Food and Agriculture Organization of the United Nations

The Structural Transformation of Latin American Economies: A sectoral Long-Term Review

This chapter presents a continent-wide and sectoral overview of the structural transformation of Latin American economies since the 1970s. In this report we call *structural transformation* the generally accepted feature of economic development, whereby countries as they experiment economic growth and develop, display a relative shrinking of the agricultural sector; i.e. as the country and agriculture itself grow the relative contribution of agriculture to overall GDP and the sector's relative contribution (as a proportion) to national income and employment fall. These universal characteristics of the development process are studied from a sectoral and macroeconomic perspective in a comparative review of Latin American development since the 1970s.

The first section of this study presents an historical overview of how development economists have understood the process of structural change. It presents some global estimates that describe the rate of structural transformation across global regions, confirming its universality. The second section discusses the particular economic forces underlying a process that is a common feature of development. We review the traditional arguments that development economists have posited as causes and present a more modern justification for this characteristic feature of development. The following section presents a description of how the process of structural transformation has manifested in Latin America, distinguishing among different characteristics that may help in defining a typology of different structural transformation paths as described by different countries in the continent. The final section provides a long-term analysis of productivity of Latin American agriculture in order to provide a better understanding of the structural transformation of the region's economies.

I. Structural Transformation: History and Facts

One of the most consistent stylized facts of the process of development of nations is the secular relative decline of the agricultural sector. This process manifests itself as a consistent decline of the relative contribution of Agriculture to domestic GDP, and usually later as a slower decline of the share of total employment dedicated to agricultural activities. In fact, (Syrquin, 1988) in an effort of specifying consistent patterns that typify the development process, notes that, in addition to the increase in the rates of output growth, which characterizes growth/development itself, there are two other characteristics: an increase in the rate of accumulation of assets (savings), and a shift in the composition of output with a *relative* contraction of agriculture and a *relative* expansion of manufactures. Furthermore, not even an increase in saving rates is as universally accepted as a characteristic of the country development experience as another trait observed: the pronounced growth in Total Factor Productivity (TFP) of the economy taken as a whole, could be behind the observed higher growth instead of, or together with, higher asset accumulation rates. Thus, the relative decline in the economic importance of agriculture appears as the most dominant feature of development, which we will interchangeably call *structural transformation*.

Early development economists (in the 1940s and 50s) did not focus on this change in the structure of output, with a relative decline of agriculture, as a feature of development, but placed a great emphasis in industrialization and a moving of resources towards manufacturing (Hirschman, 1958; Nurkse, 1953; Prebisch, 1949; Rosenstein-Rodan, 1943). Towards the middle of the previous century it was obvious that the richest countries in the world were characterized by a strong industrial sector, which does not necessarily hold true today, when the wealthiest countries are characterized by a large services economy. So although this structural transformation that characterizes the migration of assets, physical and financial capital – and most notably labor – to the industrial sector was a well-known feature of the development process, credit goes to (Kuznets, 1957) as the economist who first formalized structural change with a wealth of international data. This Kuznets transformation of output that accompanies development was also formalized in (H. B. Chenery & Taylor, 1968; H. B. Chenery, 1960; H. Chenery & Syrquin, 1975).

From the World Bank's *World Development Indicators*, starting in 1960 (for those countries that have long series of national accounts, most countries have data starting in later periods), we can observe that the Kuznets transformation remains a stable feature of economic development. In Table 1, we show for each country the correlation between the share of GDP produced by agriculture (in % points), more formally the ratio of agricultural value-added to GDP[1], and the logarithm of the level of per capita GDP (in constant 2011 US dollars). To reduce yearly noise, likely more pronounced in the agricultural sector which is subject to weather shocks, we use 5-year averages in the regressions in the table. The highly significant negative coefficient on per capita GDP demonstrates that as countries grow, and per capita GDP increases the share of agricultural value added in total GDP falls. That is, the Kuznets transformation is confirmed. In addition to the robustly negative coefficients, the goodness of fit of the regression (R^2 of 0.70 and 0.50 in the first 2 columns) emphasizes how strong, that is to say, inexorable this structural transformation is.

In columns 4 through 8, we examine whether or not this relationship has changed by testing if the rate of this structural transformation has increased or slowed. We observe that the coefficients on per capita GDP are lower for more recent periods. This is, however, consistent with a constant elasticity; as time passes and countries develop, the coefficient should decrease even if the elasticity is constant. In fact, a test that the implicit elasticity for 1960-2014, -0.7, is the same as the elasticity for 1985-2014 (column 6) is not rejected at the 95% confidence level. This elasticity implies that for every 10% of real growth in a country, the share of agriculture in GDP falls by 7%; i.e., a country with agriculture representing 15% of GDP, would display a share of agriculture in GDP of 12.9% after 10% of per capita GDP growth. The fixed-effects regression allows for country specific intercepts, which is likely given that countries are observed at different stages of their development path. Also, we test if there are regional differences in the rate of structural transformation, by including regional dummies interacting with per capita GDP. In the case of Latin America, our focus, we see that for the whole period 1960-2014, the region appears to have displayed a lower rate of transformation (coefficient positive in column 3 at the 10% significance level). This relation disappears, however, when only considering more recent data of

[1] A couple of clarifications are required, in this database agriculture includes forestry, hunting, and fishing, as well as what a narrow definition understands as agriculture: cultivation of crops and livestock production. Also, the portions of output that can be assigned to sectors are value-added (gross value of production minus consumption of intermediate inputs), and not "sectoral GDP". GDP on the other hand, is more than the sum of the different sectors' value-added as components of total GDP cannot be assigned to sectors, like import tariffs and (value-added) taxes. This "non-sectoral" GDP can amount to 10% or more of national GDP.

the last three decades. South Asia appears consistently to have a faster rate of structural transformation.

Table 1. Agricultural Value-Added as a share (%) of GDP (5-year averages)

	1960 – 2014				1985 - 2014			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pooled	Fixed Effects	Fixed Effects	Fixed Effects	Pooled	Fixed Effects	Fixed Effects	Fixed Effects
GDP per capita,	-8.64***	-13.13***	-13.42***	-11.86***	-7.83***	-10.57***	-10.76***	-10.82***
log	(0.152)	(0.416)	(0.448)	(1.061)	(0.155)	(0.473)	(0.511)	(0.857)
GDPpc x Latin			2.098*	0.533			1.336	1.4
America			(1.195)	(1.527)			(1.354)	(1.514)
GDPpc x East				0.053				-0.001
Asia				(1.284)				(1.294)
GDPpc x MENA				-3.013*				1.829
				(1.679)				(2.656)
GDPpc x N.				11.817				10.78
America				(21.853)				(15.616)
GDPpc x S. Asia				-7.475***				-5.431***
				(1.800)				(1.891)
GDPpc x SS				-2.282				1.953
Africa				(1.398)				(1.343)
Constant	88.32***	124.5***	123.2***	121.6***	80.53***	103.1***	102.4***	98.63***
	(1.247)	(3.357)	(3.432)	(3.917)	(1.296)	(3.904)	(3.968)	(4.350)
Implicit Elasticity (per capita GDP)	-0.466	-0.707	-0.723	-0.639	-0.492	-0.664	-0.676	-0.680
R2	0.698	0.448	0.45	0.461	0.71	0.362	0.363	0.373
Obs.	1399	1399	1399	1399	1050	1050	1050	1050
Nr. of Countries	170	170	170	170	170	170	170	170

Note: Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01. Data source, World Bank, World Development Indicators.

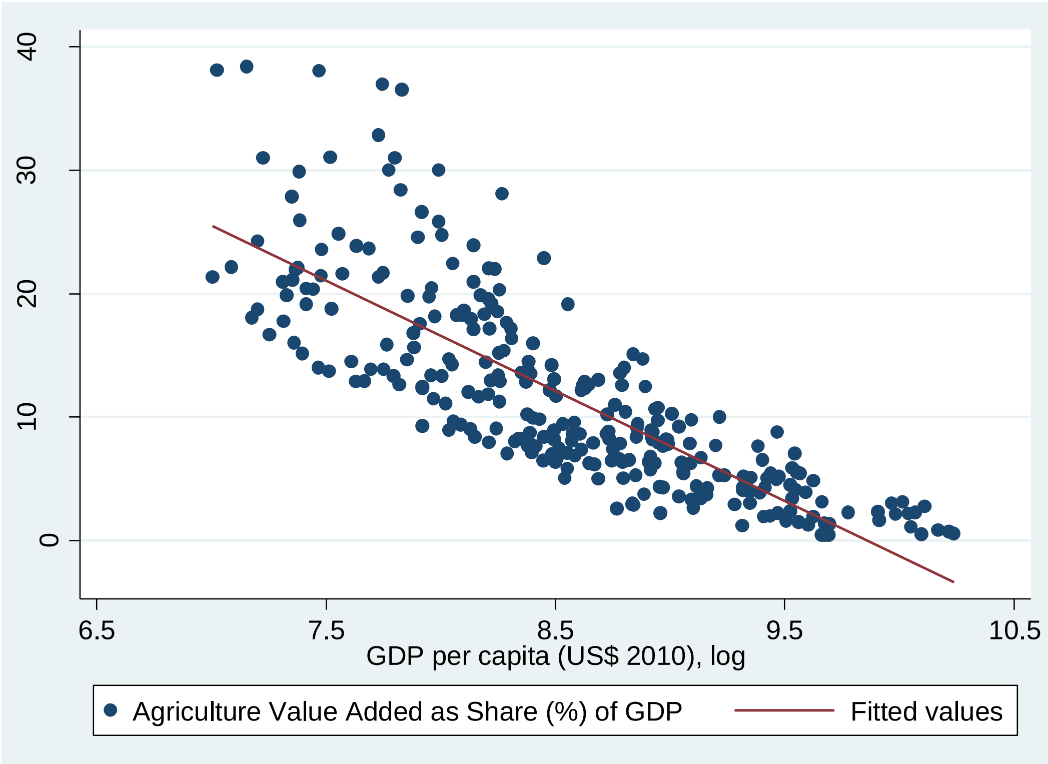
In Table 2, we replicate the analysis using only data from 32 Latin American and Caribbean countries. The estimated elasticity (-0.8 , -1) is larger than that estimated with the data of all countries available. The elasticity estimate suggests that for every percentage point in real growth the share of agriculture in GDP is reduce by almost 1 percent. Also, the table shows a high goodness of fit measure for this simple relationship: at least 50% of the variability in the ratio of agricultural value added to GDP can be explained by differences in real national income levels alone. This high fit can be observed in Figure 1, which shows that most observed values lie in close proximity to the regression line.

Table 2. Agricultural Value-Added as a share (%) of GDP (5-year averages). Latin America Sample

	1960 - 2014		**1985 - 2014**	
	Pooled	**Fixed Effects**	**Pooled**	**Fixed Effects**
GDP per capita, log	-8.944***	-11.324***	-7.615***	-9.420***
	(0.394)	(0.675)	(0.424)	(0.757)
Constant	88.183***	108.525***	75.884***	91.514***
	(3.383)	(5.770)	(3.685)	(6.557)
Implicit Elasticity (per capita GDP)	-0.762	-0.965	-0.763	-0.944
R2	0.645	0.528	0.612	0.472
Obs.	285	285	206	206
Nr. of Countries	32	32	32	32

Note: Standard errors in parentheses, * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Data source, World Bank, World Development Indicators.

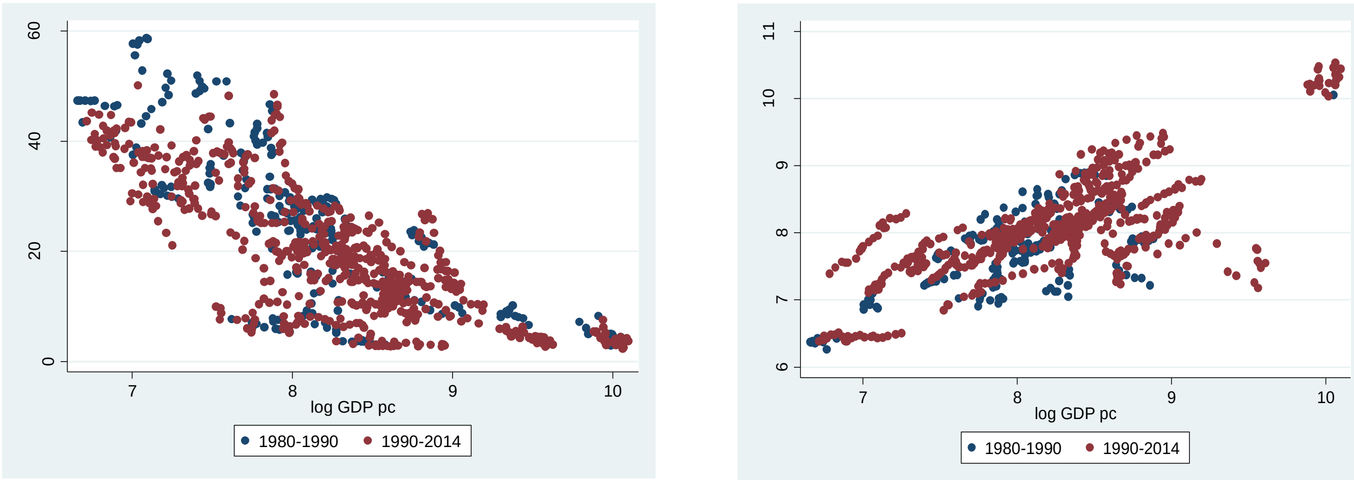
Figure 1. Structural Transformation in Latin America (1960 - 2014)



Note: 5-year averages. Data source, World Bank, World Development Indicators.

Another feature of the structural transformation of developing economies, which occurs concurrently with the decline of the participation of agriculture in GDP, is the decline of the importance of agriculture in national employment. This economic migration from agriculture into industrial sectors has long been understood as a feature of development, and perhaps as some have argued (e.g., Lewis, 1954), a necessary condition for the development of nations. The first panel of Figure 2 shows this negative correlation using Latin American data. This negative relation looks similar to the trajectory of agricultural value added. Note, however, that there are differences in the range of the vertical axis of Figures 1 and 2. For a given participation of agricultural value added in GDP, the participation of agriculture in total employment tends to be substantially higher. This result can be interpreted as if the employment transformation follows in time the transformation in sectoral composition of GDP. In fact, it appears that the transformation in employment is slower.

