A re-examination of the *Columbian* exchange:

Agriculture and Economic Development in the Long Run

Alfonso Díez Minguela
Universitat de Valéncia

Mª Dolores Añón Higón
Universitat de Valéncia

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Abstract

This paper explores the *Columbian* exchange and its impact on economic development in the long run. To do so, we have calculated the proportion of the total area harvested of *native* crops in a given year for the Old and New World countries. Our preliminary results show that there is a significant and positive correlation between *native* cultivation and economic development in the Old World. This, in turn, indicates that remaining *loyal* to what was known prior to the discovery of the New World has had a positive effect on economic development. On the other hand, the *Columbian exchange* had the opposite effect for the New World countries. These preliminary findings contribute to the existing literature on economic history and economics by providing a novel quantitative analysis on an extensively debated subject.

1. Introduction

This paper examines the *Columbian exchange* and its impact on economic development in the long run. The *Columbian exchange* refers to *"the exchange of diseases, ideas, food crops and population between the New World and the Old World following the voyage to the Americas by Christopher Columbus in 1492"* (Nunn and Quian, 2010: p. 163). The *Columbian exchange* brought new crops to the Old World such as maize, potatoes, sweet potatoes, tomatoes, peanuts or cocoa beans. However, the effects of the *Columbian exchange* were even larger in the New World where the pre-Columbian agrarian structure was, in some cases, entirely transformed. After five centuries of the discovery of the New World, it remains unclear how the *Columbian exchange* has affected economic development. This study is a first attempt to investigate the impact of the *Columbian exchange* on the course of comparative economic development. To do so, we have computed the proportion of the total area harvested of *native* crops in a given year. Then, we carry out a cross-section empirical analysis.

Our preliminary results show that the *Columbian exchange* partially explained the variance in economic development across the sample. Our estimates indicate that the those Old World countries that did not change much their agrarian structure with New World crops enjoy a high level of economic development. On the other hand, our estimates for New World countries, although less precisely, show the opposite, i.e. those New World countries that changed their agrarian structure more with Old World crops have developed more. This paper opens up a further avenue for research on the long run forces that have shaped the world economy. Moreover, our research follows (Nunn and Quian, 2010) that raised

2. Methodology

We begin by examining the empirical relationship between the *Columbian exchange* and economic development. To this end, we capture the *Columbian exchange* with the

variable *Precolumbian crops* which measures the proportion of the total area harvested of *native* crops in a given year. The total area harvested by crop in hectares for a given years is given by FAOSTAT. Then, each of the 160 crops or *items* has been accordingly classified as being *native* to the Old World or New World. To do so, we have followed several sources and distinct literatures such as Bellwood (2005), Harlan (1995), Kiple and Ornelas (2000a, 2000b), Smith (1995), Watson (1974; 2008) and Zohary et al. (2012).

Table 1. *Precolumbian crops* and area harvested, 1960 and 2010

	Proportion		**Ratio**	
	Precolumbian crops		**area harvested**	***Precolumbian crops***
Region	**1960**[a]	**2010**	**2010/1960**	**2010/1960**
Eurasia				
Northern Europe	0.924	0.966	1.3	1.0
Central Asia[b]	na	0.931	na	na
Western Asia[b]	0.933	0.899	1.2	1.0
Northern Africa[c]	0.899	0.882	1.9	1.0
Southern Asia	0.878	0.856	1.3	1.0
Western Europe	0.836	0.848	1.0	1.0
Southern Europe	0.763	0.806	0.7	1.1
Eastern Europe	0.817	0.745	0.5	0.9
South-Eastern Asia	0.733	0.730	2.2	1.0
Eastern Asia	0.768	0.693	1.2	0.9
sub-Saharan Africa				
Western Africa	0.709	0.672	2.4	0.9
Eastern Africa	0.603	0.524	2.1	0.9
Middle Africa	0.458	0.396	1.9	0.9
Southern Africa	0.367	0.389	0.8	1.1
Pacific				
Australia and New Zealand	0.979	0.988	2.7	1.0
Micronesia	0.997	0.980	2.1	1.0
Polynesia	0.879	0.914	0.9	1.0
Melanesia	0.796	0.753	2.0	0.9
	Proportion		**Ratio**	
	Precolumbian crops		**area harvested**	***Precolumbian crops***
Region	**1960**	**2010**	**2010/1960**	**2010/1960**
Central America	0.724	0.597	1.4	0.8
Caribbean	0.289	0.461	1.0	1.6
Northern America	0.308	0.340	1.2	1.1
South America	0.473	0.299	2.3	0.6

Sources: FAOSTAT 2010, Author's own calculations

Notes: a) 1961; b) The central Asian and Transcaucasian former republics of the USSR are included in Eastern Europe; c) Including Sudan.

