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North–South Trade Agreements and Agricultural Input Use

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Abstract

We estimate how developing countries' access to more advanced countries' markets, proxied by regional trade agreements (RTAs) with such countries, affects their agricultural input use (namely, the use of fertilizer and agricultural machinery). Using pooled OLS with country and year fixed effects and alternative instrumental variables, we find that having RTAs with high-income countries is associated with higher consumption of fertilizer relative to those countries that do not have such agreements—about 10 percent more. A similar result is obtained for the use of agricultural machinery per 100 square kilometres: in particular, relative to those countries that do not have RTAs with high-income countries, those countries that do have such RTAs use more than twice of agricultural machinery per 100 square kilometres.

1 Introduction

The promotion of trade liberalization as a key component of development strategies has taken place in many countries. Countries are taking liberalization measures since liberalization will create greater efficiency in resource allocation, specialization in production, knowledge and technological spillovers, and competition, and hence promote economic growth and development.

Growth in agricultural productivity has been a central issue for ensuring an increasing food demand from a growing population. There is growing evidence—both theoretical and empirical—about the role of agricultural productivity on economic growth (Gollin, 2010). Among the four channels where agriculture contributes to growth summarized by Kuznets (1968), the backward and forward linkage to the manufacturing industry are the main ones. In particular, agriculture provides raw materials to the manufacturing sector and hence gets manufactured inputs back from the manufacturing sector. For example, McArthur and McCord (2017) investigate how the use of manufactured input for agriculture improves the agricultural productivity growth and thereby facilitates the process of structural change. In their work, they show that the use of fertilizer boosts agricultural yields and economic growth.

However even though, the importance of the use of manufactured inputs in agriculture such as fertilizer and agricultural machinery is acknowledged in the literature, consumption of such inputs in agricultural production varies significantly across countries. In most developing countries, where the manufacturing sector is not yet developed, the linkage between the manufacturing and the agricultural sector is still weak and hence the agricultural sector remains under developed. Thus, one can argue that any form of economic integration such as RTAs between a developed country with a strong manufacturing sector a developing country can bring productivity growth in both countries by improving their input mix.

The existence of huge variation in agricultural input use across counties and its link to countries' participation to RTAs stems from two factors. First, if RTAs are among similar countries such as south-south RTAs, technological spillover is expected to be low and hence, RTAs among developing countries might have little impact on the pattern of agricultural input use. Second, if RTAs is among countries at different levels of economic development, it will enhance their complementarities. That is an RTA between a technologically advanced economy and traditional agrarian economy might enhance the use of improved agricultural input.

We test the above prediction by using data on agricultural input use for 66 developing countries from the period 1980 to 2015. We employ two different econometric strategies to examine the causal relationship between manufactured inputs in agricultural production and involvement in RTAs. In our first approach, we estimate the fertilizer and agricultural machinery use by pooling all other cross–sectional units and running an OLS estimation. We control for a broad set of variables such as population, agricultural land, GDP per capita, agricultural value added, and country and year fixed effects. In our second approach, we employ an instrumental variable(IV) approach for RTA membership to examine the causal link between agricultural input use and RTA membership. Hence, we find that countries' participation in RTAs increases the use of agricultural inputs. Moreover, the effect of RTA participation is much larger for those countries who have RTAs with developed countries. Our result confirms the prediction of backward linkage where the manufactured sector produces manufactured inputs for agricultural production and feeds the agricultural sector. The linkage is between countries in this case, where countries' integration facilitates factor movement and hence productivity gains. Our results suggest that relative to those countries who do not have RTAs with high-income countries, those countries who have such RTAs use about 5.7 kg/ha more of fertilizer which has substantial implications for agricultural yield gain as predicted by McArthur and McCord (2017).

they estimated that a 0.8 kg/ha increase in the use of fertilizer results an increase in yield by 7kg/ha. Similarly, developing countries' participation in RTAs with developed countries is associated with the use of about 14 more machinery per 100 square kilometers of arable land.

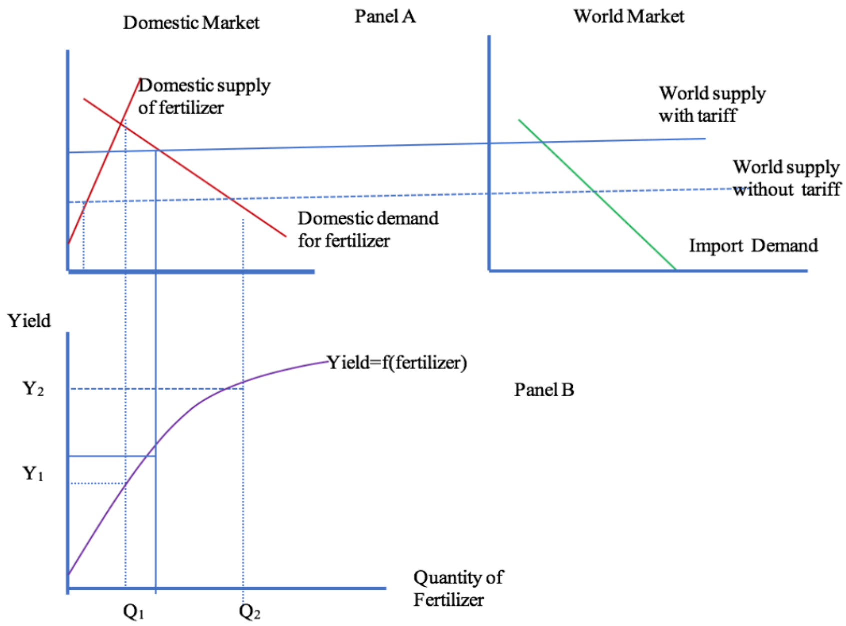
Previous studies in the area have shown qualitatively similar results. For example, a study by Ahmed et al. (1995) shows that liberalization of the agricultural input market results in a remarkable increase in adoption of new technologies such as fertilizer, power-driven equipment, high–yield variety seeds, and pesticides in Bangladesh. The North American Free Trade Agreement has increased fertilizer use in Mexico and pesticide use in the United states (Williams & Shumway, 2000).