Figure 2. Employment in Agriculture as a Share of National Employment and Mean Labor Productivity in Agriculture



Notes: Based on data from World Development Indicators

Table 3 replicates a similar analysis as that pursued in Tables 1 and 2, examining the statistical relationship between the level of real national income (GDP per capita), and the share of agricultural employment in national employment. The negative relationship that is exposed in the first panel of Figure 2, is confirmed in the regressions, however, the implied elasticities (-0.3 , -0.6) are notably (and statistically) lower than the elasticity of the share of output to real income shown in Table 2. This confirms that the rate at which the sectoral composition of employment transforms is slower than the transformation of sectoral composition of output, even as both occur concomitantly.

Table 3. Share of National Employment in Agriculture (%)

	1960 - 2014		1985 - 2014	
	Pooled	**Fixed Effects**	**Fixed Effects**	**Fixed Effects**
GDP per capita, log	-10.777***	-5.965**	-10.043***	-5.175*
	(0.976)	(2.871)	(0.955)	(2.977)
Constant	110.374***	68.937***	103.657***	61.662**
	(8.437)	(24.723)	(8.272)	(25.692)
Implicit Elasticity (per capita GDP)	-0.613	-0.339	-0.590	-0.304
R2	0.416	0.030	0.418	0.024
Obs.	173	173	156	156
Nr. of Countries	30	30	30	30

Note: Standard errors in parentheses, * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Data source, World Bank, World Development Indicators.

Another feature of the structural transformation of countries, which is implicitly derived from the two characteristics already described, is the significant rise in average labor productivity in the agricultural sector as countries develop (see panel 2 of Figure 2). Growth itself may be defined as a rise in average productivity (the ratio of value of value added over employment). However, in the case of average productivity in agriculture, this rise will tend to be sharper, because agriculture keeps growing in spite of its relative decline in total output, and it does so, while it “sheds” labor. Although approximate, this is initial evidence that agriculture is not a slow productivity growth sector. A simple statistic test on the growth of agricultural output per labor, versus non-agricultural output per labor in Latin America, does not reject that both grow at the same rate. This is not a sophisticated analysis of TFP growth, technical change, or productivity analysis (some of which is carried further below), but it is a simple indicator that, in terms of productivity growth, agriculture is not a laggard sector (*cf.* evidence presented in next section).

Given that it is not lower productivity growth that explains the structural transformation, the question arises: What are the drivers of structural transformation? This is the topic we examine in the next section.

II. Determinants of the Structural Transformation

Early development economists (e.g., Johnston & Mellor, 1961) placed emphasis on the income elasticity of demand for agricultural products as a limiting factor to the growth of the farm sector. The argument follows from Engel's law; the income elasticity of demand for agricultural products is less than one, implying that income growth translates into an ever- smaller share of the consumer's market basket being dedicated to food and other goods deriving from the farm sector. Moreover, the evidence suggests that not only is the income elasticity of the demand for food less than unity, but this elasticity tends to fall as countries become wealthier (Alderman, 1986; Anríquez, Daidone, & Mane, 2013). In practice this means that agriculture may not grow as fast as the overall economy, because it faces a *proportionally* ever-shrinking demand. If economies were closed, a country could hardly escape this demand-side obstacle, but it is hard to argue that this is the case for most small and mid-size developing economies that can grow agricultural output while facing an infinitely elastic demand at international prices.

A similar argument was brought forth by Latin American structuralist economists (e.g, Prebisch, 1949) in what eventually became known as the Prebisch-Singer hypothesis. According to this hypothesis, the international relative price of agricultural goods against manufactured goods tends to fall in the long term. This trend implies two different outcomes for countries that are net agricultural exporters. First the terms of trade are falling, and an increasing amount of exports will be necessary just to maintain a constant level of real imports. The second outcome is that this change in relative prices changes investment incentives, which should, in the long term, shift resources from the primary sector towards manufactures, promoting structural change. The argument appears compelling, but the evidence of this long-term decline in the terms of trade is not, see for example (Ocampo & Parra, 2003). While some products such as maize appear to display a negative long term real price trends, many other primary products show no trend, such as coffee, and even positive trends, such as meat and timber.

Other authors have emphasized the decreasing farm labor availability, as a result of migration into urban and industrial sectors as another cause for the fall of the contribution of agriculture to national GDP (Johnston & Mellor, 1961). Rather than an explanation for structural change, however, this shift in observed labor patterns is a feature of the same structural transformation. As a result of the structural transformation that characterizes development, employment in agriculture (as a share and often in levels) tends to fall, although it is not clear if this is a result of labor saving technical change (Hayami & Ruttan, 1971), or growing labor productivity in the non-agricultural sector, which leads to an outward shift in non-farm demand for labor and wages that attract workers from the agricultural sector.

One of the most prominent explanations for structural change of the early development economists is that technical change is lower in the agricultural sector, where productivity rises faster in the non-agricultural sector which drives the observed structural change (Clark, 1940; Hirschman, 1958; Johnston & Mellor, 1961; Lewis, 1954; Prebisch, 1949). There is an intuitive appeal to this explanation: the manufacturing sector looks modern and vibrant while agriculture seems backwards and slow. However, the evidence is far from supporting this hypothesis. For example (Martin & Mitra, 2001) showed that TFP growth is on average almost 1% higher for the agricultural sector than the industrial sector for a sample of 33 developing countries. Furthermore, even among developed countries TFP growth is higher in agriculture than in manufacturing by roughly 0.5%. These latter results corroborate those found by (Bernard & Jones, 1996), which showed that, among OECD countries and across six different industries, agriculture displayed the highest TFP growth. (Faruqui, Gu, Kaci, Laroche, & Maynard, 2003) on the other hand showed that labor productivity growth in Canada and the United States (1987 - 2000) was higher in the primary sector than in manufacturing and services. The argument here is not that agriculture *always* displays higher productivity growth than manufacturing or services, but rather that the differences in productivity growth are not universally biased against agriculture, and therefore that these productivity differences cannot be a credible explanation of the universal result of structural transformation.

One feature of agricultural production that may explain its secular decline is that one of its major factors of production is not an accruable asset. We refer of course to cultivated land, which although is not absolutely fixed, and may expand and contract following medium term economic cycles, cannot be continually accrued like physical capital, and even human capital. Countries have a comparably fixed endowment of arable land, and although technology and investments (irrigation, soil preservation and others) might expand the agricultural frontier, these expansions usually cannot be persistently sustained. This is why when an accounting of the sources of growth is performed, land which may display high returns, contributes mildly to overall sectoral growth (see example below in section IV).

Another important feature that explains the decline of agriculture's share of value added in GDP is related to the nature of technological change and the sector's measurement within the system of national accounts. First, to clarify the accounting construct that is value added: total gross value of output minus intermediate purchases. A sector's value add is the net income available to remunerate sector-specific labor and productive assets. As agriculture develops, many of the inputs that traditionally are supplied from within the sector eventually start being purchased from other industries. For example, in a less developed country power for traction is supplied by animals and feed (both supplied from within the primary sector), while a modern operation requires truck services and fuel purchased from other industries. In a less developed agriculture, fertilization and improved seeds are provided within the primary sector with manure, crop rotation, and seed self-selection; in modern agricultural industries these are purchased goods and services from chemical and other industries. Agriculture is a sector that faces steep input challenges, with a declining labor supply, and a relatively fixed supply of land. In this context growth is achieved by more intensive input use (intermediate purchases) which inevitably results in a declining share of gross value of output that is value added. A similar argument may be posited regarding the destiny of agricultural supply. A feature of the modernization of agriculture is the search for the increase in value added of the agricultural operation. The goal is to move from production with little value added, like simple grains, towards higher value export products and processed foods. Almost all of these "higher value added" products are accounted outside agriculture itself. For example, neatly packed export apples for export contain value added from the agriculture sector only in the apples themselves, the sorting and packing done outside of the farms, and the modern logistical transport services are all value added that is not accrued in the primary sector (which is attributed to agro-industry and transport services). Similarly, as countries develop less of the food consumed is unprocessed, with a growing amount of processed foods, which for agricultural accounts, counts only as intermediate demand and less sectoral value added.

This transformation may be traced by following the Input Output matrices which are used to construct a system of national accounts.[2] The total gross value of production of sector (i) is defined from the demand side as:

$$X_i = W_i + D_i + T_i \ ,$$

where total demand is equal to intermediate demand, W_i, (the row sum of the input output matrix), final demand of households and government, D_i, and the part of production exported, T_i. From the supply side, that gross value of output is composed of intermediate purchases, U_i , and value added, V_i:

$$X_i = U_i + V_i.$$

Hence one can describe value added of a sector (j) as a proportion $\nu \in (0,1)$ of the total gross value of production:

$$V_j = \nu X_j.$$

Recalling that total GDP is approximately the sum of sectoral value added, $\sum_j V_j = V$,[3] we can express the share of GDP contributed by sector (i) as:

$$V_i/V = \nu(W_i + D_i + T_i)/V. \tag{1}$$

Taking time derivatives and rearranging terms, we can express the rate of change in this ratio, what we have called throughout structural change, as:

$$\widehat{\left(\frac{V_i}{V}\right)} \approx \hat{\nu} + \alpha_W\left[\widehat{W}_i - \hat{V}\right] + \alpha_D\left[\widehat{D}_i - \hat{V}\right] + (1 - \alpha_W - \alpha_D)\left[\widehat{T}_i - \hat{V}\right]. \tag{2}$$

In this decomposition, the "hat" over the variables indicates rate of change, i.e. $\hat{x} \equiv \frac{\dot{x}}{x} = (dx/dt)/x$; the parameter α_W is the share of intermediate demand in total demand, i.e. W_i/X_i, and α_D is the share of final demand in total demand.

[2] We develop the following decomposition following ideas suggested by (Syrquin, 1988).

[3] Gross value added plus net taxes on goods and service equals gross domestic product.

Table 4. Decomposition of Structural Transformation in Chile 1986 -2008

		1986	1996	% Change	2003	% Change	2008	% Change
1	W	310,526	1,817,509	176.7	3,025,983	51.0	4,970,396	49.6
2	T	119,638	618,936	164.4	1,480,201	87.2	1,969,065	28.5
3	D	146,500	907,079	182.3	1,194,582	27.5	2,072,172	55.1
4	X (1+2+3)	576,664	3,343,523	175.8	5,700,766	53.4	9,011,633	45.8
5	VA_i	253,388	1,323,492	165.3	1,842,431	33.1	2,711,891	38.7
6	v (5/4)	43.94	39.58	-10.4	32.32	-20.3	30.09	-7.1
7	Sum VA_j	3,268,418	29,255,529	219.2	48,600,393	50.8	85,888,192	56.9
8	GDP	3,419,000	31,237,289	221.2	51,156,415	49.3	93,847,932	60.7
9	Real GDP Growth			70.9		24.9		26.6
10	Ag. in Value Added (5/7)	7.75	4.52	-53.9	3.79	-17.7	3.16	-18.3
11	Ag. in GDP (5/8)	7.41	4.24	-55.9	3.60	-16.2	2.89	-22.0
12	α_W (1/4)		0.541		0.537		0.541	
13	$\alpha_W\left[\widehat{W}_i - \widehat{V}\right]$			-23.0		0.1		-4.0
14	α_T (2/4)		0.196		0.222		0.239	
15	$\alpha_T\left[\widehat{T}_i - \widehat{V}\right]$			-10.8		8.1		-6.8
16	α_D (3/4)		0.263		0.240		0.220	
17	$\alpha_D\left[\widehat{D}_i - \widehat{V}\right]$			-9.7		-5.6		-0.4
18	Structural Change (6+13+15+17 = 10)			-53.9		-17.6		-18.3

Notes: In nominal millions of Chilean pesos. Row 9 provides for reference real growth of GDP.

In Table 4 and Table 5 we perform this decomposition for Chile and Peru respectively with the available input output matrices for 1986, 1996, 2003 and 2008 for Chile, and 1994, 2007 for Peru. In the case of Chile, between 1986 and 1996, intermediate demand for agricultural products grew (relatively) very slowly, contributing in greater portion to the decline of the participation of agriculture in GDP. However, between 1996 and 2003, both exports and intermediate demand grew faster than the economy, helping to slow down the sectoral transformation of the Chilean economy. Between 2008 and 2003 final demand grew as fast as the economy, not contributing to the structural transformation of the Chilean economy. In the case of Peru, between 1994 and 2007 both exports and intermediate demand grew faster than the economy slowing down the rate at which agriculture’s contribution to GDP falls, while final demand grew marginally slower than the economy, contributing very little to the sectoral transformation. In both countries consistently the main driver of the structural transformation is the drop in the share of gross value of production that is value added, confirming this technological/accounting change that is one of the main drivers of observed structural change.

Table 5. Decomposition of Structural Transformation in Peru (1994 -2007)

		1994	2007	% Change
1	W	6,532	23,771	129.2
2	T	295	2,146	198.4
3	D	4,394	13,588	112.9
4	X (1+2+3)	11,222	39,505	125.9
5	VA_i	7,487	19,074	93.5
6	v (5/4)	66.72	48.28	-32.3
7	Sum VA_j	88,974	293,190	119.2
8	GDP	98,579	319,693	117.7
9	Real GDP Growth			56.3
10	Ag. in Value Added (5/7)	8.41	6.51	-25.7
11	Ag. in GDP (5/8)	7.60	5.97	-24.1
12	α_W (1/4)		0.592	
13	$\alpha_W\left[\widehat{W}_i - \hat{V}\right]$			5.9
14	α_T (2/4)		0.040	
15	$\alpha_T\left[\hat{T}_i - \hat{V}\right]$			3.2
16	α_D (3/4)		0.368	
17	$\alpha_D\left[\widehat{D}_i - \hat{V}\right]$			-2.3
18	Structural Change (6+13+15+17 = 10)			-25.6

Notes: In nominal millions of Peruvian soles. Row 9 provides reference real growth of GDP.