Table 1 illustrates our main variable for each major region. At a first glance, Northern Europe seems not to have gained much from the *Columbian exchange,* since 96.6 per cent of the total area harvested in 2010 was cultivated with Old World crops. In contrast, more than 60 per cent of the total area harvested in Middle Africa and Southern Africa was cultivated with New World crops. Although the *Columbian exchange* had a greater impact in the New World table 1 also shows that Central America has been the most *loyal* region to the traditional American crops. This variation in the agrarian structure, as a result of the *Columbian exchange*, is at the core of our analysis. The analysis is performed for a sample of a maximum 183 countries, classified in the Old World (i.e. Europe, Asia and Africa), and the New World.

Table 2 provides the descriptive statistics for the key variable of interest. The first panel covers the extended sample of all countries, while the second and third panel show the descriptive statistics for the sample of countries of the Old World and New World, respectively. As dependent variable in our analysis we use two measures of development. The first one, widely used in growth studies, is the GDP per capita on a PPP basis for 2000 (drawn from the World PENN table); while our second proxy will be the food supply (form FAOSTAT), both in natural log terms.

Our variable of interest is *Precolumbian crops* and it is measured as previously defined. We also control for the institutional and technological state of development in the 1500s. To control for the degree of institutional development in 1500 we use the variable *statehist in 1500*, which takes into account whether what is now a country had a supra-tribal government, the geographic scope of that government, and whether that government was indigenous or by an outside power in 1500 (see Chanda and Putterman, 2007). In addition, we also use the variable *agyears* that is the number of millennia since a country transitioned from hunting and gathering to agriculture (see Putterman and Trainor, 2006). To proxy for the degree of technological development in the 1500s we use the variable *technoindex* created by Comin et al. (2010).

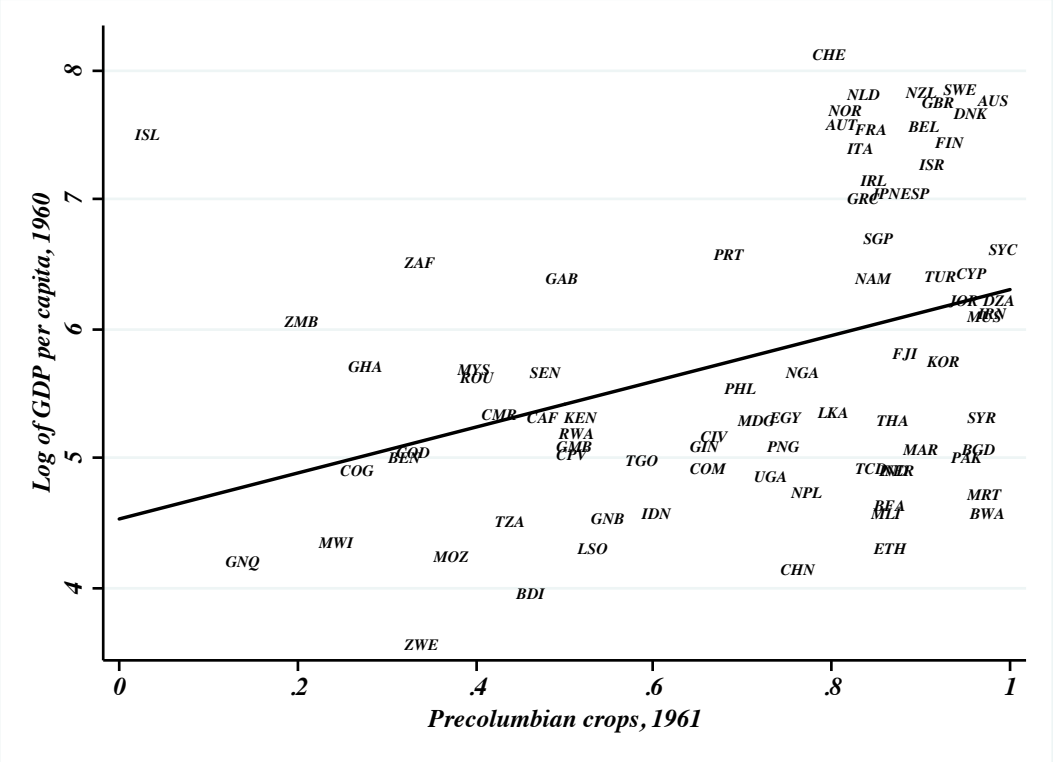
Additionally, we also control for other geographical variables that have been shown to determine economic development. These variables are the natural logarithm of total land (drawn from FAOSTAT); the absolute distance to the equator; the average

distance to nearest ice-free coast (1000 km) from Nunn and Puga (2010) and the proportion of land with an elevation above 3000 meters.