2 Theoretical Motivation

For a simple agricultural production function y=f(Land, Labor, K) where K stand for all manufactured inputs in agricultural production (fertilizer, agricultural-machinery and tractors), employment of any one of these inputs below the optimal amount forces other input to be used above the optimal level. In most developing countries where labor and land are in relative abundance, capital input is scarce. Hence, any mechanism that facilitate capital use convenient might optimize the factor input mix and hence output growth.

Assume country i is small a country (i.e, it can not influence on international prices of agricultural input). A small country has a relatively inelastic supply curve for agricultural inputs due to capacity constraints. Figure 1, shows the theoretical link between trade liberalization and demand for fertilizer in panel A and fertilizer use and yield in panel B. This paper is thus a modest attempt to empirically show the theoretical link represented in panel A.

Figure 1: Trade liberalization, Production technology and yield



Let the representative producer production function be:

$$Y = AL^{\alpha}K^{\beta}N^{\theta}, \tag{1}$$

and a representative producer's maximization problem be:

$$maxY = AL^{\alpha}K^{\beta}N^{\theta} \tag{2}$$

subject to $wL + rK + RN \leq C$

where Y is agricultural yield , L is labor, K is capital, and N is land. w,r and R are respectively, the price of labor, the price of capital, and the price of land.

The first order condition for maximization is thus:

$$\alpha AL^{\alpha-1}K^{\beta}N^{\theta} = 0 \tag{3}$$

$$\beta AL^{\alpha}K^{\beta-1}N^{\theta} = 0$$

$$\theta AL^{\alpha}K^{\beta}N^{\theta-1} = 0$$

Solving the three equations simultaneously:

$$L^* = \frac{\alpha C}{w\left[\alpha + \beta + \theta\right]}$$
$$K^* = \frac{\beta C}{r\left[\alpha + \beta + \theta\right]}$$
$$N* = \frac{\theta C}{R\left[\alpha + \beta + \theta\right]} \tag{4}$$

For constant returns to scale(CRS): $L^* = \frac{\alpha C}{w}$, $K^* = \frac{\beta C}{r}$, and $N^* = \frac{\theta C}{R}$.

Thus, $Y^* = AL^{*\alpha}K^{*\beta}N^{*\theta} = A\left(\frac{\alpha}{w}\right)^{\alpha}\left(\frac{\beta}{r}\right)^{\beta}\left(\frac{\theta}{R}\right)^{\theta}C.$

Assume K is the only tradable input across countries. Hence, for the country who imports the capital input, the price of capital is r=r*+t, where t is the per unit tariff for capital inputs.

Therefore,

$$\frac{dK^*}{dt} = \frac{dK^*}{dr}\frac{dr}{dt} = -\frac{\beta C}{r^2} < 0 \tag{5}$$
$$\frac{dY}{dt} = \frac{dY}{dr}\frac{dr}{dt} < 0$$

This model predicts that any trade policy that reduces tariffs such as a free trade agreement increases the use of capital inputs in the agricultural sector and thereby agricultural production.

3 Overview of Countries' Participation in RTAs and Agricultural Input Use

Despite low participation of developing countries in RTAs, every country is a member of at least one RTA. Most of the RTAs that developing countries belong to are mainly South–South RTAs, characterized by poor RTA implementation and a weaker link to the process of industrialization. Yet there is an increasing trends of South–South RTA as compared to North–South RTAs (Poole, Santos-

Paulino, Sokolova, & DiCaprio, 2017).

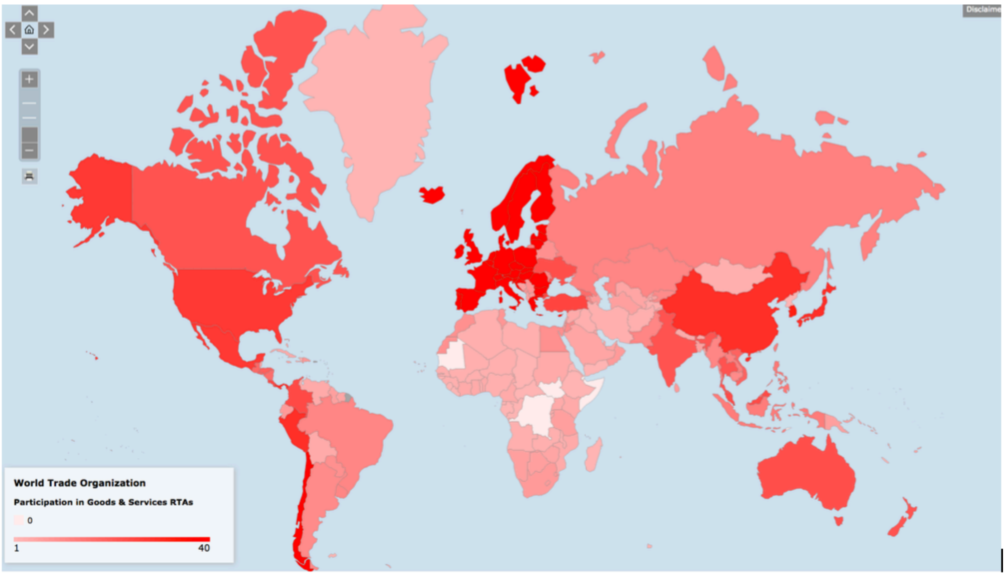


Figure 2: Map of countries' participation on RTAs

Source: WTO, 2018.

As it is clearly shown in figure 2, RTA participation is much higher in the South-East Asia, Europe, North America, and parts of Latin America. Surprisingly, such variation is also reflected in countries level of growth and moreover agricultural input use. Figure 3 shows the variations in fertilizer use across regions. The time series data of the trend in fertilizer use generally shows an increasing trend which of course coincides with the proliferation of RTAs in the early 1980s and the high jump observed after 1990.