III. Differences in the structural change of Latin American economies: a typology.

In order two describe different patterns of structural change among Latin American economies, we first turn to establishing that it is an unequivocal result of the non-agricultural economy growing comparatively faster than agriculture in terms of value added. To show this, notice that the participation of agriculture in GDP may be described as:

$$\frac{Y_A}{Y} = \frac{Y_A}{(Y_A + Y_N)},$$

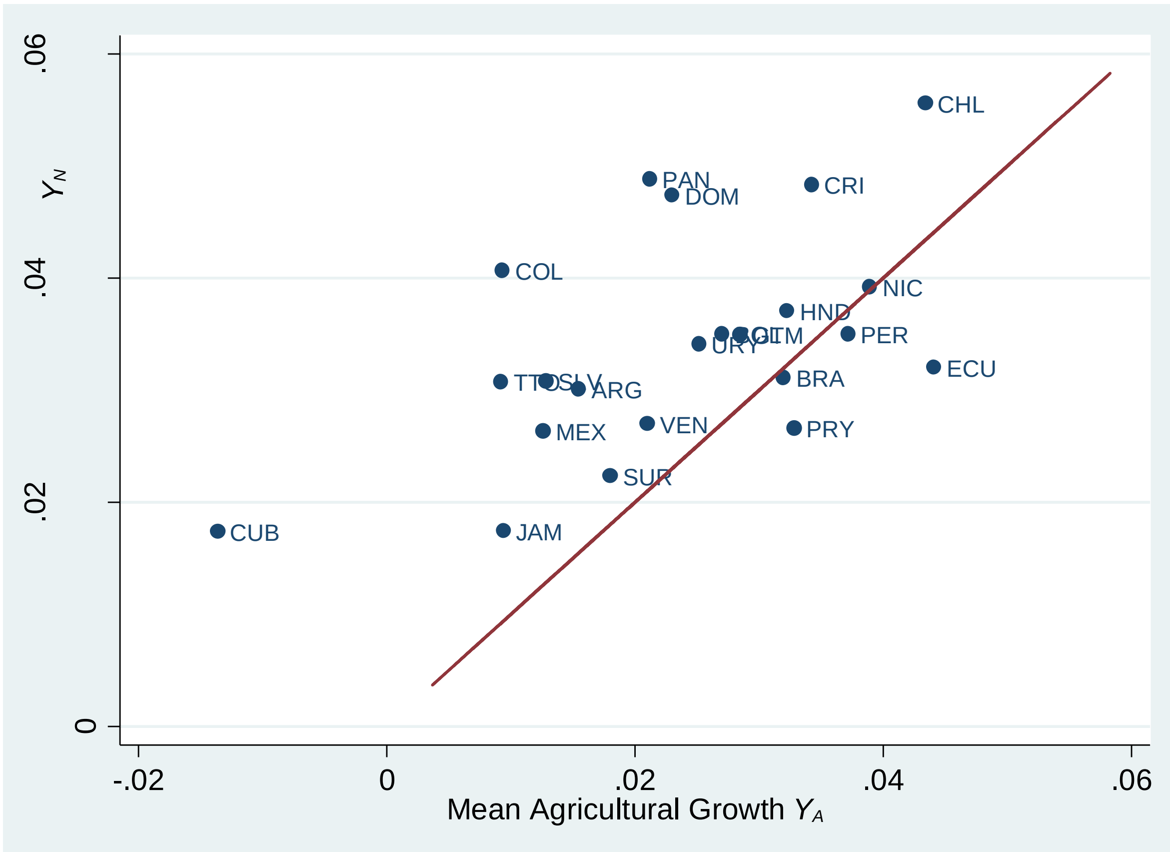
where Y_A is agricultural value added, Y is GDP, and Y_N is the value added of non-agricultural sectors. Taking time derivatives from this expression, and rearranging, we can express the rate of change of the share of agriculture in GDP as:

$$\widehat{\left(\frac{Y_A}{Y}\right)} = (1 - \alpha_A)[\hat{Y}_A - \hat{Y}_N], \tag{3}$$

where, $\alpha_A \equiv \frac{Y_A}{(Y_A + Y_N)}$. This expression demonstrates two things. First, the fall in the participation of agriculture in GDP can only happen if the growth rate of non-agricultural value added is faster than the rate of growth in agriculture. And second, that the more advanced the economy is within its transition, and thus $(1 - \alpha_A)$ is larger, the faster deviations in growth rates translate into the relative decline of agriculture. The first result is important, because it tells us that the transition can happen with agriculture growing rapidly or with agricultural value added expanding slowly, as long as the rest of the economy is growing even more rapidly. What drives structural change is the gap between sectoral growth rates.

This lesson is what leads us to examine Figure 3, where in a scatter plot average growth rates of both sectors are described for the period 1984 - 2012. The choice of period is important. The reader must recall that Latin America as a whole suffered a profound economic crisis in 1982, after which at different stages the region underwent a period of profound structural reforms, mostly characterized by trade openness and macro reforms (exchange rate liberalization, inflation and public debt control, among other reforms). (See, for example, Lora, 2012.). In the figure, note the red line describes a 45 degree line or an iso-growth line, and that the ending year is the latest possible without dropping countries. Countries above the red line are experimenting what we have described as structural change, while countries below experience the contrary sectoral transformation. With the exception of Peru, Ecuador, Paraguay, and marginally Brazil, most Latin American Countries have experienced structural transformation. However, clearly the transformation is not the same for a country like Chile with an extremely dynamic agriculture, compared to Mexico, with similar differentials in sectoral growth rates, but with much slower agricultural development.

Figure 3. Growth of Agricultural and Non Agricultural Value Added in Latin America (1984-2012)



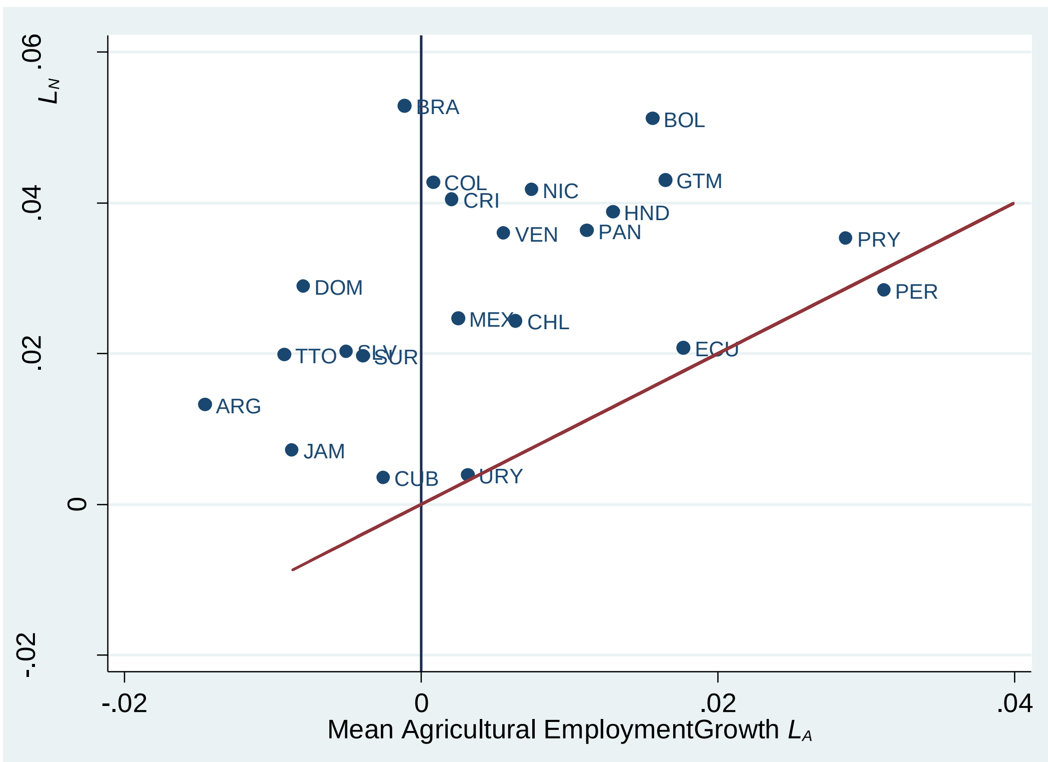
Note: Source World Development Indicators of the World Bank. Mean growth rates calculated as compound annual growth rates, i.e. $\left(\frac{y_{t+s}}{y_t}\right)^{1/s} - 1$. Period considered is 1984 – 2012, except for Paraguay and Nicaragua, where due to data limitations, starting years are 1991 and 1994 respectively.

It is straight forward to recreate a similar decomposition, like that presented in (3), for the rate at which the labor market transforms:

$$\widehat{\left(\frac{L_A}{L}\right)} = (1 - \beta_A)[\hat{L}_A - \hat{L}_N], \tag{4}$$

where $\beta_A \equiv \frac{L_A}{(L_A+L_N)}$, L_A is employment in agriculture, and L_N is employment in non agricultural sectors. Figure 4 displays mean growth rates of employment in agricultural and non-agricultural sectors. The red line is the iso-growth line: countries above it display faster growth in non agricultural employment and therefore structural transformation of their labor markets. It is noteworthy that that is the case of all Latin American countries with the exception of Peru, where agricultural employment has grown faster than non-agricultural employment. The vertical blue line, provides another important reference, as countries to the left of this line, have experienced negative growth in agricultural employment, which emphasizes their structural transformation of labor markets (see equation (4)). With negative growth of agricultural employment we observe Argentina, and Central America, (El Salvador) and Caribbean countries (Trinidad and Tobago, Jamaica , Cuba, and Dominican Republic). The majority of countries in the region nonetheless, display positive growth of agricultural employment.

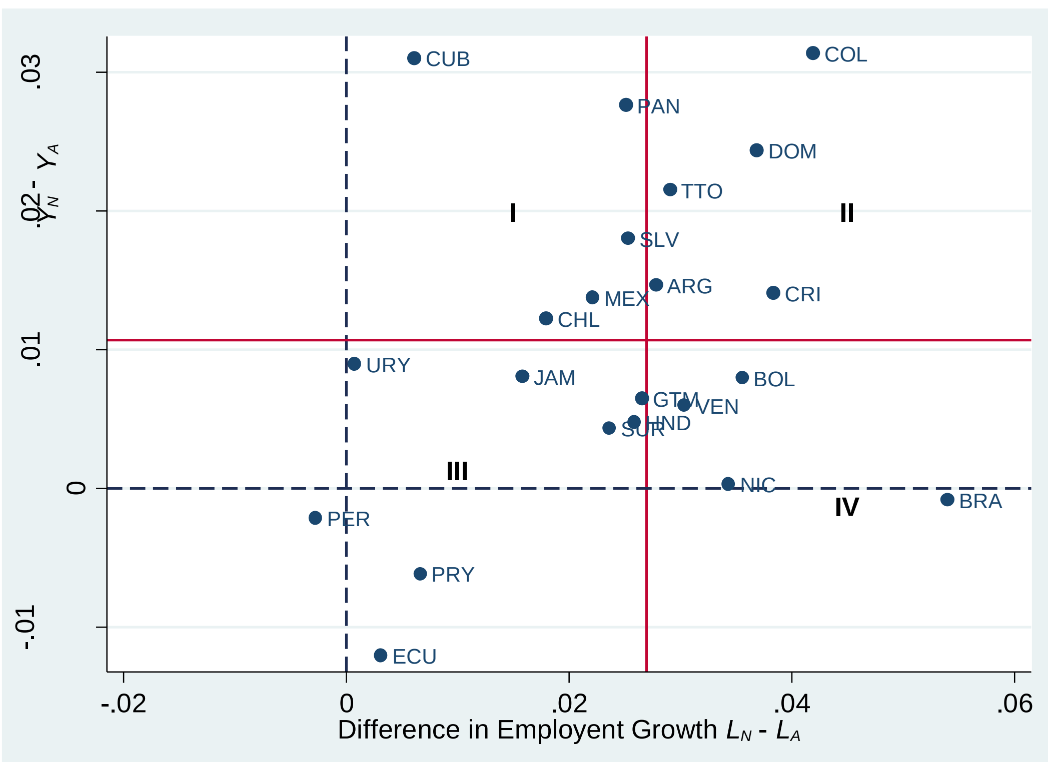
Figure 4. Growth Agricultural and Non Agricultural Employment in Latin America (1984-2012)



Note: Source World Development Indicators, FAOSTAT, and national sources. Employment figures are less reliable, some countries report only urban employment surveys, which affects comparability, and justifies the data collection effort. Figures used reported in appendix. Mean growth rates calculated as compound annual growth rates. Period considered is 1984 – 2012.

Given that we can observe the changes in economies in terms of GDP and labor markets we have two dimensions on which to observe structural transformation. **Error! Reference source not found.** explores these dimensions in a scatter plot. In the figure, the horizontal and vertical lines indicate observed average rates of (differential) value added and labor growth among countries in the region. These red lines generate four quadrants across which countries distribute proportionally 5, 5, 8 and 4 countries. It also allows us to classify countries into four types. In the first quadrant (I) we have countries that have displayed a higher than average transformation of output, but lower than average transformation (or migration) of its labor force. The second quadrant (II) shows countries that are fast transformers in output and labor markets. The third group (III), gathers the countries that are transforming slow both in terms of sectoral composition of output and labor. Finally, the fourth group of counties (IV) contains those where labor is migrating fast from the agricultural sector, but display slow transformation of the sectoral composition of output.

Figure 5. Difference in Employment and Output Growth Rates: Agriculture vs. Non Agriculture



Note: Source World Development Indicators of the World Bank. Mean growth rates calculated as compound annual growth rates. See period coverage differences under figures 3 and 4.

In the following sections of this report, there will be an in-depth focus placed on two countries. The first country selected lies in quadrant III, and it is unique, as the only country that between 1984 and 2012 has increased the output and labor share of agriculture, which is shown in the figure, with Peru as the only country lying to the Southwest of the origin of the graph. The second country chosen for a thorough analysis lies in quadrant IV, Nicaragua, among same quadrant countries it is selected for its relatively lower development level, and good data availability. The study of these countries will be complemented with the evidence from a country in the second quadrant, which is more advanced in its structural transformation, and has good data availability for comparison, Chile. No country from the second quadrant will be studied in detail, but these countries that have experienced fast transformation, such as Panama and Colombia, will be considered in further cross country analysis.

