GDP per capita were consistent in their effect towards poverty. Gini coefficient had a positive significant effect to squared poverty while GDP per capita showed a significant reducing effect to the squared poverty level. This observation conforms with the fact that an increase in inequality worsens poverty while an increase in a countrys income lifts people out of poverty. Notably, time

Table 3. Estimation results with poverty gap as dependent variable.

Variables	OLS		Random Effects		Fixed Effects	
	Coef	se	Coef	se	coef	se
lnGINI	12.472***	3.835	18.452***	5.299	21.755**	9.064
lnGDP per capita	-7.078***	0.788	-6.226***	1.110	-6.410**	2.490
lnFDI (ratio to GDP)	-0.188	0.239	-0.155	0.198	-0.188	0.331
lnAID (ratio to GDP)	-0.311*	0.159	-0.174	0.278	0.122	0.316
lnREMIT (ratio to GDP)	-0.759**	0.342	-0.319	0.382	-0.226	0.597
y84	0.973	2.280	1.147	1.348	1.122	0.742
y87	1.300	2.564	0.882	1.663	0.678	1.489
y90	-0.713	2.009	-0.836	1.303	-1.051	1.154
y93	-2.322	1.842	-1.602	1.173	-1.513	1.418
y96	-1.797	1.978	-2.062	1.291	-2.170	1.677
y99	-1.545	1.903	-2.322*	1.299	-2.447	1.828
y02	-1.507	1.955	-2.582**	1.307	-2.648	1.738
y05	-0.535	2.032	-1.852	1.393	-1.884	1.835
ESP	0.170	1.329	-0.463	2.794		
LAC	0.494	1.465	-3.379	2.321		
MENA	-1.870	1.239	-4.521**	2.273		
SA	0.061	1.702	-0.499	3.432		
SSA	6.680***	1.763	5.616*	3.391		
_cons	9.708	15.225	-13.219	20.154	-22.193	33.184
N	293		293		293	
No. of countries			65		65	
R2	0.6981		0.678		0.5469	
F-statistics	37.56					

Note: *** p<0.01, ** p<0.05, * p<0.1

dummies displayed similar results with other estimation. This reaffirms the claim that the decrease in poverty is in accordance with the Millennium Development Goals.

In this study, other sources of external funding such as FDI and ODA were considered as control variables in analyzing the effect of remittances to level, depth, and severity of poverty aside from controlling income inequality and GDP per capita. However, results in the estimation of official aid with fixed effects estimation showed inconsistency with what was expected relative to its effect on poverty. In two estimations using fixed effects method, ODA displayed a positive association with the measures of poverty (Table 1 and 2). This suggests that in controlling the country- specific effect, an increase in the official aid tends to worsen level of poverty. However, this should be interpreted with caution since all estimates were insignificant in the first place. Nevertheless, it can be argued that such behavior of development aid captures the increasing humanitarian aid when the country experiences negative shocks such as natural disasters, political chaos, and economic turmoil. Meanwhile, the effect of FDI reported the expected sign having negative association with poverty, but in all estimation it turned out to be insignificant. Although FDI is reputed as the biggest source of external funding in developing countries, its effect seems to not reach the poor since the effect is not that pronounced. With regard to the main variable, the level of remittance remained significant at 5% level in pooled OLS estimation but the rest of the panel estimations effect was insignificant. Though estimates showed a negative sign, it was hardly evident that such estimate was significantly different from zero. It is only in pooled OLS estimation that remittances proved to be significant in its effect in reducing poverty. However, estimates from pooled OLS do not have the confidence of bias-free estimate.

The difference in behavior of these main sources of external funding may be related to the effects of each transfer to the economy according to whoever receives these monetary transfers. Note that FDI and ODA are transfers from institutions to institutions while remittances are individual unrequited transfers. Remittances being private transfers at household level directly benefited families of the migrant workers left behind in developing countries. Institution level transfer and household level transfer could have a different effect towards affecting poverty. The assumption that remittances have a reducing effect on poverty holds but it is not at all evidently supported by the panel data analysis. So then, it depends on the countrys capacity to maximize the economic benefits gained from these transfers.