3.1 Agricultural Input and Yield

The use of improved seeds, fertilizers and other agronomy technologies has been stated in the literature as the driving force for the 1960s Green Revolution in Asia Hazell (2009). A field experiments by Yousaf et al. (2017), in china has shown the impact of fertilizer use on agricultural yield: the application of fertilizers enhanced crop yields by 19–41% for rice and by 61–76 % for rapeseed. Similarly, a field experiment in Kenya by Duflo, Kremer, and Robinson (2008) has demonstrated that the use fertilizer results in a 36 % increase in the mean rate of return

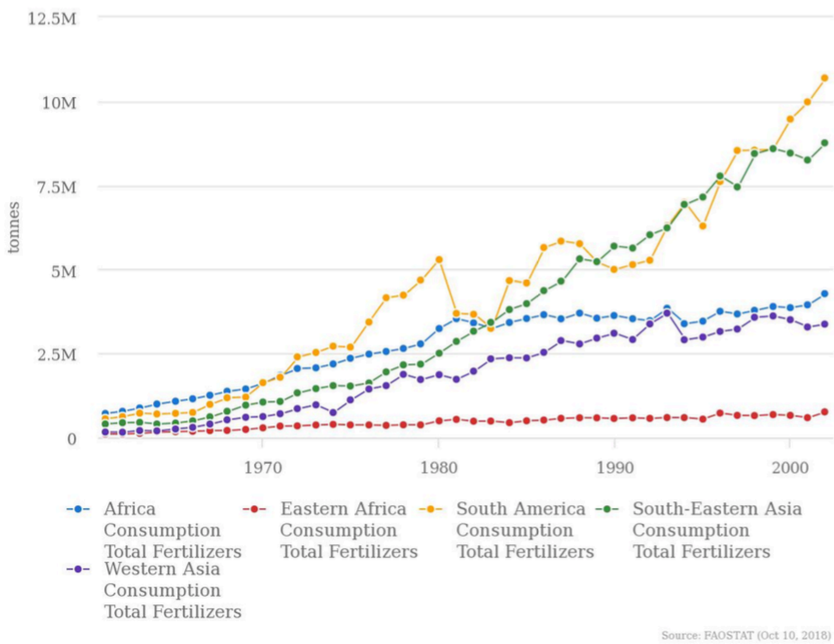


Fig 3 . Fertilizer consumption by region

Source: FAOSTAT, 2018

over a season, implying that there is 69.5 % increase in the rate of return on an annualized basis. Similarly by exploiting the global distribution of fertilizer production and associated differences in transportation distance across countries as a source of exogenous variation, McArthur and McCord (2017) find that the use of improved inputs such as fertilizer results a huge productivity gain in the agricultural output. Figure 4 and 5 show a simple correlation between fertilizer use per hectare and yield as well as the use of agricultural machinery and yield respectively for our sample.

4 Data and Identification Strategies

4.1 Data

Data for this study is mainly from FAOSTAT. The estimation strategy is based on country pair data over longer period of time. This dataset deviates from the standard panel data structures which we take into account in our estimation strategy.

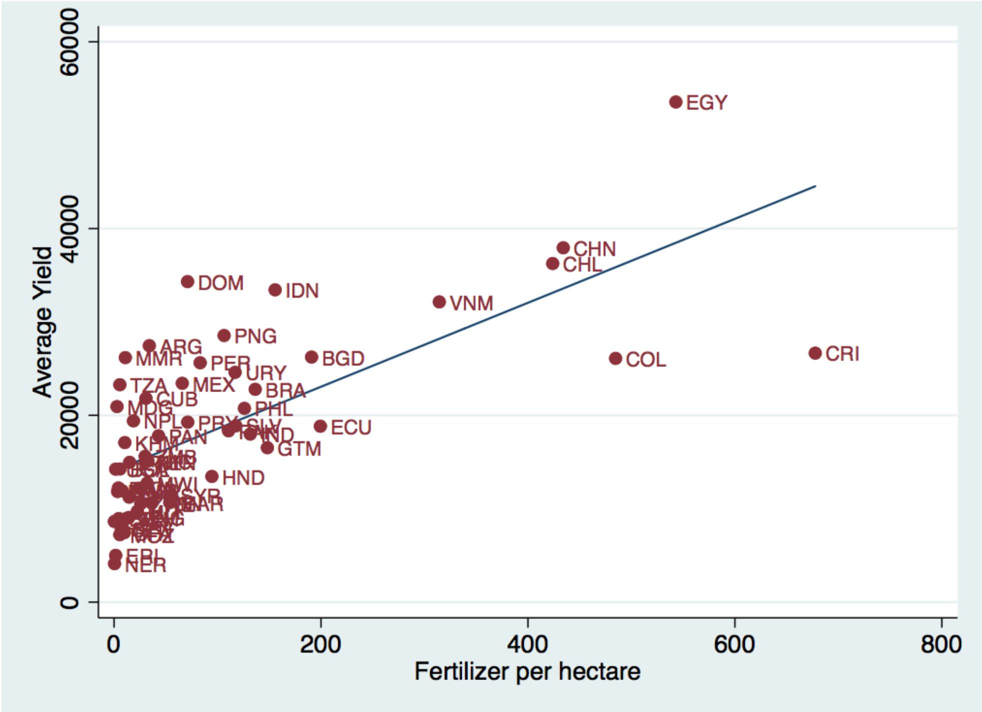


Figure 4: Correlation Between Average fertilizer use per hectare and average yield

Source: authors' calculation based on data from FAOSTAT, 2018

In our analysis, we consider the time span from 1980 to 2015. But the time series data for our key outcome variables is not uniformly available for those years. For example, fertilizer use per hectare is available in two different way of measurement according to the FAOSTAT data. From 1961 to 2001, they use one way of measurement and from 2002 to 2015 they use a different way of measurement Yet there is no harmonization between the two. Hence, to avoid any bias associated with this, we rely on estimation of fertilizer use after 2002. For agricultural machinery use data is available until 2009. Therefore, in this paper we estimate the fertilizer use and agricultural machinery use in a separately. Fertilizer consumption is defined as inline with WDI(2018) as "measur[ing] the quantity of plant nutrients used per unit of arable land. Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground rock phosphate)". Thus, fertilizer consumption in kilograms per hectare of arable land is used in the analysis. Regarding agricultural machinery use, WDI (2018) define and as the number of