The proposed typology is useful, because it considers structural transformation in terms of sectoral income and labor markets. Nevertheless, there are other important dimensions ignored. In particular, it is important to distinguish and understand whether or not the transformation is happening as a result of a stagnant agriculture, which forces resources and people to migrate to other sectors, or whether agriculture plays a vibrant and supportive role in the development of the country. Clearly, implications for rural welfare in particular are radically different in both scenarios. In the next section we unpack growth in the agricultural sector to determine the drivers, and their contribution

IV. Productivity in Latin American Agriculture. A long-term view (1970 - 2013)

The goal of this exercise is to construct a complete decomposition of growth in agricultural output, to understand the separate contributions that technological progress and accumulation of assets make to total growth in output. This analysis is comparable to the effort of Trindade & Fulginiti (2015), but we are expanding country coverage to nineteen Latin American countries, as well as the time horizon. The starting point for this exercise is to establish the relationship between inputs and agricultural growth within a neo-classic production function framework, expressed in logarithms as:

$$y_{it} = TE_{it} + f(x_{it}, t; \beta). \tag{5}$$

In this context, y_{it} is agricultural output for country i at time t; TE_{it}, is technical efficiency, an index contained within the unit interval that expresses how close a country i is to the frontier of maximum possible production, defined by the function $f(\cdot)$. The production function $f(\cdot)$ is a function of x_{it} a vector of J inputs, time (t), and a vector β of estimated coefficients of the linearized form of the production function. Over time, the production function evolves according to the following expression:

$$\dot{y}_{it} = \dot{TE} + \sum_j \frac{\partial f(x_{it}, t; \beta)}{\partial x_{jit}} \dot{x}_{jit} + \frac{\partial f(x_{it}, t; \beta)}{\partial t}. \tag{6}$$

This expression indicates that growth of output (note that given that we have (5) expressed in logs, the time change expression, with a dot above the variable, indicates growth rates), is a result of changes in the accumulation of assets, $\sum_j \frac{\partial f(x_{it}, t; \beta)}{\partial x_{jit}} \dot{x}_{jit}$, and changes in technology: what is usually known as changes in Total Factor Productivity, or also colloquially as the Solow residual. Furthermore, TFP growth can be decomposes into:

$$\dot{TFP} = \dot{TE} + \frac{\partial f(x_{it}, t; \beta)}{\partial t} \tag{7}$$

changes in technical efficiency, i.e. changes in how productively inputs are used, and technical change, or how the frontier of maximum achievable production changes over time.

The production function is linearized using a translog specification. The estimation technique chosen, stochastic frontier (see (Kumbhakar & Lovell, 2003)), identifies the level of technical efficiency by making assumptions about its distribution. In this exercise we assume that technical efficiency is distributed truncated normal, with a mean that is conditional to (determined by) a vector of observables, and is estimated jointly with the production function. Additionally, we allow for heteroscedasticity of the technical efficiency indicator u_{it} (see (8), below), in a structured way, explained by a vector of observable country characteristics. The production function $f(\cdot)$, conditional mean, and heteroscedasticity components are estimated jointly by maximum likelihood, using the STATA command prepared by (Belotti, Daidone, Ilardi, & Atella, 2013).

Hence, the model estimated can be described by the following equation (considering six inputs described below):

$$y_{it} = a + \sum_{j=1}^{6} b_j\, x_{jit} + \frac{1}{2}\sum_{j=1}^{6} c_{jj}\, {x_{jit}}^2 + \sum_{j=1}^{6}\sum_{k>j}^{6} c_{jk}\, x_{jit}x_{kit} + d\, t + \frac{1}{2}\, f\, t^2 + \sum_{j=1}^{6} g_j\, tx_{jit} - u_{it} + v_{it}. \quad (8)$$

Here a, b_j, c_{jk}, d, f, and g_j are estimated coefficients of the production function, x_{kit} indicates input k, for country i, at time t, u_{it} is the skewed (truncated normal) estimator of the log of technical efficiency, and v_{it} is the mean zero, normally distributed standard econometric error. Symmetry is imposed by estimating off diagonal coefficients, c_{jk}, only once.

When estimating a *production* function, an output index is preferred to a value index (or value added). We use FAO's agricultural production index (FAOSTAT) from 1970 to 2013 as the quantity index that measures the variable of interest, y_{it}. Six different inputs are considered in the production function: *i*) Labor in agriculture, *ii*) capital stocks (proxied by tractors), *iii*) Livestock as stock, *iv*) agricultural land, *v*) fertilizers, and v*i*) pesticides. Employment, economically active persons in agriculture (in thousands) is obtained from FAOSTAT.

The measure of capital stock, proxied here by the number of tractors in the country (FAOSTAT), requires a brief discussion. Regardless of the specific approach to estimation, a productivity analysis decomposes output growth into that which can be explained by input accumulation and that which is explained by changes in technology and efficiency. If a factor is not well measured, unavoidably growth will be attributed to technical progress which could be explained by not well accounted-for factor accumulation. For countries with more modern agricultural sectors, such as Argentina, Chile and Brazil, it is likely that a simple count of tractors would be a less appropriate proxy for capital stock in agriculture, because tractors would represent a shrinking value of total capital, which would include specialized structures and machinery for particular crops, and other investments, such as in-site irrigation. In spite of the drawbacks, this variable as has been traditionally used in the literature, *cf.* (Headey, Alauddin, & Rao, 2010; Trindade & Fulginiti, 2015).

Livestock is a composite index of stock of farm animals using (Hayami & Ruttan, 1971) weights. Agricultural land, also from FAOSTAT, follows FAO's definition of agricultural land, which includes land used on permanent crops, annual crops, and pastures. Fertilizers, measures the sum in tons of three main fertilizers consumed: nitrogen (N), phosphorus (P_2O_2), and potassium (K_2O), from FAOSTAT. Finally, pesticides, from FAOSTAT, measures in tons the sum of the different active ingredients contained in pesticides and used in agricultural production.

Additionally, to allow for variable means and variance of technical efficiency, we use a vector of six variables, expected to be correlated with the level of technical efficiency. First, we use per capita GDP (in 2005 US$), as an indicator of the level of development of the country. We include trade openness (measured as overall trade value over GDP), likely correlated with ease of importing technology and best-practices. As an indicator of health we use life-expectancy at birth, obtained from UNDP website. We also include an indicator of irrigation coverage, which is the share of agricultural land that has some form of irrigation infrastructure over total agricultural land, from AQUASTAT, FAO website. Education is likely a major determinant of technical efficiency; in this analysis it is proxied by government spending in education as a percentage of GDP, from World Development Indicators. Finally, we include time in this vector to allow for time shifting effects on technical efficiency.

The full set of regression results is presented in Appendix II of this chapter. Here we concentrate on the results that can be derived from this regression. The first result relates to technical efficiency, which indicates how efficiently inputs are used in production, or how close the country is to the maximum production (or frontier) in terms of proportional output distance (with 1 signaling production at the frontier). Table 6 shows average technical efficiencies by country and period (1970-1984) versus (1985-2013). As argued above, these two periods are sensible after considering that they broadly define a pre-structural reform era and a post-reform era. Technical efficiency for the full sample ranges between 0.2 and 0.99. However, as the table shows, averages are rather low. The technical efficiency index averages 0.43 for the first period and 0.51 during the second. All countries display higher mean technical efficiency scores over the second period as revealed by the fourth column of the table. Technical efficiency does not correlate well with income levels, the correlation between (log) per capita GDP and efficiency is only 0.11 for the first period, although it does grow to 0.25 for the second period. In fact, the most technically efficient countries are Ecuador and Dominican Republic, which are not the wealthiest. Placing the focus on the three countries of particular interest for this report, we see distinctly different stories. Peru had the highest rise in their technical efficiency, moving from average efficiency level to the third most efficient country in the sample. While Chile was the most efficient country over the first period, its efficiency level grew the least, becoming the fourth most efficient country during the second period. Nicaragua on the other hand, is one of the least technically efficient countries in the sample, and displayed little growth of technical efficiency to remain one of the least technically efficient countries in the sample.

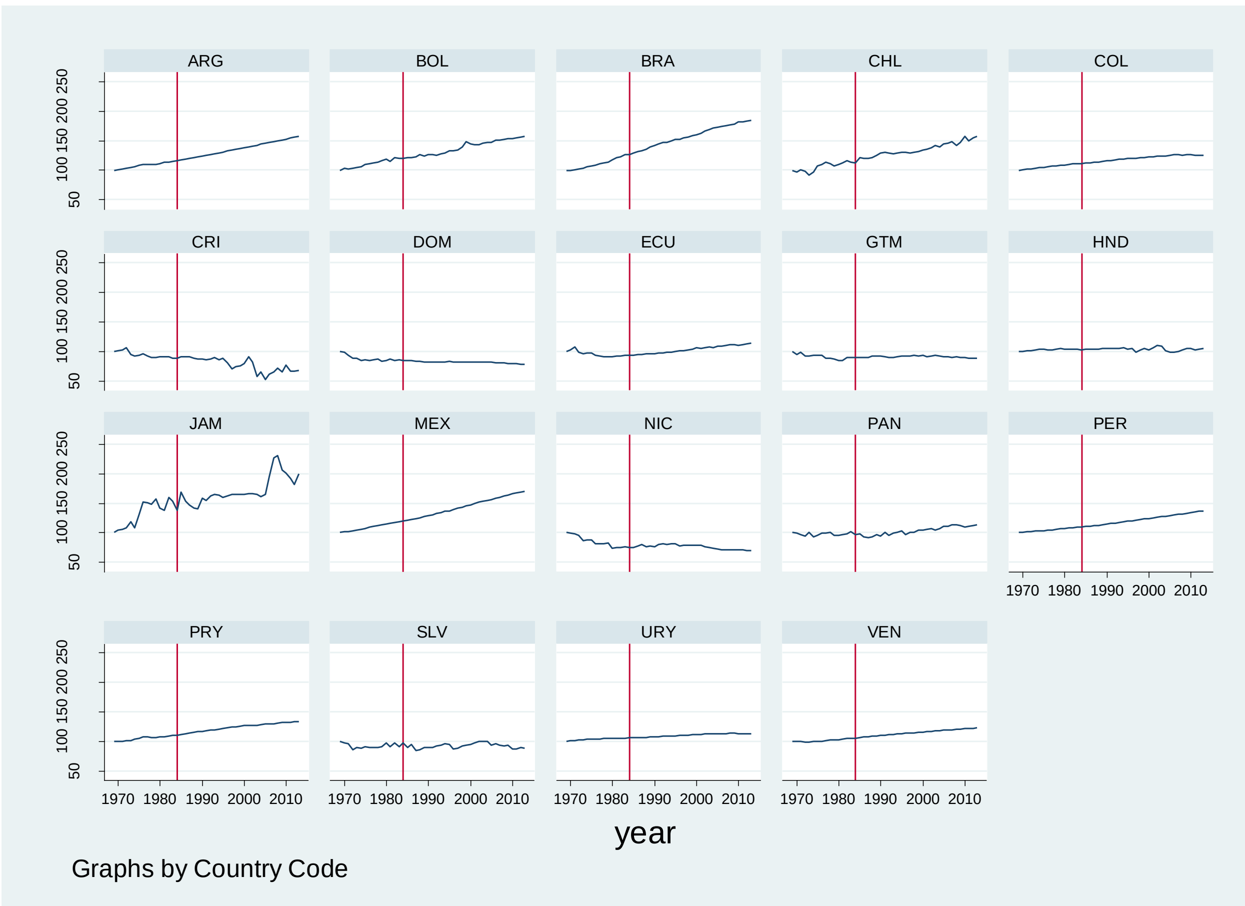
Table 6. Average Technical Efficiency by Period and Country

COUNTRY	1970-1984	1985-2013	% CHANGE
ARGENTINA	0.368	0.398	7.82
BOLIVIA	0.271	0.324	17.74
BRAZIL	0.312	0.370	17.29
CHILE	0.595	0.668	11.49
COLOMBIA	0.340	0.408	18.19
COSTA RICA	0.437	0.588	29.67
DOMINICAN REPUBLIC	0.575	0.741	25.43
ECUADOR	0.717	0.868	19.11
EL SALVADOR	0.340	0.408	18.05
GUATEMALA	0.487	0.574	16.38
HONDURAS	0.425	0.465	8.89
JAMAICA	0.541	0.584	7.75
MEXICO	0.445	0.558	22.61
NICARAGUA	0.317	0.368	14.74
PANAMA	0.430	0.458	6.18
PARAGUAY	0.374	0.388	3.75
PERU	0.492	0.673	31.21
URUGUAY	0.369	0.410	10.56
VENEZUELA, RB	0.376	0.455	19.01
TOTAL	0.432	0.511	16.70

Note: Authors' calculations.

These results can be contrasted with what is illustrated in Figure 6, that shows the evolution of the Total Factor Productivity for each country. The red line in the figures dissects each graph for the year 1984. Remember that TFP sums technical efficiency and technical change or technological progress. The graph conveys in one picture the disparate trajectories of TFP among Latin American countries. Brazil, Chile, Bolivia, and Mexico display high TFP growth over the whole period, but Central American countries in general display little TFP growth over the period. The case of Peru is special, the country transitioned from a slow to fast TFP growth country between periods. Nicaragua on the other hand, shows negative TFP growth over the period, a result of negative technical change.

Figure 6. Evolution of Total Factor Productivity by Country



Notes: Authors'calculations

Table 8 and Table 9 provide a complete accounting of agricultural production growth, by factor accumulation (separated by the six inputs included). Factor accumulation accounting requires the factor elasticities displayed in Table 7. We note that factor elasticities sum to 0.91, and constant returns to scale is rejected for the full sample. Livestock displays the highest elasticity 0.53 (proportional contribution to output), while land and fertilizers have similar elasticities of about 0.15. Table 8 and Table 9 show that on average agricultural growth was higher during the second period (1985-2013), and it is TFP growth that explains most of this jump in output growth rates.

Table 7. Estimated Input Elasticities

	ELASTICITY
AGRICULTURAL LABOR	0.060**
	(0.027)
TRACTORS	-0.002
	(0.018)
LIVESTOCK	0.529***
	(0.063)
LAND	0.134***
	(0.047)
FERTILIZERS	0.148***
	(0.011)
PESTICIDES	0.041***
	(0.006)
RETURNS TO SCALE	0.910

Notes: Standard errors in parentheses, * $p<0.10$, ** $p<0.05$, *** $p<0.01$. Constant returns to scale rejected.