Table 2. Descriptive statistics

	All sample			Old World			New World		
variable	mean	sd	N	mean	sd	N	mean	sd	N
Precolumbian Crops, 2000	0.670	0.274	207	0.755	0.223	163	0.356	0.209	44
statehist in 1500	0.338	0.313	149	0.392	0.307	122	0.092	0.205	27
agyears	4.714	2.434	171	5.141	2.457	139	2.859	1.122	32
technoindex	0.466	0.317	120	0.542	0.305	97	0.144	0.068	23
Log GDP per capita, 2000	8.355	1.334	188	8.227	1.412	151	8.878	0.760	37
Log food Supply, 2000	7.861	0.197	176	7.858	0.208	139	7.872	0.152	37
Land	8.234	3.187	226	8.461	3.052	175	7.457	3.535	51
Distance to equator	25.434	17.150	240	27.108	17.718	187	19.527	13.534	53
Distance to coast	0.255	0.384	233	0.282	0.403	182	0.158	0.290	51
Elevation above 3000	1.389	6.236	228	1.315	6.538	177	1.645	5.098	51

Figure 1. Economic development and *Precolumbian crops* in the Old World, 1960

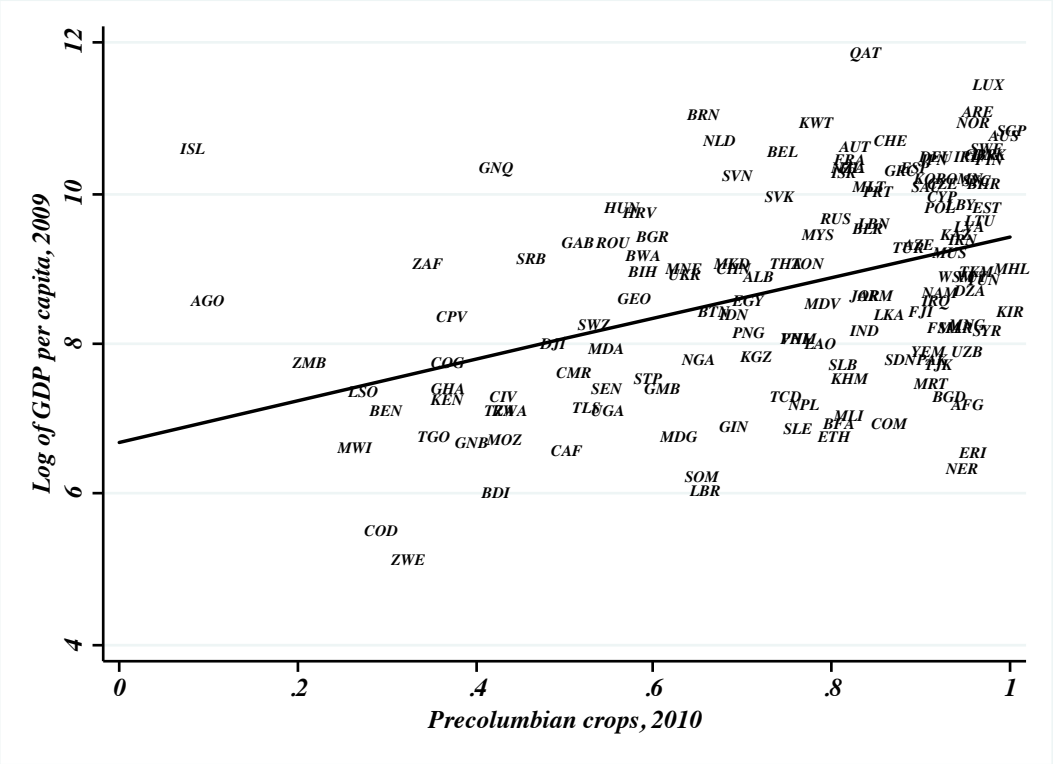


Sources: Penn World Tables 7.0 and FAOSTAT. Author's own calculations
Notes: The regression line, $y = 4.533 + 1.765x$, R^2: 0.138, $N = 82$

Additionally, table 1 illustrates the ratio of change for the period 1960-2010. The increasing demand for agricultural products had led to a considerable expansion of the

total area harvested. However, it does seem that the agrarian structure has not changed much over the last fifty years. For this reason, we study the long run and exploit the cross-section variation in this paper. Figure 1 shows the relationship between economic development and our main variable, *Precolumbian crops*, in 1960. Figure 2 illustrates the relationship between economic development and our main variable, *Precolumbian crops*, in 2010. Generally speaking, the relationship appears to be positive which implies that Old World countries that did not changed much their agrarian structure with the discovery of the New World enjoy a higher level of economic development, measured as the natural log of Gross Domestic Product (GDP) per capita.