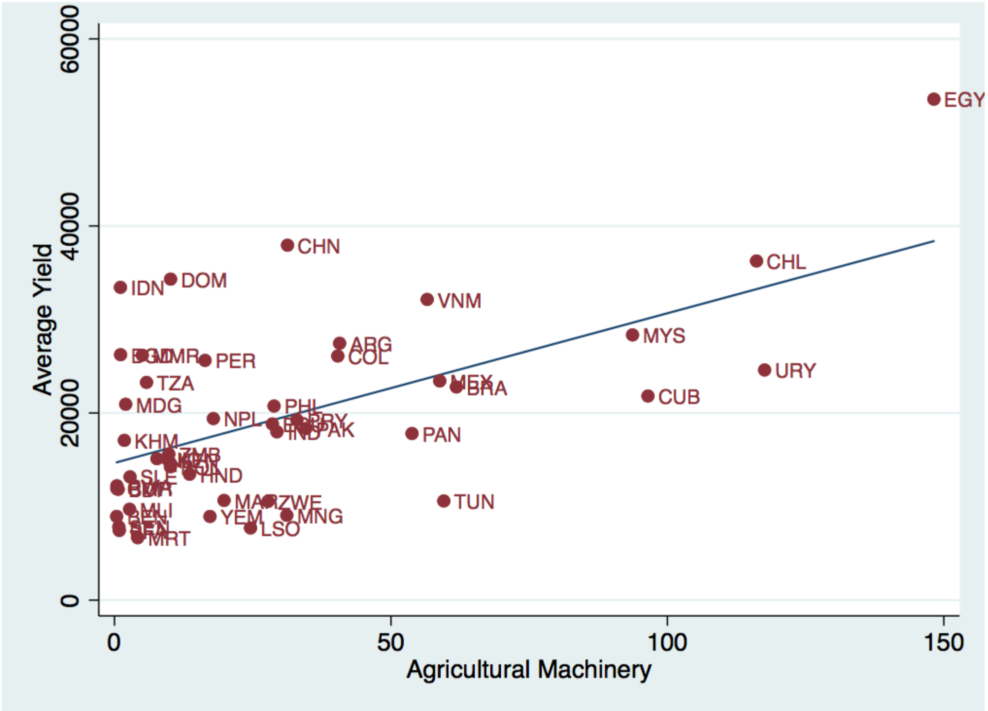


Figure 5: Correlation Between Average Machinery use per 100 sq.km. and average yield

Source: authors' calculation based on data from FAOSTAT, 2018

agricultural machinery and tractors per 100 sq. km of agricultural land which is arable.

The key independent variable is whether a given country is participating in any RTAs at time t. Thus, we use country-pair data over a long period of time. Data for such gravity variables comes from the WTO and the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) database. For capturing the effect of North–South RTAs, we create an interaction term whether the RTA is between a developing country and a high-income country (High Income RTA) Other controls include, Agricultural land (share of land that is arable), log of GDP per capita, Population and log of agricultural value added. All this data comes from WDI(2018).

4.2 Empirical Strategy

Our interest is assessing whether country i's agricultural input use is affected by any trade policy measures (specifically RTA membership status).□

$$Input_{it} = \alpha_i + \beta RTA_{ijt} + \theta RTA_{ijt} \cdot North_j + X'\gamma\ + \eta_t + \epsilon_{it} \qquad (6)$$

Where $Input_{it}$ is country i's manufactured input use in agricultural production at time t. RTA_{ijt} is a dummy variable equal to 1 if country i and j have an RTA at time t. The interaction variable is a dummy variable capturing whether the RTA is with a developed country or not; X is a set of control variable such as agricultural land, log of GDP per capita, population, and log of agricultural value added. α_i and η_t are country-specific and year fixed effects, respectively. Finally, ϵ_{it} is the common idiosyncratic error term.

4.3 Instrumenting for Membership in RTAs

Omitted variable bias might be a problem here making our key explanatory variable endogenous. We use an instrumental variable approach to identify the causal link between RTA membership and agricultural input use. Many historians and political scientists believe that the driving force behind the establishment of the European Coal and steel Community(ECSC) in 1951 was mainly to solidify peace and other major wars in Europe. Martin, Mayer, and Thoenig (2012) has shown that there is a high probability for country pairs to have an RTA if they have a higher frequency of war. Hence, we use history of bilateral conflict as an instrument for the formation of RTAs between country pairs. We believe that past history of conflict between county pairs has no direct impact on the current utilization of agriculture input. Since the purpose of our paper is to highlight the effect of RTAs with high–income countries, we use an additional instrument to identify the second endogenous variable. The second instrument is motivated by the domino theory of regionalism—regional integration between countries harms the non-members' trade and hence induce them to be pro-membership active(Baldwin, 1993). Hadjiyiannis, Heracleous, and Tabakis (2016) use this domino theory of regionalism to derive instrument for the formation of RTAs. In their paper, they use the number of free-trade areas(FTAs) and number of custom unions(CU) agreements signed between a country pair and the rest of the world as an instrument for the xistence of an RTA between the country pair. In our paper we deviate slightly from the Hadjiyiannis et al. (2016) approach by excluding the number of RTAs signed by the country included in our dependent variable. This approach will help us to reduce the risk of non fulfilment of the exclusion restriction. In other words, the number of RTAs signed by country i directly affects country i's agriculture input use. Hence, we exclude this part and consider only the number signed RTAs by country j as an instrument for the formation of an RTA between countries i and j.

$$RTA_{ijt} = \delta_i + \phi_1 Conflict_{ij} + \phi_2 Num\_RTA_j + X'\varphi + \tau_t + \xi_{it}, \tag{7}$$

where the set of controls, country specific and year specific fixed effects are as defined above, $Conflict_{ij}$ is a dummy variable equal to 1 if country pair i,j has had past conflict, and Num_RTA_j the number of RTAs signed by country j with the rest of the world.