Table 8. Average annual growth of agricultural production decomposed in factor accumulation and Total Factor Productivity Growth (1970 - 1984)

Country	Ag. Prod. Growth	Labor	Trac-tors	Live-stocks	Land	Ferti-lizer	Pesti-cides	Total inputs	Tech-nical Change	Tech. Eff. Change	Total TFP
Argentina	1.54	0.36	0.11	0.24	-0.03	-0.30	-0.01	0.37	0.94	0.23	1.17
Bolivia	3.08	0.45	1.40	4.33	-0.53	0.22	-0.32	5.56	-1.55	-0.93	-2.48
Brazil	3.75	-0.44	-0.76	5.00	-0.23	-1.50	-0.20	1.87	1.63	0.26	1.88
Chile	2.05	-0.76	-0.01	0.72	0.07	1.10	-0.05	1.07	0.88	0.11	0.98
Colombia	3.05	0.94	-0.21	1.70	-0.03	0.21	-0.21	2.40	0.39	0.26	0.65
Costa Rica	3.07	-0.78	-0.23	1.34	0.85	1.43	-0.26	2.36	0.48	0.23	0.71
Dominican Rep.	2.46	0.28	-0.15	1.73	-0.07	1.25	-0.79	2.25	1.01	-0.80	0.21
Ecuador	1.47	0.76	0.61	1.05	0.39	0.88	-0.09	3.59	0.78	-2.91	-2.12
El Salvador	1.87	0.05	0.54	-0.48	-0.01	0.40	-0.04	0.46	0.36	1.06	1.42
Guatemala	2.57	0.07	-0.38	1.36	-0.43	2.02	-0.14	2.51	0.04	0.03	0.06
Honduras	1.00	0.15	-1.07	1.47	0.01	0.56	-0.02	1.09	-0.04	-0.06	-0.10
Jamaica	0.86	-0.20	0.67	0.10	-0.23	-0.38	-0.63	-0.67	1.09	0.44	1.53
Mexico	3.66	0.07	-0.40	2.61	-0.05	0.31	-0.15	2.39	1.04	0.23	1.26
Nicaragua	0.65	0.43	-0.82	0.32	-0.09	2.10	2.10	4.05	-5.10	1.70	-3.40
Panama	1.35	-0.04	-0.68	0.04	0.47	0.97	0.12	0.87	0.30	0.18	0.48
Paraguay	4.34	1.32	1.16	1.13	0.58	0.31	0.00	4.51	-0.05	-0.12	-0.16
Peru	1.17	-0.11	0.03	-0.49	-0.12	0.18	0.06	-0.45	1.16	0.46	1.62
Uruguay	-0.11	-0.81	-0.03	0.16	-0.23	0.06	0.01	-0.84	0.43	0.30	0.73
Venezuela	3.01	-0.06	0.32	1.00	0.12	1.95	-0.31	3.01	0.00	0.00	0.00
Total	2.15	0.09	0.01	1.23	0.02	0.62	-0.05	1.92	0.15	0.08	0.23

Notes: Authors' calculations.

Chile based its growth during the first period on fertilizer and livestock accumulation, with technical change adding also an important portion of overall output growth. During the second period, Chile displayed the fastest TFP growth in the sample, driven by a rapid rate of technical change, which was the main contributor to growth. Among factors, it was fertilizer accumulation the factor that explains the largest share of observed growth. During both periods labor contributes negatively to growth, describing the fact that employment in agriculture has fallen. In Peru on the other hand, during the first period, a meager growth rate is explained by a small change in TFP, with factor accumulation overall contributing negatively to growth. During the second period, however, Peru is one of the top performers in the region, with both TFP and factor accumulation explaining roughly 2% each of an overall 4% growth rate. Among factors, livestock, fertilizers and pesticides, make the largest contributions to observed growth. Nicaragua, displays a completely opposite pictures for both periods. During the first period, meager growth was based in fast factor accumulation, countervailing the negative impact of a sharp fall in TFP. During the second period, the country improved agricultural output growth rates, based on relatively fast TFP growth, counterbalancing very little growth based on factor accumulation. This latter result suggests an overall low rate of investment in agriculture in the country during the period.

Table 9 Average annual growth of agricultural production decomposed in factor accumulation and Total Factor Productivity Growth (1985 - 2013)

Country	Ag. Prod. Growth	Labor	Trac-tors	Live-stocks	Land	Ferti-lizer	Pesti-cides	Total inputs	Tech-nical Change	Tech. Eff. Change	Total TFP
Argentina	2.28	-0.04	0.37	-0.06	0.34	0.74	0.12	1.46	0.70	0.11	0.81
Bolivia	3.76	0.27	0.66	1.92	-0.12	-0.61	0.13	2.25	1.12	0.39	1.51
Brazil	3.78	0.03	-0.29	1.84	0.14	0.12	-0.29	1.55	1.96	0.27	2.23
Chile	3.38	-0.20	-0.01	-0.24	0.01	1.22	-0.07	0.71	2.42	0.25	2.67
Colombia	2.26	0.04	0.00	-0.12	-0.04	0.28	0.12	0.28	1.12	0.86	1.99
Costa Rica	3.36	0.03	0.10	0.02	-0.51	1.34	0.42	1.40	1.37	0.60	1.96
Dominican Rep.	1.79	-0.23	0.00	0.07	-0.08	0.51	0.39	0.66	8.05	-6.92	1.13
Ecuador	3.26	0.32	-0.04	0.37	-0.02	0.85	-0.35	1.13	1.48	0.64	2.12
El Salvador	1.14	-0.07	-0.24	0.14	0.02	1.12	0.25	1.22	-0.04	-0.04	-0.08
Guatemala	3.91	0.25	0.34	1.49	-0.04	1.06	-0.06	3.02	0.50	0.39	0.89
Honduras	2.81	0.15	-0.14	-0.14	0.07	1.56	-0.18	1.32	1.03	0.45	1.49
Jamaica	0.89	-0.03	-0.09	0.26	-0.13	-0.77	-0.51	-1.29	1.50	0.68	2.18
Mexico	2.11	0.01	-0.36	0.08	0.00	0.07	-0.15	-0.36	2.21	0.26	2.47
Nicaragua	2.62	0.07	-0.83	0.37	-0.03	0.39	0.23	0.19	-5.65	8.08	2.43
Panama	0.99	-0.04	-0.26	-0.13	0.24	0.80	-0.23	0.38	0.48	0.14	0.61
Paraguay	3.88	0.41	0.69	0.65	0.38	1.38	0.20	3.71	0.13	0.04	0.17
Peru	3.90	0.21	0.14	0.84	-0.29	0.45	0.49	1.86	1.65	0.39	2.04
Uruguay	2.92	0.10	0.25	-0.15	-0.15	2.20	0.46	2.72	0.11	0.09	0.20
Venezuela	2.75	-0.01	0.01	0.30	0.00	0.24	-0.30	0.24	1.72	0.79	2.51
Total	2.73	0.07	0.01	0.39	-0.01	0.68	0.03	1.18	1.14	0.41	1.54

Notes: Authors' calculations.

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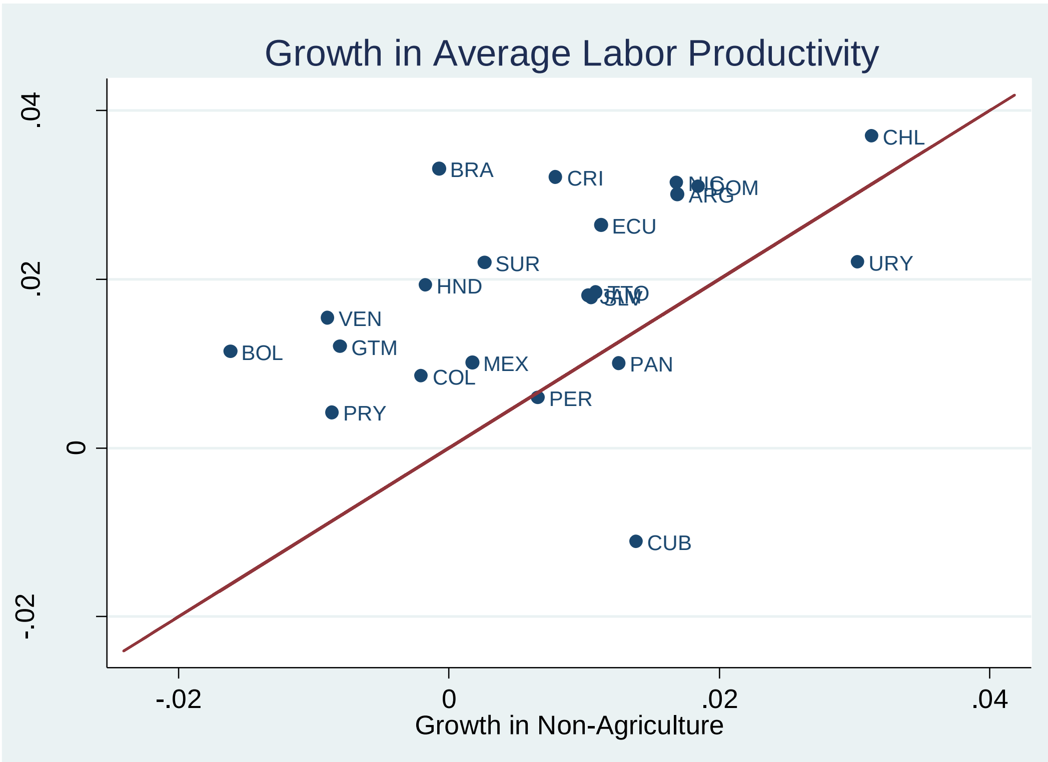
Appendix I

Figure I.1. Average labor productivity growth in Agriculture and Non Agricultural Sectors.



Appendix II

Stochastic Frontier Estimation of Agricultural Production Function

Production Function					Mean u	Var. (u)
LnX1	-3.563***	LnX2 LnX3	-0.158**	GDP per capita,	0.047**	-3.840***
	(0.600)		(0.062)	log	(0.023)	(0.785)
LnX2	1.882***	LnX2 LnX4	0.289***	Trade (% of GDP)	-0.001*	-0.002
	(0.450)		(0.044)		(0.000)	(0.022)
LnX3	-1.52	LnX2 LnX5	0.016	Life expectancy	-0.021***	-0.279**
	(1.122)		(0.019)	at birth	(0.003)	(0.140)
LnX4	-1.032	LnX2 LnX6	-0.060***	Irrigation ratio (%)	-0.075***	0.223**
	(1.277)		(0.013)		(0.006)	(0.104)
LnX5	1.039**	LnX3 LnX4	0.474***	Government exp.	-0.001	-1.199**
	(0.449)		(0.143)	Educ. (% GDP)	(0.007)	(0.508)
LnX6	0.271	LnX3 LnX5	-0.003	Time	0.002	0.111*
	(0.173)		(0.062)		(0.008)	(0.064)
LnX1 LnX1	0.086***	LnX3 LnX6	0.015	Constant	2.117***	42.648***
	(0.023)		(0.020)		(0.502)	(10.427)
LnX2 LnX2	-0.038*	LnX4 LnX5	-0.114**	σ_u	0.073	
	(0.022)		(0.046)	σ_v	0.094	
LnX3 LnX3	-0.427***	LnX4 LnX6	0.03	Log-likelihood	575.272	
	(0.136)		(0.018)	F-test p-value	0	
LnX4 LnX4	-0.506***	LnX5 LnX6	0.033***	Obs.	855	
	(0.168)		(0.008)			
LnX5 LnX5	0.076***	Time (t)	0.061*			
	(0.022)		(0.033)			
LnX6 LnX6	-0.006	Time Time	0			
	(0.007)		(0.000)			
LnX1 LnX2	-0.108***	t LnX1	0.002***			
	(0.022)		(0.001)			
LnX1 LnX3	0.445***	t LnX3	0.006***			
	(0.058)		(0.001)			
LnX1 LnX4	-0.253***	t LnX4	-0.013***			
	(0.057)		(0.004)			
LnX1 LnX5	-0.082***	t LnX5	0.006**			
	(0.018)		(0.003)			
LnX1 LnX6	-0.037***	t LnX6	0			
	(0.012)		(0.001)			
Var. (v)	-4.719***	t LnX7	0			
	(0.081)		(0.000)			
		Constant	33.528***			
			(5.337)			

Notes: Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01. Data source, World Bank, World Development Indicators. Inputs x_i, in order are: 1. Labor in agriculture, 2. tractors, 3. Livestock as stock, 4. agricultural land, 5. fertilizers, and 6. pesticides

Chapter 2. Agriculture's contribution to economic development in Chile, Nicaragua and Peru

Contents

Introduction

This chapter addresses the contribution to national development and growth of the agricultural sector, focusing on three countries: Chile, Nicaragua and Peru. The focus of attention is on the performance of the farm sectors in terms of aggregate measures of the production of agricultural commodities, the generation of rural incomes for farm and farm-worker families, and sectoral integration with the rest of the economy and international markets. While later chapters will address in greater detail the welfare consequences at the household level of the sector's performance, here we examine broad indicators of the recent transformation of the farm and food industry, such as sectoral value added, employment and trade. The question of sectoral integration in regional and world markets is particularly important, because the recent evolution of the agricultural sector and the rural economy more generally in Latin America has been influenced in major part by trends in globalization and changes in policies favorable to domestic commerce and trade.

Since the late 1980s with widespread structural reforms, market liberalization and various bi- and multilateral trade agreements, Latin American economic growth has benefited from increased trade and capital flows, both encouraging investment from domestic and international sources. In most countries, the resulting shifts in incentives facing the farm and food sectors as comparative advantages in global markets evolved – together with demographic and technological changes – produced significant shifts in the composition of production and in the demand for farm labor, land and other factors, all of which had important implications for the structure of farming and rural incomes. Certainly policy shifts, globalization and the more general transformation of the farm sector have produced both winners and losers in both the urban and rural sectors, but poverty rates overall have declined with economic growth, and rural poverty rates in particular have fallen significantly.

The three countries on which this chapter focusses are in three distinct stages of agricultural transformation and economic development. Chile, an early policy reformer, was also one of the first countries in the region to show an accelerated transformation of the agricultural and food sector toward the sophisticated and internationally-integrated model of the developed world. It was also one of the first countries to reap the benefits of market liberalization and an aggressive policy of making a series of free-trade agreements with partners from both within Latin America and beyond. These benefits have been observed in terms of not only increased per-capita agricultural and non-agricultural value added, but relatively rapid declines in the incidence of poverty, especially rural poverty. Chile's agricultural development success and sectoral transformation was marked by a rapid increase in farm exports, the exposure of domestic producers to international competition, a decline in the primary farm sector's share in national income, and a concomitant expansion of the food processing industry and its importance in the rural economy.

After a series of reforms in the 1990s, Peru began its own accelerated growth and export orientation of the farm and food sector in the late 1990s and early 2000s, although developments have conditioned on the country's specific historical and demographic situation. In fact, in terms of aggregate figures, as shown in the previous chapter, the Peruvian farm sector's share of the country's total value added has not significantly changed and its rural labor force has not notably altered, despite significant declines in rural poverty rates, trade liberalization and agriculture's shift toward international markets. This stability in the relative economic importance of primary agriculture is all the more remarkable given the high rates of economic growth of the overall economy. Nicaragua, in contrast to both Chile and Peru, has not shown – as yet – an obvious structural transformation of its agricultural sector, although the economy has grown relatively rapidly over the past two decades. Nicaraguan agriculture has grown along the rest of the economy, recently maintaining a share of national income of approximately 18 to 20 percent and the farm labor force has only slowly declined. The relative tardiness of Nicaragua's agricultural transition is obviously correlated with the country's recent difficult political history and the problems of jumpstarting a stagnated development process more generally.