Figure 2. Economic development and *Precolumbian crops* in the Old World, 2010



Sources: Penn World Tables 7.0 and FAOSTAT. Author's own calculations
Notes: The regression line, $y = 6.695 + 2.732x$, R^2: 0.179, $N = 148$

3. Empirical results

In this section we briefly explore the effects of the Columbian exchange of crops on economic development. Table 3 shows the results for the whole sample. The OLS regressions presented in columns (1) and (5) reveal the unconditional positive relationship between our main variable and economic development, captured as the natural log of GDP per capita and Food supply (kcal/capita/day).

Table 3. The *Columbian exchange* and economic development, all sample

	Dependent variable is Log GDP per capita, 2000				Dependent variable is Log Food supply (kcal/cap/day), 2000			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Precolumbian crops, 2000	0.747*	0.363	0.422	-0.535	0.170***	0.094	0.084	-0.026
	(0.392)	(0.589)	(0.510)	(0.720)	(0.059)	(0.078)	(0.076)	(0.098)
statehist in 1500		0.662				0.149**		
		(0.466)				(0.065)		
agyears			0.108**				0.028***	
			(0.047)				(0.007)	
technoindex in 1500				1.973***				0.330***
				(0.515)				(0.065)
Constant	7.824***	7.764***	7.509***	7.709***	7.748***	7.755***	7.673***	7.748***
	(0.281)	(0.345)	(0.317)	(0.369)	(0.041)	(0.049)	(0.046)	(0.058)
Observations	183	145	164	114	175	143	156	111
R-squared	0.022	0.040	0.061	0.163	0.050	0.101	0.160	0.251
Adjusted R-squared	0.016	0.026	0.049	0.148	0.044	0.088	0.149	0.237

Notes: (i) Heteroskedasticity robust standard errors estimates are reported in parentheses; (ii) *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table 4. The *Columbian exchange* and economic development, Old World

	Dependent variable is Log GDP per capita, 2000				Dependent variable is Log Food supply (kcal/cap/day), 2000			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Precolumbian crops,	2.661***	2.006**	2.517***	1.205	0.378***	0.265***	0.315***	0.217**
	(0.573)	(0.767)	(0.558)	(0.746)	(0.081)	(0.094)	(0.084)	(0.099)
statehist in 1500		0.844*				0.180***		
		(0.499)				(0.069)		
agyears			0.122**				0.029***	
			(0.049)				(0.007)	
technoindex in 1500				2.332***				0.375***
				(0.554)				(0.066)
Constant	6.196***	6.310***	5.682***	5.992***	7.578***	7.603***	7.481***	7.517***
	(0.442)	(0.488)	(0.344)	(0.410)	(0.062)	(0.063)	(0.052)	(0.062)
Observations	146	118	133	92	139	116	126	89
R-squared	0.168	0.182	0.247	0.355	0.155	0.223	0.291	0.446
Adjusted R-squared	0.162	0.168	0.236	0.341	0.149	0.210	0.279	0.433

Notes: (i) Heteroskedasticity robust standard errors estimates are reported in parentheses; (ii) *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Nevertheless, once we control for the level of institutional and technological development in the 1500s, the statistical significance vanishes. This calls for a fragmented empirical analysis in which Old and New Worlds are separated. Table 4

illustrates a positive correlation between our main variable of interest and economic development. Remarkably, once we control for the level of institutions and technology in the 1500s, the statistical significance of *Precolumbian crops* remains. These findings suggest that those countries of the Old World that remained *loyal* to their native cultivation enjoy a higher level of economic development.

Table 5. The *Columbian exchange* and economic development, New World

	Dependent variable is Log GDP per capita, 2000				Dependent variable is Log Food supply (kcal/cap/day), 2000			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Precolumbian crops, 2000	-0.570	-2.626**	-1.761*	-2.263	-0.308**	-0.476**	-0.379*	-0.458**
	(0.945)	(1.124)	(1.005)	(1.309)	(0.133)	(0.199)	(0.193)	(0.205)
statehist in 1500		0.049				-0.04		
		(0.766)				(0.182)		
agyears			-0.181				0.008	
			(0.145)				(0.026)	
technoindex				1.693				-0.129
				(1.656)				(0.412)
Constant	9.079***	9.679***	9.945***	9.286***	7.978***	8.043***	7.976***	8.074***
	(0.313)	(0.406)	(0.373)	(0.444)	(0.050)	(0.067)	(0.100)	(0.091)
Observations	37	27	31	22	36	27	30	22
R-squared	0.019	0.272	0.246	0.197	0.137	0.203	0.137	0.204
Adjusted R-squared	-0.009	0.211	0.192	0.112	0.112	0.137	0.073	0.12