5 Empirical Results

5.1 Descriptive statistics

We start to analyze our estimation results by presenting the descriptive statistics for the main variables used in table 1. For the sample of 66 developing countries used in the paper, their average fertilizer consumption is about 119.5 kg/ hectare whereas the number of agricultural machinery used is about 34 per 100 square kilometres of arable land. The use of fertilizer across countries varies significantly. For example, in our sample, for the period between 2002 and 2015 fertilizer use varies from a minimum of less than 1 kilogram per hectare in most Sub-Saharan countries to more than 1000 kilograms per hectare in Southeast Asian countries. This variation is of course reflected in terms of economic integration through RTAs. Sub-Saharan African countries are the less integrated with high income countries; from the total of RTAs they have only 6.08 percent are with high income countries. Whereas East Asia & Pacific countries are relatively integrated through trade agreements; from the total RTAs they have about 36 percent is with high income countries. In table 2 we present the pooled OLS

Table 1 : Descriptive Statistics

	Mean	Standard Deviation	Observation
Fertilizer per hectare	119.52	239.30	169,192
Agricultural machinery	34.16	54.92	208,193
RTA	0.06	0.24	801,179
Agricultural land (% of land area)	41.94	20.46	795,548
GDP per capita, PPP (constant 2011 international $)	4864.40	4562.49	363,858
Population (in million)	51.92	173.38	800,991
Agriculture value added per worker	2439.71	325.67	447,572

result after controlling country and year fixed effects. The dependent variable in all of the columns is the log of fertilizer use per hectare for the period 2002 to 2015. Our key variable is the dummy variable RTA equal 1 if a country has RTAs in force at time t. For the purpose of examining North—South RTA effect, we create an interaction between RTA membership status and whether the partner country is high-income country or not. The coefficient on RTA is about 0.10 and strongly significant. After controlling other factors including country and year specific factors, fertilizer consumption for countries who are members of any RTAs is 10 % more than those countries who don't have. In column 1 and 2 we added the interaction between RTA membership status and whether the partner country is a member of the European union(EU). The result confirmed that,

Table 2: Estimated Results for Fertilizer use(2002-2015)

	(1)	(2)	(3)	(4)	(5)	(6)
	Pooled OLS with year and country fixed effect Dependent Variable: Log of fertilizer consumption per hectare					
RTA	0.10***	0.10***	0.10***	0.11***	0.10***	0.10***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
EU_RTA	0.05***	0.08***				
	(0.01)	(0.00)				
High Income_RTA			0.03***	0.04***		
			(0.01)	(0.01)		
High income + upper middle Income_RTA					0.02***	0.03***
					(0.01)	(0.01)
Agricultural Land		-0.02***		-0.02***		-0.02***
		(0.00)		(0.00)		(0.00)
Log GDP per capita		0.21***		0.21***		0.21***
		(0.01)		(0.01)		(0.01)
Log population		2.18***		2.18***		2.18***
		(0.07)		(0.07)		(0.07)
Log (agricultural value add)		0.22***		0.22***		0.22***
		(0.02)		(0.02)		(0.02)
Country FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	169015	159092	169015	159092	169015	159092
Number of countries	59	59	59	59	59	59

Note: Standard errors in parentheses (clustered in country pairs) $*p < 0.10$, $**p < 0.05$, $***p < 0.01$*: where RTA denote Dummy variable=1 if the country have any RTA with any trading partner)* , *EU_RTA &* High Income_RTA *Income refers dummy variable=1 if country i's(the unit of interest country) RTA is with EU and high income country respectively;* Agricultural land *refers to percentage of arable land from total area;* Log GDP per capita is log of *GDP per capita, PPP (constant 2011 international $);* Log (population) is the log of total population: Log agricultural Value Add *is Agriculture value added per worker (constant 2010 US$):* High income + high middle Income_RTA is RTA with high income and upper middle income countries .

having RTA with EU member country is associated with consumption of more fertilizers compared to others who do not have such RTA. To address the North–South RTAs, we use the interaction between RTA and all high-income trading partner as a key variable for our research question in column 3 and 4. The coefficient on High Income_RTA, which represents the North—South RTAs, is 0.04 and statistically significant. Finally, we report the result which includes the upper middle income and high-income countries in column 5 and 6. Though, the magnitude marginally declines as it is expected, the result is qualitatively similar.

5.2 Instrumenting RTA and its Interactions

From column 1 through 3 of table 3, we use conflict history as an IV for RTA and the number of RTAs signed by partner country with the rest of the world as an IV for each respected interactions of RTAs. The coefficient for RTA in column 1 and 2 is consistent with what we found in table 2. And fertilizer consumption per hectare for countries' having RTA with either EU countries or high-income countries is 8 percent and 11 percent higher than those who do not have respectively. Column 3 presents the result for RTAs with high and upper middle income countries—the coefficient for RTA become insignificant, whereas the coefficient for RTA with high and upper middle income is 0.16 and statistically significant. Thus our instrumental variable approach revealed that most of the effect of RTA comes from an RTA with high and upper middle. income countries: implying that RTAs with low and lower middle income countries have negligible impact on fertilizer use. Apart from the RTA variables, GDP per capita, population and agricultural value add which represents the relative importance of agricultural sector in the economy, are associated with higher consumption of fertilizer. Whereas agricultural land has negative and significant coefficient. The implication of the negative sign in the agricultural land size can possibly be, countries who have large agricultural land practices extensive farming than intensive and technology based farming system. To maintain the fertility of the land, farmers usually use the practice of shifting cultivation and fallowing system. But this practice is common where farmers have better access for agricultural land. For example a study on Peruvian amazon, Coomes, Grimard, and Burt (2000) shows that relative to those households who have less access to land, households with better access to land uses fallowing system for longer time.

Table 4, Presents the estimated results for agricultural machinery use. Covering from 1980 to 2009, the impact of having an RTA with any country is positive and statistically significant. For example, the estimated coefficient for having

RTAs with high-income countries in column 4 is 0.94 and it is statistically significant. Relative to those countries who do not have RTAs with high-income countries, agricultural machinery use is more than 100 percent higher for those who have RTAs with high income countries. Similar to fertilizer use, we instrument RTAs with conflict and number of RTAs signed by the partner country with the rest of the world and reported in table 5. The result confirmed similar and more strong evidences for the causal link between countries membership to RTAs with high-income country and agricultural machinery use.

In table 6, we report the robustness check for our benchmark regression for both dependent variables. We believe that legacy of colonial relationship still observed in terms of economic integration and development cooperation. Hence, we use colonial link as an additional exogenous variation for over-identification test and checking the robustness of our baseline result. The result from column 1, shows that our result is consistent with our main result of table 2 and 3. Similar result is observed in column 3 for agricultural machinery use. Finally, the p-value for our over-identification test confirmed that, our instruments are indeed exogenous.