For each country the following sections will address overall economic growth, poverty reduction and the evolution of other measures of economic performance, such as employment and poverty levels, and life expectancy, childhood mortality and other health indicators. Because agriculture is a heterogeneous sector, where possible we present information by geographic zones and by subsector. Then the chapter turns to a discussion of the role of agriculture in the national economies of Chile, Nicaragua and Peru. First, we review the evidence of the importance of agriculture's forward and backward links to the rest of the economy in national accounts. Then we examine econometrically the relationship between the performance of agriculture and economic growth. And finally we present an estimation of the relationship between farm labor demand and the performance of agriculture and non-agriculture to examine which sector has been driving recent labor outcomes.

A brief review of recent agricultural development trajectories of Chile, Nicaragua, and Peru

Chile

Chile has experienced relatively rapid income growth and decreases in poverty rates. Table 1 shows the progress made over the last two decades, since 1990. From a national headcount poverty rate of 38 percent, in both urban and rural areas, currently Chile has reached a nationwide incidence of poverty of 14.4 percent. Moreover, measures of the depth of poverty also fell substantially. More noteworthy and a reflection of the thoroughness of Chile's agricultural transformation, the official poverty rate in rural areas fell faster than that of urban areas, reaching approximately 11 percent by 2011 (Table 2). And both the poverty gap measure and the dispersion of incomes fell more rapidly in rural areas than urban. The reasons for this especially rapid decline in rural poverty are explored in a later chapter which address micro-level data on household income sources and employment; but in addition to the overall increases in agricultural income since 1990, two reasons for the notably more rapid decline in poverty rates in rural compared to urban areas have been the expansion of off-farm employment for small-farm families and the diversification of rural incomes out of farming and into manufacturing and services, (Soto, 2014).

Table 1. National poverty measures: Chile, 1990-2011

Poverty measure	*1990*	*1996*	*2003*	*2011*
FGT0 (Headcount)	0.383	0.231	0.186	0.144
FGT1	0.148	0.078	0.062	0.045
FGT2	0.079	0.038	0.032	0.022
Monthly per capita income[1]	134,530	182,882	200,539	247,821

Notes: Authors' calculations using CASEN National Household Surveys. 1. In 2011 Chilean Pesos.

Table 2. Rural poverty measures: Chile, 1990-2011

	1990	*1996*	*2003*	*2011*
FGT0 (Headcount)	0.387	0.303	0.199	0.108
FGT1	0.148	0.101	0.065	0.035
FGT2	0.081	0.049	0.032	0.018
Monthly per capita income	99,846	88,535	113,606	167,261
rural p.c. inc. relative to urban[1]	74%	48%	57%	67%

Notes: Authors' calculations using CASEN National Household Surveys. 1. In 2011 Chilean Pesos.

Income inequality in Chile has long been noted (Sapelli, 2011a) as being more acute than in other countries in a similar state of economic development, but measures of inequality have generally declined since 1990, as seen in Table 3. This is explained in part in the 1990s by the fact that autonomous incomes among the lower-income deciles rose faster than income among the higher deciles. In the 2000s, by contrast, much of the decline in income inequality has been due to the increase in targeted social support, (Sapelli, 2011b). Again, as in the case of poverty, measures of income inequality in rural areas have fallen more than in urban areas, and recently are overall lower in rural areas (Table 4). In fact, inequality measures began generally higher in rural areas two decades ago. For example, the Gini coefficient stood at 0.56 nationally in 1990, while the rural Gini was almost 0.6; but in 2011, the Gini for rural areas had declined to 0.475, lower than the national Gini of 0.514

Table 3. National income inequality measures: Chile, 1990-2011

Index	*1990*	*1996*	*2003*	*2011*
Coefficient of Variability	1.939	1.761	2.249	1.545
Std. deviation of logs	0.991	0.981	0.954	0.887
Gini	0.563	0.537	0.538	0.514
Theil	0.676	0.630	0.673	0.540

Notes: Authors' calculations using CASEN National Household Surveys.

Table 4. Rural income inequality measures: Chile, 1990-2011

Index	*1990*	*1996*	*2003*	*2011*
Coefficient of Variability	2.829	1.713	2.377	1.717
Std. deviation of logs	0.979	0.838	0.840	0.808
Gini	0.596	0.487	0.502	0.475
Theil	0.921	0.543	0.622	0.516

Notes: Authors' calculations using CASEN National Household Surveys.

While overall national poverty rates have declined with rising incomes and improved measures of income inequality, there remain notable differences between regions in income distributions. As Table 5 shows, in 1990 the incidence of poverty was particularly high in the regions immediately to the north and south of greater Santiago. Today these regions continue to have the highest poverty rates, although less than half of what were the rates in 1990. The bulk of the agricultural population is found in the Santiago region and the Center South, the former associated with export-oriented crops and the latter with traditional field crops and livestock grazing. Together, these two regions have over three-quarters of the national labor force, and an even higher proportion of farm families, with most small-farm families located in the Center South. Over time, average labor incomes have been consistently relatively high and unemployment rates have been consistently low in Santiago, which accounts in major part for the large metropolitan area's attraction for net immigration and population growth.

Table 5. Regional headcount poverty incidence: Chile, 1990-2011

	1990	*1996*	*2003*	*2011*
Far North	0.314	0.186	0.146	0.106
Center North	0.426	0.246	0.205	0.161
Santiago (Region)	0.327	0.146	0.130	0.114
Center South	0.439	0.326	0.249	0.180
Far South	0.308	0.170	0.130	0.074

Notes: Authors' calculations using CASEN National Household Surveys.

In addition to significant improvements in rural income and poverty rates, agriculture's share of the total labor force has been in steady decline. Table 6 shows by economic sector the share of total employment and monthly labor incomes. From 17 percent of employment in 1990, the labor force in agriculture today is below ten percent.

Labor incomes in agriculture have always been lower than in other sectors, but the ratio of average agricultural to average national labor income has fallen from about 86 percent in 1990 to 68 percent in 2011. This relative decline in average farm labor income reflects that, while wages in the rest of the economy have climbed with a shift toward a better-educated and more productive workforce, agriculture still employs a larger proportion of low-skilled workers. But these are averages across all employed in agriculture, farm-owners as well as farm employees. This illustrates that the relatively more impressive declines in rural poverty relative to urban has been due – not to a more rapid overall increase in the distribution of agricultural labor income across all income groups – but to much higher rates of increase in the incomes of the poorest in rural areas relative to urban areas.

Table 6. Share of total employment by sector: Chile, 1990-2011

	1990		1996		2003		2011	
	Share of Employ-ment	Labor Income per month	Share of Employ-ment	Labor Income per month	Share of Employ-ment	Labor Income per month	Share of Employ-ment	Labor Income per month
Agriculture	0.171	74,648	0.149	138,032	0.131	217,441	0.097	331,056
Mining	0.023	117,784	0.019	346,589	0.015	553,778	0.027	773,587
Industry	0.172	80,938	0.148	217,271	0.133	338,535	0.101	442,303
Services	0.629	91,352	0.678	247,662	0.718	362,275	0.774	497,717
1000s employed	4,431	87,215	5,356	228,800	6,004	344,224	6,918	483,747

Notes: Authors' calculations using CASEN National Household Surveys.

Table 7. Regional shares of national employment, regional monthly labor income per capita and unemployment rates: Chile, 1990-2011

	1990			1996			2003			2011		
	Share of Employ-ment	Labor Income	Unem-ployment Rate	Share of Employ-ment	Labor Income	Unem-ployment Rate	Share of Employ-ment	Labor Income	Unem-ployment Rate	Share of Employ-ment	Labor Income	Unem-ployment Rate
Far North	0.054	334,056	0.081	0.055	419,236	0.050	0.059	422,084	0.094	0.060	548,448	0.064
Center North	0.147	235,492	0.096	0.151	307,870	0.065	0.152	343,775	0.111	0.153	417,284	0.078
Santiago (Region)	0.434	295,168	0.079	0.436	461,156	0.049	0.441	547,761	0.093	0.442	561,217	0.064
Center South	0.350	235,473	0.085	0.342	276,572	0.065	0.332	335,071	0.097	0.330	394,669	0.097
Far South	0.016	280,130	0.080	0.017	363,890	0.047	0.016	473,266	0.070	0.016	565,205	0.064
Country	4,431	267,417	0.084	5,356	371,283	0.057	6,004	438,171	0.097	6,918	483,747	0.077

Notes: Authors' calculations using CASEN National Household Surveys. Income in real 2011 Chilean pesos.

Given their high correlation with other measures of household welfare, income levels and poverty rates are likely the most important measures of development. Nevertheless, other indicators are useful to gauge the multidimensional impacts of development on welfare. We focus here on measures of health outcomes for which we have data. As shown in Table 8 since 1990 child mortality rates have fallen by half, from 19 per 1000 live births to about 8 in 2011. Life expectancy has risen almost eight years over the same period. The rates of severe infant stunting and infant wasting were already relatively low by the mid-1990s and have fallen slightly since. With respect to health access, two indicators are shown in Table 9. Chilean rural areas have lower rates of adult dental care (in the last six months) than the national average, and these rates have not changed significantly since 1990. Access to the Pap test for women, however, has increased significantly over the same period, with rural and national rates appearing almost equal in the latest period for which we have data.

Table 8. Chile: Health Indicators

Indicator	1990	1996	2003	2011	2015
Child mortality (per 1000 < 5 yr)	19.1	12.5	9.5	8.7	8.1
Life expectancy	72.7	75.2	77.9	80.6	-
Infants stunted (% <5 years)	-	0.7	0.6	0.5	-
Infants wasted (% < 5 years)	-	0.5	0.5	0.3	-

Note: From WHO data sources.

Table 9. Chile: Health Access Indicators

	National				Rural			
	1990	1996	2003	2011	1990	1996	2003	2011
Older than 15 and received dental care last 6 months	0.184	0.127	0.194	NA	0.112	0.068	0.114	NA
Female older than 15 took Pap test last 3 yrs.	0.394	0.512	0.515	0.555	0.355	0.472	0.534	0.566

Note: Prepared by authors using CASEN surveys.

Nicaragua

Economic growth in Nicaragua has been relatively rapid since the mid-1990s and, despite an abrupt slow-down during the 2008-2009 period, national income has increased at rates above the regional average. The government has maintained macroeconomic policy discipline, and the country has increased exports and attracted foreign investments. Since the year 2010, overall economic growth has averaged above 4 percent, and poverty rates have fallen significantly since the mid-2000s. Table 8 shows the decline in poverty since 2005, when the national headcount poverty rate stood at 48 percent. More recently the poverty rate has fallen below 30 percent. Extreme poverty fell from about 15 percent to 8 percent. The country's rural poverty rate has always been notably higher than the urban poverty rate, but it too has declined significantly from 70 percent in 2005 to 50 in 2013. Nicaragua's rural poor people are for the most part located in the higher-density, central region of the country.

Measures of the depth of poverty also fell substantially in Nicaragua, both nationally and in rural areas, especially since 2009 (Table 9). The relative decline in rural poverty measures, however, has been less than the national measures, suggesting that income gains among low-income groups associated with economic growth have been relatively greater in urban areas. Nevertheless, both the poverty gap measure and the dispersion of incomes fell notably more in rural areas than urban. And the rural per-capita consumption measure relative to the national has remained steady since 2005. In 2013 the yearly per-capita consumption expenditures were 65 percent of the national estimate, essentially unchanged from the ratio of rural-to-national expenditure of 64 percent in 2005.

Table 10. National poverty measures: Nicaragua, 2005-2013

	2005	***2009***	***2013***
FGT0 (Headcount)	0.483	0.425	0.296
FGT1	0.173	0.141	0.081
FGT2	0.082	0.063	0.032
Per Capita Consumption Nominal ($C/year)	10,095	16,906	31,674

Notes: Authors' calculations using EMNV National Household Surveys

Table 11. Rural poverty measures: Nicaragua, 2005-2013

	2005	***2009***	***2013***
FGT0 (Headcount)	0.703	0.633	0.501
FGT1	0.281	0.232	0.150
FGT2	0.141	0.111	0.062
Per Capita Consumption ($C 2013)	12,815	14,888	20,659
Rural Consumption / Urban Consumption %	64.4	67.3	65.2

Notes: Authors' calculations using EMNV National Household Surveys

Income and consumption inequality measures in Nicaragua are in the middle range of country estimates, and less than its Central American neighbors, some of which report significantly higher Gini coefficients. Nicaragua's consumption inequality at the national level has declined with growth, as seen in Table 10. The high proportion of the rural population in poverty and the concentration of wealthier families in urban areas explain the relatively low measures of consumption inequality in 2005 and 2013, as shown in Table 11. Notably, however, during the downturn year of 2009, the measures of consumption inequality in rural areas jumped above those of urban areas, highlighting that the economic disruptions that occurred in that year had a disparate impact across income groups.

Table 12. National consumption inequality measures: Nicaragua, 2005-2013

	2005	***2009***	***2013***
Coefficient of Variability	0.901	0.835	0.961
Std. deviation of logs	0.728	0.727	0.616
Gini	0.415	0.399	0.365
Theil	0.299	0.273	0.264

Notes: Authors' calculations using EMNV National Household Surveys

Table 13. Rural consumption inequality measures: Nicaragua, 2005-2013

	2005	2009	2013
Coefficient of Variability	0.727	1.101	0.543
Std. deviation of logs	0.560	0.738	0.528
Gini	0.326	0.455	0.286
Theil	0.191	0.391	0.133

Notes: Authors' calculations using EMNV National Household Surveys

As in the case of Chile, in Nicaragua there remain notable differences between regions in income distributions and poverty levels, although national poverty rates have declined with rising incomes and reduced inequality measures (Table 12 and Table 13). In the mid-2000s, the incidence of poverty was particularly high in the central and Atlantic zones; and rural poverty was even worse, reaching over three-quarters of the rural population. While the Managua region had the highest income levels, nevertheless a fifth of the population fell below the poverty line in 2005. By 2013, poverty rates in Managua had fallen to just below 12 percent. The incidence of poverty in the central zone and the Atlantic plains also fell significantly, in both urban and rural areas, especially in the Atlantic zone. Poverty rates in rural areas, however, remain elevated in all regions, particularly in the central highlands, where poverty rates in rural areas is 60 percent.