Contrary to the significant and mitigating effects of remittances in reducing poverty in developing countries found in literature, findings in this study could aid in understanding the real impact of remittances in the developing world. Chami et al. (2008) on their article reminded authors of published articles who summed the three aggregates of remittances to reconsider their claim towards the effect of remittances. Results may not reflect the true behavior of remittances. In this study, only the

Table 4. Estimation result with squared poverty gap as dependent variable.

Variables	OLS		Random Effects		Fixed Effects	
	coef	se	Coef	se	Coef	se
lnGINI	9.624***	2.736	14.010***	3.950	16.518**	6.676
lnGDP per capita	-3.889***	0.530	-3.301***	0.710	-2.968*	1.678
lnFDI (ratio to GDP)	-0.119	0.166	-0.084	0.147	-0.120	0.240
lnAID (ratio to GDP)	-0.082	0.111	-0.130	0.176	-0.034	0.207
lnREMIT (ratio to GDP)	-0.529**	0.245	-0.303	0.296	-0.268	0.446
y84	0.659	1.460	0.805	0.868	0.786	0.496
y87	1.047	1.815	0.913	1.226	0.787	1.179
y90	-0.374	1.278	-0.325	0.839	-0.475	0.754
y93	-1.445	1.197	-0.814	0.732	-0.776	0.844
y96	-0.992	1.317	-1.088	0.865	-1.242	1.119
y99	-0.926	1.238	-1.435*	0.848	-1.641	1.181
y02	-0.974	1.272	-1.666*	0.853	-1.854	1.129
y05	-0.198	1.328	-0.907	0.910	-1.094	1.164
ESP	-1.117	0.905	-1.702	1.630		
LAC	-0.067	0.959	-2.923**	1.484		
MENA	-0.670	0.872	-2.477*	1.492		
SA	-0.581	1.146	-1.118	1.987		
SSA	3.028***	1.172	2.438	2.131		
_cons	-5.105	10.600	-23.164	14.692	-35.294	24.050
N	293		293		293	
No. of Countries			65		65	
R2	0.61		0.5882		0.4352	
F-statistics	22.41					

Note: *** p<0.01, ** p<0.05, * p<0.1

data on workers remittances were exclusively used in analyzing the effect of remittance on poverty rather than summing all the three series of remittances (workers remittances, compensation of employees and migrant transfers).

Chami et al. (2008) showed that such practice of summing the three series is problematic and could lead to faulty conclusions. This would imply that in the past, remittance variable might have been over represented thereby bloating the level remittances and so do its effect on poverty and other economic indicators.

Conclusions

Based on the results of the study, the following conclusions can be drawn. Remittances may contribute to the reduction of poverty as manifested by the negative relationship of remittances to the level, depth, and severity of poverty. However, this effect disappeared when controlling for individual country-specific effect. This implies that the effect of remittances on poverty is mixed and further analysis at the household level might help clarify this mixed results. Since remittance is a matter of private household activity, the government cannot directly regulate how the recipients use these remittances. But it would be helpful for the government to empower the families of migrant workers in terms of its decision on how to best use the remittances they received. This could be a government program guiding migrant workers on how to maximize the benefit from remittances so that when migrant workers return home, they can still have a reliable source of income. It is recommended that remittance-enhancing policy through formal channels should be encouraged by developing countries in order to properly account the level of remittances. In addition, it would be interesting to conduct a cross-section analysis and investigate how different countries help migrant workers better manage their remittances, their programs and what challenges are faced by the government. Results of this study may further provide a significant input not just to policy makers but to the migrant workers and remittance- recipient households on maximizing the benefit of remittances.

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