Table 3: 2SLS Results for Fertilizer use(2002-2015)

	(1)	(2)	(3)
	Dependent Variable: Log of fertilizer consumption per hectare		
	The Second Stage		
RTA	0.13***	0.11***	0.08
	(0.03)	(0.04)	(0.06)
EU_RTA	0.08***		
	(0.03)		
High Income_RTA		0.11**	
		(0.05)	
High income + Upper middle Income_RTA			0.16**
			(0.10)
Agricultural Land	-0.02***	-0.02***	-0.02***
	(0.00)	(0.00)	(0.00)
Log GDP per capita	0.21***	0.21***	0.21***
	(0.01)	(0.01)	(0.01)
Log population	2.18***	2.19***	2.19***
	(0.07)	(0.07)	(0.07)
Log agricultural Value Add	0.22***	0.22***	0.22***
	(0.02)	(0.02)	(0.02)
Country FE	YES	YES	YES
Year FE	YES	YES	YES
	First stage for RTA		
Conflict	0.38***	0.38***	0.38***
	(0.04)	(0.04)	(0.04)
Number of RTAs country j have	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
F statistic	132.35	132.35	132.35
	First stage		
	EU_RTA	High Income_RTA	High income + upper middle Income_RTA
Conflict	0.01	0.01	0.01
	(0,01)	(0.01)	(0.01)
Number of RTAs country j have	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
F statistic	68.31	68.31	68.31
N	159092	159092	159092

*Note: Standard errors in parentheses (clustered in country pairs) *p < 0.10, **p < 0.05, ***p < 0.01: where RTA denote Dummy variable=1 if the country have any RTA with any trading partner)* , EU_RTA & High Income_RTA *Income refers dummy variable=1 if country i's(the unit of interest country) RTA is with EU and high income country respectively;* Agricultural land *refers to percentage of arable land from total area;* Log GDP per capita is log of *GDP per capita, PPP (constant 2011 international $);* Log (population) is the log of total population: Log agricultural Value Add *is Agriculture value added per worker (constant 2010 US$):* High income + high middle Income_**RTA** is RTA with high income and upper middle income countries . *the number of RTAs country j is the number of RTAs the partner country has with the rest of the world.*

Table 4: Estimated Results for Agricultural Machinery Use (1980-2009)

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: log of agricultural machinery use					
RTA	0.20***	0.19***	0.03***	0.03***	0.05**	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
EU_RTA	0.84***	0.78***				
	(0.02)	(0.02)				
High Income_RTA			1.00***	0.94***		
			(0.01)	(0.01)		
High income + high middle Income_RTA					0.83***	0.76***
					(0.02)	(0.02)
Agricultural Land		-0.02***		-0.02***		-0.02***
		(0.00)		(0.00)		(0.00)
Log GDP per capita		0.27***		0.27***		0.27***
		(0.00)		(0.00)		(0.00)
Log population		0.85***		0.85***		0.85***
		(0.02)		(0.01)		(0.02)
Log agricultural Value Add		0.37***		0.37***		0.37***
		(0.00)		(0.00)		(0.00)
Country FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	208399	208399	208399	208399	208399	208399
Number of countries	47	47	47	47	47	47

Note: Standard errors in parentheses (clustered in country pairs) $*p < 0.10$, $**p < 0.05$, $***p < 0.01$*: where RTA denote Dummy variable=1 if the country have any RTA with any trading partner)* , EU_RTA & High Income_RTA Income *refers dummy variable=1 if country i's(the unit of interest country) RTA is with EU and high income country respectively;* Agricultural land *refers to percentage of arable land from total area;* Log (GDP per capita) is log of *GDP per capita, PPP (constant 2011 international \$);* Log (population) is the log of total population: Log agricultural Value Add *is Agriculture value added per worker (constant 2010 US\$):* High income + upper middle Income_RTA is RTA with high income and upper middle income countries. *the number of RTAs country j is the number of RTAs the partner country has with the rest of the world.*

Table 5: 2SLS Results for Agricultural machinery use

	(1)	(2)	(3)
	Dependent Variable: Log of agricultural machinery		
	The Second Stage		
RTA	0.45***	0.32*	0.06
	(0.05)	(0.08)	(0.18)
EU_RTA	0.62***		
	(0.22)		
High Income_RTA		0.90***	
		(0.31)	
High income + Upper middle Income_RTA			1.38***
			(0.49)
Agricultural Land	-0.02***	-0.02***	-0.02***
	(0.00)	(0.00)	(0.00)
Log GDP per capita	0.28***	0.28***	0.27***
	(0.00)	(0.00)	(0.00)
Log population	0.82***	0.83***	0.85***
	(0.02)	(0.02)	(0.02)
Log agricultural Value Add	0.37***	0.37***	0.35***
	(0.01)	(0.01)	(0.01)
Country FE	YES	YES	YES
Year FE	YES	YES	YES
	First stage for RTA		
Conflict	0.10*** (0.00)	0.10*** (0.00)	0.10*** (0.00)
Number of RTAs country j have	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
F statistic	412.89	412.89	412.89
	First stage		
	EU_RTA	High Income_RTA	High income + upper middle Income_RTA
Conflict	0.02*** (0.00)	0.02*** (0.00)	0.02*** (0.00)
Number of RTAs country j have	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
P-value	[0.000]	[0.000]	[0.000]
N	208399	208399	208399

Note: Robust standard errors in parentheses $*p < 0.10$, $**p < 0.05$, $***p < 0.01$*: where RTA denote Dummy variable=1 if the country have any RTA with any trading partner) , EU_RTA &* High Income_RTA *Income refers dummy variable=1 if country i's(the unit of interest country) RTA is with EU and high income country respectively; Agricultural land refers to percentage of arable land from total area;* Log GDP per capita is log of *GDP per capita, PPP (constant 2011 international $);* Log (population) is the log of total population: Log agricultural Value Add *is Agriculture value added per worker (constant 2010 US$):* High income + high middle Income_RTA is RTA with high income and upper middle income countries . *the number of RTAs country j is the number of RTAs the partner country has with the rest of the world.*

Table 6: Robustness Check (using alternative Instruments)