Table 14. Regional headcount poverty incidence: Nicaragua, 2005-2013, all households

	2005	***2009***	***2013***
Managua	0.212	0.225	0.116
Pacífico	0.478	0.392	0.185
Central	0.625	0.536	0.444
Atlántico	0.645	0.580	0.390

Notes: Authors' calculations using EMNV National Household Surveys

Table 15. Regional headcount poverty incidence: Nicaragua, 2005-2013, rural household

	2005	2009	2013
Managua	0.354	0.335	0.205
Pacífico	0.615	0.548	0.315
Central	0.768	0.688	0.604
Atlántico	0.766	0.688	0.482

Notes: Authors' calculations using EMNV National Household Surveys

As seen in Table 14, despite significant development in terms of national income and reduced poverty rates, agriculture's share of the total labor force still remains relatively high and has fallen only a few percentage points over the last decade. From 36 percent of employment in 2005, Nicaragua's labor force in agriculture today is 32 percent. As in other developing countries, labor incomes in agriculture are significantly lower than in other sectors, but the ratio of average agricultural to average national labor income has *increased* from about 70 percent in 2005 to 74 percent in 2014. Relative to labor income in the services sector, agricultural incomes have increased from about 56 percent to 64 percent. Table 15 shows the regional distribution of the labor force, average monthly labor incomes, and unemployment rates. Where agricultural employment is relatively more concentrated

– the central and Atlantic zones – labor incomes were the lowest in 2005, but unemployment rates were low, unsurprising in regions where farming provides a large proportion of employment opportunities. The share of employment in these comparatively poorer regions grew significantly from 2005 to 2014, from 43 percent to 52 percent. By 2014, the central highlands remained the poorest region in terms of labor income, but the average labor income in the Atlantic region exceeded the national average.

Table 16. Share of total employment by sector: Nicaragua, 2005-2014

	2005		2009		2014	
	Share of Employment	Labor Income (nominal)	Share of Employment	Labor Income	Share of Employment	Labor Income (nominal)*
Agriculture	0.356	8,515	0.352	11,025	0.321	21,288
Mining	0.004	9,339	0.005	18,344	0.007	58,692
Industry	0.141	10,656	0.111	18,535	0.113	29,678
Services	0.499	15,303	0.527	24,056	0.550	33,368
1000s employed	2,103	12,209	2,315	18,772	2,745	28,952

*/preliminary

Table 17. Regional shares of national employment, regional monthly labor income per capita and unemployment rates: Nicaragua, 2005-2014

	2005			2009			2014		
	Share of Employ-ment	Labor Income (nominal)	Unem-ployment Rate	Share of Employ-ment	Labor Income (nominal)	Unem-ployment Rate	Share of Employ-ment	Labor Income (nominal)*	Unem-ployment Rate
Managua	0.255	15,967	0.065	0.244	25,106	0.090	0.243	40,619	0.063
Pacífico	0.301	12,559	0.043	0.298	19,184	0.068	0.239	26,715	0.049
Central	0.317	10,005	0.022	0.319	15,137	0.037	0.354	21,906	0.035
Atlántico	0.127	9,328	0.013	0.139	15,094	0.016	0.164	30,112	0.021
Country	2,103	12,209	0.039	2,315	18,772	0.057	2,745	28,952	0.043

Notes: Authors' calculations using EMNV National Household Surveys

Peru

Since significant policy reforms, Peru has experienced relatively rapid economic growth yearly rates, averaging above 5 percent for several years. With this growth, poverty rates have fallen significantly since 2005 from 56 percent to 23 percent recently (Table 16). The rates of extreme poverty have decreased even more notably, from 16 percent to 4 percent during the past decade. Peru's rural poverty in 2005 stood at slightly over 69 percent of the rural population, and remains significantly higher than the national poverty rate. Nevertheless it has declined to 46. Extreme poverty rates in rural areas have also fallen significantly from 38 percent (more than half the rural poor) in 2005 to 15 percent (less than a third of the rural poor) in 2014. While incomes in urban and rural areas have grown with economic development, urban areas have shown a faster decline in the incidence of poverty than rural areas. The rural poverty rate a decade ago was 25 percent higher than the urban rate; today the rural poverty rate is double that of urban areas. Nevertheless, Peru has shown impressive gains in welfare measures in both urban and rural areas, much like Chile experienced from the mid-1980s to the late-1990s.

Table 18. National and rural poverty measures: Peru, 2005-2014

National	2005	2010	2014
Poor	0.556	0.308	0.227
Extremely poor	0.158	0.076	0.043
Rural	2005	2010	2014
Poor	0.693	0.610	0.460
Extremely poor	0.379	0.238	0.146

Notes: Authors' calculations using ENAHO National surveys.

Peru's income and consumption inequality measures were in the higher range of country estimates in 2005, comparable to its neighbor, Chile. The consumption and income Gini coefficients at the national level have declined notably with growth over the last decade, as seen in Table 17.

Table 19. National consumption inequality measures: Nicaragua, 2005-2013

	2005	2010	2014
Expenditure Gini	0.435	0.392	0.369
Income Gini	0.52	0.46	0.44

Notes: Authors' calculations using ENAHO National surveys.

Peru also exhibits significant differences between regions in income distributions, poverty rates, and extreme poverty. With the decline in national poverty rates, all major regions have also experienced a decrease in the incidence of poverty and income inequality, as seen in Table 18 and Table 19. In the mid-2000s, the incidence of poverty was particularly high in the north and center mountain regions and in the eastern, forest zone, reaching over 70 percent of the populations in those areas. The incidence of extreme poverty was also high in these regions. The central coastal region showed the greatest relative prosperity, although poverty rates reach 36 percent. With rapid economic development, poverty rates have fallen throughout the country, especially along the Pacific coast and the central mountain region. Extreme poverty has also fallen dramatically, although extreme poverty rates remain at about a fifth of the population living in the northern mountain regions. On the Pacific center and southern coast, including the Lima metropolitan area, extreme poverty rates have fallen to near zero. In terms of poverty rates, today the most worrisome regions are in the mountains and beyond in the eastern, forested areas. These are also the regions in which average per capita incomes are significantly lower than the national average and where income inequality measures exceed the national Gini.

Table 20. Regional headcount poverty incidence: Peru, 2005-2014

	2005		***2010***		***2014***	
Zone	**Poverty**	**Extreme**	**Poverty**	**Extreme**	**Poverty**	**Extreme**
North coast	0.53	0.07	0.31	0.03	0.23	0.03
Center coast	0.36	0.01	0.15	0.00	0.09	0.00
South coast	0.40	0.03	0.14	0.01	0.10	0.00
North mountain	0.78	0.40	0.63	0.28	0.54	0.21
Center mountain	0.72	0.33	0.42	0.13	0.35	0.09
South mountain	0.58	0.24	0.40	0.12	0.23	0.04
East	0.70	0.25	0.40	0.13	0.30	0.06
Lima metro area	0.42	0.03	0.16	0.01	0.12	0.00
National	0.56	0.16	0.31	0.08	0.23	0.04

Notes: Authors' calculations using ENAHO National surveys.

Table 21. Regional per capita monthly incomes and Gini coefficient: Peru, 2005-2014

	2005		***2010***		***2014***	
Zone	**Income Monthly p.c.**	**Gini**	**Income Monthly p.c.**	**Gini**	**Income Monthly p.c.**	**Gini**
North coast	478	0.415	647	0.389	735	0.381
Center coast	576	0.377	750	0.353	798	0.306
South coast	606	0.401	945	0.433	992	0.382
North mountain	267	0.495	384	0.525	439	0.474
Center mountain	345	0.500	510	0.461	535	0.438
South mountain	387	0.500	545	0.467	682	0.445
East	339	0.448	578	0.453	623	0.440
Lima metro area	964	0.498	1128	0.415	1280	0.390
National	571	0.520	754	0.464	849	0.441

Notes: Authors' calculations using ENAHO National surveys. Income figures in 2014 Nuevos Soles.

As seen in Table 20, with rapid economic development, Peruvian agriculture's share of the total labor force has fallen over the last decade, from about 32 percent to a still high 25 percent recently. Labor incomes in agriculture in 2005 were 36 percent of the national average, but grew more rapidly than other sectors so that by 2014 had increased to 45 percent of the national average. Relative to labor income in the services sector, agricultural incomes have increased from about 33 percent to 44 percent. The regional distribution of the labor force is shown in Table 21, along with average monthly labor incomes, and unemployment rates. Over two-fifths of the agricultural labor force is located in the highland/mountain regions (about 46 percent) and another fifth is located in in the forest regions to the east. About one-third of the farm labor force is distributed on the Pacific coast. In addition, about 58 percent of agricultural land is in the highlands. So it is not surprising that, as in Nicaragua, where agricultural employment is relatively more concentrated, labor incomes tend also to be lowest. Again, as elsewhere, in Peru's regions where farming provides a large proportion of employment opportunities, unemployment rates are lower than the national average. Over the last decade, in these regions, more dependent on agriculture and relatively poorer, their share of national employment fell slightly, as did the labor-force share of all other regions, except metropolitan Lima.

Table 22. Share of national employment, regional monthly labor income per capita and unemployment rates by sector: Peru, 2005-2014

	Share of employment			Labor Income (soles 2014)			Unemployment rate		
	2005	*2010*	*2014*	*2005*	*2010*	*2014*	*2005*	*2010*	*2014*
Agriculture	32.04	25.42	25.31	347	440	578	1.0%	0.7%	0.7%
Mining	0.58	0.49	0.52	825	1464	1325	10.2%	2.7%	2.1%
Industry	9.18	10.18	9.32	1238	1310	1415	7.1%	3.7%	3.6%
Services	58.19	63.92	64.84	1038	1213	1340	7.3%	5.3%	4.5%
All	100	100	100	962	1149	1273	5.3%	4.0%	3.5%

Notes: Authors' calculations using ENAHO National surveys.

Table 23. Regional shares of national employment, regional monthly labor income per capita and unemployment rates: Peru, 2005-2014

	Share of employment			Labor Income (soles 2014)			Unemployment rate		
Zone	*2005*	*2010*	*2014*	*2005*	*2010*	*2014*	*2005*	*2010*	*2014*
North coast	14.3	14.2	13.9	741	951	1021	6.1%	4.2%	3.8%
Center coast	6.6	6.4	6.7	888	968	1110	5.3%	4.7%	3.4%
South coast	2.2	2.0	2.1	784	1165	1232	6.9%	5.6%	3.6%
North mountain	7.8	6.8	6.3	676	870	938	0.9%	1.6%	1.8%
Center mountain	13.8	12.7	13.1	789	886	984	3.0%	3.2%	2.2%
South mountain	15.6	14.6	15.1	737	993	1193	3.9%	2.6%	3.0%
East	13.1	12.6	12.4	682	896	984	2.7%	2.2%	2.4%
Lima metro area	26.7	30.7	30.5	1323	1439	1563	8.2%	5.5%	4.7%
National	100	100	100	962	1149	1273	5.1%	3.9%	3.4%

Notes: Authors' calculations using ENAHO National surveys.

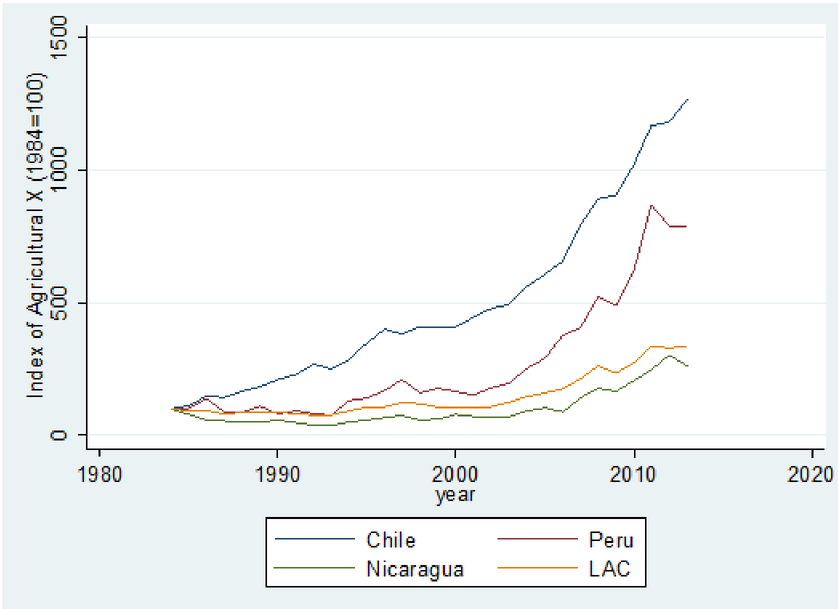
The role of agriculture in the national economy

The evolution of the sector's importance in international trade

The data since the mid-1980s demonstrate that foreign trade in agricultural and food products has grown in importance for the farm sector across the Latin America and the Caribbean region. As noted previously, exposure to world markets, via unilateral border policy reforms and trade agreements, has played a significant role in altering incentives facing farmers and investors, encouraging shifts in the scale and composition of farm production. The consequent changes in farming techniques, cropping patterns and downstream activities have had impacts on the use of inputs, especially on the demand for farm labor. International trade has been a major driver in the agricultural transformation experienced in the region, and the growth of the value of trade in turn has been a notable outcome of that transformation.

As Figure 1 makes clear, the regional index of the real value of international commerce in agricultural and food products did not take off until after policy major reforms began to be implemented across many LAC countries starting in the mid-1980s. Since the early 1990s, farm and food sector exports from countries in the region have more than tripled in real value. With respect to trade performance, however, the region is heterogeneous, with some countries, such as Chile and Peru, experiencing extremely high rates of growth in real value of exports. Chile, which had implemented structural, trade, and sectoral policy reforms comparatively early, began to increase exports several years before the rest of the region. Today, the real value of Chile's agricultural and food exports is over 12 times the value of the mid-1980s. The evolution of Peru's exports matched that of the region taken as a whole, until the period of significant policy reforms, and thereafter the country's value of farm and food exports have grown more rapidly than that of Chile. By contrast, Nicaragua's exports declined slightly and stagnated, underperforming the region as a whole, until the mid-2000s. Since the mid-2000s, however, the country's export performance has been very rapid. Nevertheless, it should be noted that today the accumulated growth since the mid-1980s in the real value of farm exports of Nicaragua is approximately what Peru had already attained nearly a decade earlier, and what Chile had attained two decades earlier.