Notes: (i) Heteroskedasticity robust standard errors estimates are reported in parentheses; (ii) *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table 6. The *Columbian exchange* and economic development, Old World

	Dependent variable is Log GDP per capita, 2000				Dependent variable is Log Food supply (kcal/cap/day), 2000			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Precolumbian crops, 2000	2.006**	1.429***	2.517***	1.620***	0.265***	0.185***	0.315***	0.155**
	(0.767)	(0.528)	(0.558)	(0.524)	(0.094)	(0.056)	(0.084)	(0.078)
statehist in 1500	0.844*	-0.071			0.180***	0.017		
	(0.499)	(0.381)			(0.069)	(0.053)		
agyears			0.122**	0.026			0.029***	0.013**
			(0.049)	(0.040)			(0.007)	(0.005)
Land		-0.033		-0.07		0.009		0.009
		(0.073)		(0.059)		(0.008)		(0.009)
Distance to equator		0.046***		0.042***		0.007***		0.007***
		(0.006)		(0.006)		(0.001)		(0.001)
Distance to coast		-1.005***		-1.016***		-0.175***		-0.157***
		(0.232)		(0.209)		(0.029)		(0.026)
Elevation above 3000		-0.020*		-0.019**		-0.002		-0.003
		(0.010)		(0.008)		(0.002)		(0.002)
Constant	6.310***	6.504***	5.682***	6.767***	7.603***	7.504***	7.481***	7.463***
	(0.488)	(0.671)	(0.344)	(0.577)	(0.063)	(0.071)	(0.052)	(0.084)
Observations	118	118	133	133	116	116	126	126
R-squared	0.182	0.611	0.247	0.577	0.223	0.647	0.291	0.608
Adjusted R-squared	0.168	0.590	0.236	0.556	0.210	0.628	0.279	0.588

Notes: (i) Heteroskedasticity robust standard errors estimates are reported in parentheses; (ii) *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table 5 shows the OLS regressions for New World countries. Although the relationship between the *Columbian exchange* and economic development appears to be negative and statistically significant, it seems that our variable of interest is more sensitive to the control variables when GDP per capita is used as dependent variable. Finally, we conduct a robustness check our previous results by including other control variables that are relevant in the literature of economic development (tables 6 and 7). In particular, we examine whether the inclusion of exogenous geographical variables alter our results. From all of the specifications we observe that our results are robust to the inclusion of these control variables.

Table 7. The *Columbian exchange* and economic development, New World

	Dependent variable is Log GDP per capita, 2000				Dependent variable is Log Food supply (kcal/cap/day), 2000			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Precolumbian crops, 2000	-2.626**	-2.248	-1.761*	-1.407	-0.476**	-0.526**	-0.379*	-0.336**
	(1.124)	(1.544)	(1.005)	(0.949)	(0.199)	(0.187)	(0.193)	(0.155)
statehist in 1500	0.049	0.608			-0.04	0.065		
	(0.766)	(0.885)			(0.182)	(0.216)		
agyears			-0.181	-0.049			0.008	0.014
			(0.145)	(0.181)			(0.026)	(0.033)
Land		-0.005		-0.041		0.033*		0.021
		(0.09)		(0.077)		(0.017)		(0.018)
Distance to equator		0.023		0.030**		0.004**		0.006***
		(0.014)		(0.011)		(0.002)		(0.002)
Distance to coast		-0.058		-0.025		-0.093		-0.071
		(0.560)		(0.532)		(0.096)		(0.090)
Elevation above 3000		-0.026		-0.011		-0.008		-0.006*
		(0.021)		(0.018)		(0.005)		(0.003)
Constant	9.679***	9.214***	9.945***	9.336***	8.043***	7.699***	7.976***	7.661***
	(0.406)	(0.770)	(0.373)	(0.642)	(0.067)	(0.158)	(0.100)	(0.152)
Observations	27	27	31	31	27	27	30	30
R-squared	0.272	0.436	0.246	0.41	0.203	0.554	0.137	0.514
Adjusted R-squared	0.211	0.267	0.192	0.262	0.137	0.42	0.073	0.387

Notes: (i) Heteroskedasticity robust standard errors estimates are reported in parentheses; (ii) *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

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