	(1)	(2)
	Log of fertilizer consumption per hectare	Log of agricultural machinery
	Panel A: The Second Stage	
RTA	0.11***	0.33*
	(0.04)	(0.17)
High Income_RTA	0.12**	0.87***
	(0.05)	(0.32)
Agricultural Land	-0.02***	-0.02***
	(0.00)	(0.00)
Log GDP per capita	0.21***	0.28***
	(0.01)	(0.01)
Log population	2.19***	0.83***
	(0.07)	(0.04)
Log agricultural Value Add	0.22***	0.37***
	(0.02)	(0.01)
	Panel B: First stage for RTA	
Conflict	0.10***	0.10***
	(0.00)	(0.00)
Number of RTAs country j have	0.001***	0.0001***
	(0.000)	(0.000)
Colonial relationship	0.1**	0.01
	(0.05)	(0.01)
Number of RTAs country j have	0.001***	0.001***
	(0.000)	(0.000)
F statistic	89.7	25.18
	Panel C: First stage the interaction	
Conflict	0.06***	0.02***
	(0,02)	(0.00)
Number of RTAs country j have	0.0001***	0.0001***
Colonial relationship	0.09***	0.01
	(0.03)	(0.01)
F statistic	41.49	16.51
	Panel D: Results from over Identification Test	
Hansen J statistic	0.027	0.001
p-value (from chi- squared t[st)	[0.9742]	[0.9742]
N	159092	208399

Note: Standard errors in parentheses (clustered in country pairs) *p < 0.10, **p < 0.05, ***p < 0.01*: where RTA denote Dummy variable=1 if the country have any RTA with any trading partner)* , **EU_RTA** & **High Income_RTA** *Income refers dummy variable=1 if country i's(the unit of interest country) RTA is with EU and high income country respectively;* **Agricultural land** *refers to percentage of arable land from total area;* **Log GDP per capita** is log of *GDP per capita, PPP (constant 2011 international $);* **Log (population)** is the log of total population: **Log agricultural Value Add** *is Agriculture value added per worker (constant 2010 US$):* **High income + Upper middle Income_RTA** is RTA with high income and upper middle income countries ,**Log Agricultural trade as ratio of GDP** *is the sum of agricultural export and import as a ratio of GDP in log form. the number of RTAs country j is the number of RTAs the partner country has with the rest of the world.*

In Table 7, we examine the channel through which the response in agriculture input is observed following countries RTA membership with high income countries. Because of data availability I did three exercises for fertilizer from column 1 to 3 and only one exercise for agricultural machinery. When countries sign an RTA with developed country, there might be an increase in both demand for agricultural output by country's RTA partner and hence an increase in demand for agricultural input. In other words, the increase in agricultural input use following formation of RTA might be either through an increase demand for agricultural output by RTA partner or through increase in access for factor markets. To identify that, in column 1 we control for an interaction term between RTA and import demand for agricultural output by the country's RTA partner. The coefficient for import demand for agricultural output by RTA partner in column 1 is zero and our coefficient of interest is consistent with the benchmark result. Column 2 and 3, is an RTA with net exporter of fertilizer. In all of the exercises the result holds. Finally in column 4, we did for agricultural machinery use by controlling RTA partner's demand for agricultural output. The result confirmed that an RTA with high income country still holds. Moreover, agricultural output demand by RTA partner has positive and significant impact on agricultural machinery use.

In our main result of table 3 and 5 we have shown that when we control for RTA with upper middle income and high income country , the coefficient for RTA alone becomes insignificant. Implying RTA between both low income countries have no impact on our outcome variable.

In table 8, we did a falsification test. Our falsification test follows from the argument that if the claim that developing countries have RTAs with high income countries, there will be a technology transfer from advanced countries to developing countries explained by the use of improved inputs for agriculture. If the above claim is true, the impact of having RTA with developing will not have any impact on fertilizer and agricultural machinery use by developed coun-

Table 7: Identifying the channel

	(2)	(2)	(3)	(4)
	Log fertilizer	Log fertilizer	Log fertilizer	Log of agricultural machinery
RTA	0.05	0.12***	0.12***	-0.16
	(0.04)	(0.00)	(0.01)	(0.10)
High Income_RTA	0.04***			1.42***
	(0.01)			(0.03)
RTA with net exporter of fertilizer		0.02**		
		(0.01)		
RTA with high income net exporter of fertilizer			0.04***	
			(0.01)	
Agricultural Land	-0.02***	-0.02***	-0.02***	-0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
Log GDP per capita	0.21***	0.21***	0.21***	0.20***
	(0.02)	(0.01)	(0.02)	(0.01)
Log population	2.18***	2.18***	2.18***	0.74***
	(0.09)	(0.07)	(0.09)	(0.06)
Log agricultural Value Add	0.22***	0.22***	0.22***	0.30***
	(0.02)	(0.02)	(0.02)	(0.02)
			(0.00)	
Log(import of agricultural output by RTA partner)	0.00			0.02**
	(0.00)			(0.01)
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	95188	159092	95188	90009

Note: Standard errors in parentheses (clustered in country pairs) ***p < 0.10, **p < 0.05, ***p < 0.01*** *: where* ***RTA*** *denote Dummy variable=1 if the country have any RTA with any trading partner)* **, Agricultural land** *refers to percentage of arable land from total area;* **Log GDP per capita** is log of *GDP per capita, PPP (constant 2011 international $);* **Log (population)** is the log of total population: **Log agricultural Value Add** *is Agriculture value added per worker (constant 2010 US$):* **High Income_RTA** *Income refers dummy variable=1 if country i's(the unit of interest country) RTA is with high income country.* ***RTA with high income net exporter of fertilizer*** *(dummy =1 if RTA is with high income and net exporter of fertilizer),* ***RTA with net exporter of fertilizer*** *(RTA with net exporter of fertilizer) and finally we have log of import of agricultural output by RTA partner.*

tries. Thus, For fertilizer use and agricultural input use, we estimate high income countries agricultural input use on having an RTA with low income countries. The result for both inputs coefficients are statistically zero. The implication of such result is thus, developing countries exposure to the international market through RTA with high income countries have significant spillover effect on use of manufactured aids of production for agricultural sector..

Table 8: Falsification Test

	(2)	(4)
	log fertilizer	log machinery
RTA	0.01	0.00
	(0.00)	(0.00)
Low Income_RTA	-0.01	-0.00
	(0.01)	(0.00)
Agricultural Land	-0.02***	0.001***
	(0.00)	(0.00)
Log GDP per capita	1.55***	-0.39***
	(0.03)	(0.01)
Log population	3.61***	1.33***
	(0.02)	(0.02)
Log agricultural Value Add	0.61***	0.11***
	(0.01)	(0.00)
Country FE	YES	YES
Year FE	YES	YES
N	99593	70112

Note: Standard errors in parentheses (clustered in country pairs) $*p < 0.10$, $**p < 0.05$, $***p < 0.01$*: where* ***RTA*** *denote Dummy variable=1 if the country have any RTA with any trading partner)* , ***Agricultural land*** *refers to percentage of arable land from total area;* **Log GDP per capita** is log of *GDP per capita, PPP (constant 2011 international $);* **Log (population)** is the log of total population: **Log agricultural Value Add** *is Agriculture value added per worker (constant 2010 US$):* **High Income_RTA** *Income refers dummy variable=1 if country i's(the unit of interest country) RTA is with high income country.*, **Low Income_RTA** refers dummy variable=1 if country i has RTA with low income country.

6 Conclusion

In our analysis, we documented that countries having RTA uses more fertilizer and agricultural machinery per units of arable land. Moreover, our paper shows a strong links between regional trade agreement with high-income countries and fertilizer use as well as agricultural machinery use. We employ both pooled OLS with country and year fixed effects as well us instrumental variable approach to present the causal link between the variable of interest. We use theory driven instruments such as conflict and domino (number of RTAs partner country have with the rest of the world) to identify our factor demand equation so that to produce causal link. From table 2, through table 6, our result confirms that countries who have RTAs use more agricultural inputs which has a great implication on yield and structural change as it is posited by McArthur and McCord (2017). This result gives a hint that the role of economic integration with heterogeneous countries in terms of economic activity has a complimentary effect for the domestic economy to the process of structural transformation. Hence, in signing an RTAs, identifying domestic production gaps and finding a trading partner who can fill that gap either in transfer of production technology and filling the short run consumption demand should due attention.

We believe this paper is a starting point to explore the link between agricultural input use and trade integration. In the future more robust result can be found if we add agricultural output and overall structural transformation for the economy in relation to trade integration by considering a detailed evidences on factors affecting agricultural activity.

References

Ahmed, R., et al. (1995). Liberalization of agricultural input markets in bangladesh: Process, impact, and lessons. *Agricultural Economics*, *12*(2), 115–128.

Baldwin, R. (1993). *A domino theory of regionalism* (Tech. Rep.). National bureau of economic research.

Bell, C. (1972). The acquisition of agricultural technology: its determinants and effects. *The Journal of Development Studies*, *9*(1), 123–159.

Coomes, O. T., Grimard, F., & Burt, G. J. (2000). Tropical forests and shifting cultivation: secondary forest fallow dynamics among traditional farmers of the peruvian amazon. *Ecological economics*, *32*(1), 109–124.

Duflo, E., Kremer, M., & Robinson, J. (2008). How high are rates of return to fertilizer? evidence from field experiments in kenya. *American economic review*, *98*(2), 482–88.

Gollin, D. (2010). Agricultural productivity and economic growth. *Handbook of agricultural economics*, *4*, 3825–3866.

Hadjiyiannis, C., Heracleous, M. S., & Tabakis, C. (2016). Regionalism and conflict: Peace creation and peace diversion. *Journal of International Economics*, *102*, 141–159.

Hazell, P. B. (2009). *The asian green revolution* (Vol. 911). Intl Food Policy Res Inst.

Kuznets, S. S., Kuznets, S. S., et al. (1968). Toward a theory of economic growth, with reflections on the economic growth of modern nations.

Martin, P., Mayer, T., & Thoenig, M. (2012). The geography of conflicts and regional trade agreements. *American Economic Journal: Macroeconomics*, *4*(4), 1–35.

McArthur, J. W., & McCord, G. C. (2017). Fertilizing growth: Agricultural inputs and their effects in economic development. *Journal of development* *economics*, *127*, 133–152.

Poole, J. P., Santos-Paulino, A. U., Sokolova, M. V., & DiCaprio, A. (2017). The impact of trade and technology on skills in viet nam.

Williams, S. P., & Shumway, C. R. (2000). Trade liberalization and agricultural chemical use: United states and mexico. *American Journal of Agricultural Economics*, *82*(1), 183–199.

Yousaf, M., Li, J., Lu, J., Ren, T., Cong, R., Fahad, S., & Li, X. (2017). Effects of fertilization on crop production and nutrient-supplying capacity under rice-oilseed rape rotation system. *Scientific reports*, *7*(1), 1270.

7 Appendix A

List of countries in the Sample

Iso	Country	Iso	Country	Iso	Country	Iso	Country
ARG	Argentina	EGY	Egypt, Arab Rep.	MLI	Mali	PRY	Paraguay
BDI	Burundi	ERI	Eritrea	MMR	Myanmar	RWA	Rwanda
BEN	Benin	ETH	Ethiopia	MNG	Mongolia	SDN	Sudan
BFA	Burkina Faso	GHA	Ghana	MOZ	Mozambique	SEN	Senegal
BGD	Bangladesh	GTM	Guatemala	MRT	Mauritania	SLE	Sierra Leone
BOL	Bolivia	HND	Honduras	MWI	Malawi	SLV	El Salvador
BRA	Brazil	HTI	Haiti	MYS	Malaysia	SYR	Syrian Arab Republic
CAF	Central African Republic	IDN	Indonesia	NAM	Namibia	TUN	Tunisia
CHL	Chile	IND	India	NER	Niger	TZA	Tanzania
CHN	China	KEN	Kenya	NIC	Nicaragua	UGA	Uganda
CIV	Côte d'Ivoire	KHM	Cambodia	NPL	Nepal	URY	Uruguay
CMR	Cameroon	LAO	Lao PDR	PAK	Pakistan	VNM	Vietnam
COL	Colombia	LBR	Liberia	PAN	Panama	YEM	Yemen, Rep.
CRI	Costa Rica	LSO	Lesotho	PER	Peru	ZMB	Zambia
CUB	Cuba	MAR	Morocco	PHL	Philippines	ZWE	Zimbabwe
DOM	Dominican Republic	MDG	Madagascar	PNG	Papua New Guinea		
ECU	Ecuador	MEX	Mexico				