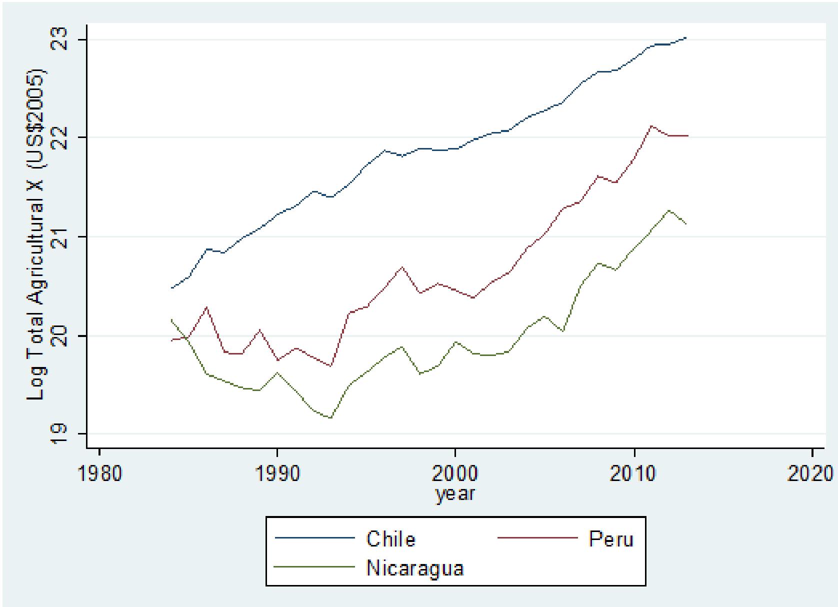
Figure 1. Index of the real value of exports of agricultural and food products from Chile, Nicaragua, Peru and the LAC region, 1984-2013.



Source: Authors' calculations from FAOSTAT.

To put the absolute level of the value agricultural and food exports into context, Figure 2 shows the evolution of the *natural log* of the value of sectoral exports over the same period, 1984-2013. Note that Chile's value of exports has been significant relative to the country's size for several decades; and moreover that the growth in export value has been at a very steady rate since the mid-1980s, perhaps slowing somewhat after 1996 only to accelerate to previous growth rates in the mid-2000s. The absolute value of farm and food exports from Chile's larger neighbor, Peru, has been gaining on Chile since the early 2000s. Nicaragua's farm export decline and stagnation during the period roughly spanning 1985-1995 is clear. But beginning in the mid-2000s, the value of exports Nicaragua has been growing at a high average rate approximately that of Peru. And in terms of population, to Nicaragua (about one-fifth the population of Peru) the level of farm and food exports is relatively much more important.

Figure 2. Log of real value of exports of agricultural and food products from Chile, Nicaragua and Peru, 1985-2015.

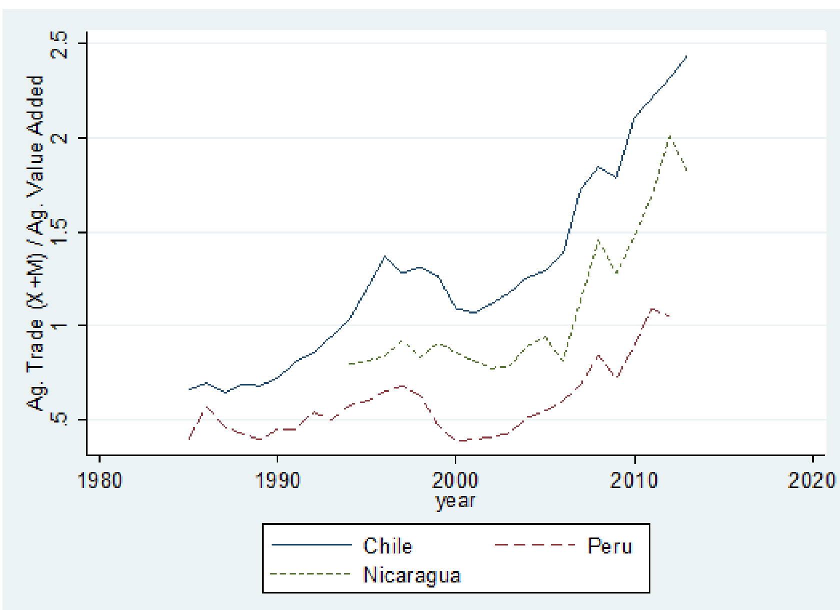


Source: Authors' calculations based on FAOSTAT.

To highlight the rise of the importance for the farm and food sector's international trade, Figure 3 interest. Trade openness is an indicator of both trade policy and the response of both the farm and food sector and consumers to the trade policy environment. Trade openness is evaluated using the sum of exports and imports of agricultural and food products relative to the net income generated by the sector as measured by sectoral value added. In the case of many Latin American countries, the agricultural transformation seen over the last two decades has resulted in the growth of both agricultural exports and food imports. This is, of course, due to a combination, first, of countries' finding their comparative advantages and importing goods that would have been home-grown, and, second, of rising incomes that lead to higher demand for food products generally. In the case of Chile, for example, the country shifted resources from traditional cereal crops and beef to export-oriented fruits and horticultures, and intensive poultry and pork production (and, perhaps surprisingly, dairy). As incomes increase, food and feed grain and beef imports grew, along with imports of higher-value foods, such as European cheeses, hams, processed products, and off-season citrus from the United States.

As Figure 3 indicates the trade openness of Chile has increased by over three times since the mid-1980s. In the mid-1990s, Chile began to export and import more farm and food products than the agricultural sector generated in net income. Today, trade value is nearly 2.5 times the sector's net income. Note also the radical change in the trade openness index of Nicaragua since the mid-2000s. Even prior to the shift in the index, Nicaragua had a relatively high degree of trade value relative to sectoral income. In part this is due to Nicaragua being a relatively small country in terms of population, but also the nature of Nicaragua's natural resource base has given it a comparative advantage in beef and coffee. Peru's trade openness index, by contrast, has had a relatively low trade openness index, due in part to the country's size. Only very recently has the total value of exports and imports risen above net sectoral income. If the Chilean pattern holds, however, Peru's agricultural trade openness index should continue its present high-growth trajectory.

Figure 3. Farm and food trade openness index, Chile, Nicaragua and Peru, 1985-2015.



Source: Author's calculations from FAOSTAT.

The forward and backward links of agriculture in national accounts[1]

The agricultural sector is intertwined with other sectors of the economy, contributing intermediate inputs to the food processing industry and in its turn purchasing inputs for farm production. With development, the agricultural sector becomes more closely integrated with the rest of the economy even as the size of the primary sector declines relatively. As the transformation of the sector progresses, the apparent size of primary agriculture (activities directly related to crops and livestock) as measured by national accounts decreases in relative terms, often leading to the popular perception that farming is in decline. Official measures of agricultural income, however, are an indicator of primary activities on the farm, and not activities beyond the farm gate, the income from which would be attributed to other, non-agricultural sectors. Selection, packing, processing and other activities, if done off-farm, are counted in manufacturing and the workers would be considered non-farm employees. With development and the increasing sophistication of the food sector, various important rural activities are taken off the farm and out of the primary agriculture column in national accounts and classified as manufactures. Moreover, many activities that produce intermediate inputs for farming – fertilizers, energy and traction, some machinery and labor services, etc. – which were formerly on-farm activities, are now provided by non-agricultural sectors. In short, simply as a matter of accounting definitions, the more sophisticated and specialized actors become, and the more important agriculture becomes to the rest of the economy, the smaller the farm sector appears to be in comparison.

Over the last several decades evidence has accumulated that agricultural growth has significant spillover effects that impact other sectors, effects that go beyond the farm sector's direct contribution to GDP. Quantitative research demonstrates that the growth of agricultural production in much of Latin America has had significantly positive impacts on employment, the labor income of unskilled workers and poverty, and the performance of the non-agricultural economy e.g., (Anríquez and López, 2007; Bravo-Ortega and Lederman,

[1] This section relies on an approach presented for Chile in (Foster and Valdés, 2015), based on (Anríquez et al., 2005). It was recently applied to Nicaragua and reported in (World Bank, 2015).

2005; Byerlee et al., 2008; de Ferranti et al., 2005). In the following sections, we discuss measures of primary agriculture's effect on the rest of the economy using two approaches. First, we present measures from national accounts of the forward and backward links of the farm sector to other sectors, and estimates of an "expanded agricultural value added." This accounting approach gives a snapshot of the degree to which agriculture is integrated with and supports other national productive sectors. Second, in the following section, we investigate econometrically the role of the agricultural sector in influencing the growth of the non-agricultural sector, and vice versa, using panel data of sectoral value-added in Latin America and the Caribbean. We present an econometric analysis of the effects of the farm sector's value-added growth on employment for the three countries of focus in this study, Chile, Nicaragua, and Peru.

Information from national accounts permits the disaggregation of the destination of an economic sector's products or services between intermediate consumption and final demand, comprising household consumption, government and foreign buyers (exports), and a part used in investment. In the case of intermediate consumption, the sector's product is used as an input for the same sector and others sectors. In the case of primary agriculture, intermediate consumption by secondary industry is both often physically close geographically in rural areas, and often something that would have been done on the farm itself in the past. For example, consider three non-primary activities usually closely associated with agriculture and which have a significant degree of backward linkage to the primary farm sector: milk and meat processing and winemaking. In national accounts these sectors or activities would be classified as manufacturing, if done off farm, and so not counted in agricultural value added. Nevertheless, inputs coming from the primary sector usually make up a significant share of industry costs, and these processing sectors would very likely not exist without local, primary production of livestock and grapes. Moreover, these secondary sectors are commonly and very reasonably assumed to be part of the agricultural and rural economy for analytical and policy purposes. There are obviously conceptual differences between the perspective usually adopted by agricultural policy analysts and the accounting system used in official statistics.

Although one might be tempted – when attempting to assess the "true" importance of agriculture – to attribute to the farm sector the entire value added of related sectors. But simply summing the value added of closely-related activities would likely exaggerate the role of *domestic* agriculture. A secondary sector's value added could be attributable to contributions from multiple sectors, and imported agricultural products in some cases (such as grains) could substitute for domestic sources. An alternative to a simple sum to estimate the linkages of agriculture to the rest of the economy is to weight of the participation of the domestic primary sector in the value added of other sectors. One can calculate an appropriate fraction of the value added of each sector and add it to that of primary agriculture. One method is to take the proportion "claimed" by the farm sector from the dependence that each sector has on agriculture as input or as destination of sales. Following the approach detailed in (Foster and Valdés, 2015), an "expanded value-added" measure for agriculture would be the sum of the national accounts' value added, VA, plus a proportion of the value added of related industries, where F represents the "strength" of the linkage ($0 \le F < 1$): $VA_{\text{Ag expanded}} = VA_{\text{Ag}} + F \cdot VA_{\text{others}}$. This sector-specific proportion for a particular forward-linked sector (such as grain milling or meat production) depends on the share of the domestic farm sector's product in the forward-linked sector's intermediate input costs. For a particular backward-linked sector (such as fertilizers or animal feed), the proportion depends on the share of that sector's total intermediate sales to primary agriculture. The exact formulae for this calculation are given in the appendix.

Chile

Table 22 presents the results of this calculation of the forward and backward linkages of the farm sector as reported in (Foster and Valdés, 2015) for Chile. Four reference years for the national accounts were available (1986, 1996, 2003 and 2008). With economic development, the country's share of income deriving from the primary agricultural sector declines, and in the case of Chile the sectors contribution to total value added fell by two-third between 1986 and 2008, while nevertheless growing significantly in absolute real-dollar terms. The sector became more specialized and integrated with other sectors through greater use of intermediate inputs, although it grew rapidly in terms of the value of production and income generation. The overall trend has contributed in major part to an increased efficiency of the sector, due to the more integrated sector’s requirement of fewer land and labor resources to generate its own inputs (e.g., "horsepower" from horses and oxen now replaced by tractors and fuel). This transformation of Chilean agriculture has released land and agricultural labor for production destined for sales to other sectors and for export. Simultaneously with this increased specialization and integration, the rest of the economy also grew rapidly, both factors leading to a decline in primary agriculture’s official share in national income from 7.5 percent in 1986 to 2.5 percent in 2008, where it approximately remains today.

The size of forward linkages has declined from 2.2 percent to 1.69 percent of total national value added, due primarily to rapid economic growth in the rest of the economy. But note that these forward links, which represented about 30 percent of the official value added of agriculture in 1986, now represent 67 percent. And while backward links as a percentage of national income have declined, they now represent 22 percent of agricultural value added, whereas in 1986 only 9 percent of farm sector value added. By including backward and forward linkages the size of the sector increases by over 80 percent, to 4.8 percent of total value added. Including the primary forestry sector, which is important in Chile, backward and forward links would lift the forestry and agricultural value added from 3.4 percent to 5.4 percent, an increase of almost 60 percent increase. Adding Chilean aquaculture and fisheries, which are also significant primary sectors, to forestry and agriculture would produce the renewable resource sector as a whole. With backward and forward linkages, this renewable resource sector would represent 6.4 percent of national income. Certainly in the case of Chile, and very likely most other middle and high income countries, the largest proportion of the expansion of GDP comes from forward linkages.

Table 24. Value added of the sector (current prices) agriculture and its linkages, 1986, 1996, 2003 and 2008: value added as a share of national income

Year	Value-added agriculture %	Value of forward linkages %	Value of backward linkages %	Total %
1986	7.49	2.22	0.71	10.42
1996	3.72	2.09	0.78	6.59
2003	3.07	1.42	0.73	5.21
2008	2.53	1.69	0.55	4.78

Source: Calculated by the authors (Central Bank data) figures for 2003, and figures for 1986 and 1996 in Table 1 Anríquez, Foster and Valdes, 2005. Total represents the percentage of this component in the total VA of the economy.

Nicaragua

Applying this same methodology to Nicaragua's 2006 national accounts, the World Bank recently found that the expanded agricultural value added rises from the official estimate of 17.5 percent to 22.5 percent of total VA, (World Bank, 2015). The primary sector in Nicaragua comprises coffee, sugar, live animals, forestry, fishery, and basic grains. The estimate grows to over 27 percent of national income, if to this basic primary sector is added meat production, sugar, dairy, and other food industries, tobacco, and wood products. That is, over a quarter of national income can be considered strongly linked to the primary sector and closely-related sectors dependent on the primary sector for inputs. Clearly, in the case of Nicaragua, much less economically developed than Chile, deceleration or acceleration of growth of agriculture would significantly affect growth in the rest of the economy to a greater degree than the official statistics of agriculture's value added of 17.5 percent would suggest.

Table 25. Value added of the sector (current prices) agriculture and its linkages in Nicaragua, 1994 - 2007: value added as a share of national income

Year	Value-added agriculture %	Value of forward linkages %	Value of backward linkages %	Total %
2006	17.48	4.11	0.93	22.52

Source: From (World Bank, 2015).

Peru

Peru's agricultural sector's relative size compares to Chile's a decade earlier. This comparison is useful, because it shows how remarkable is Peru's forward links, both in terms of size and its growing importance (see Table 24). This forward linkages highlight how agriculture is well connected with sector's that are important in the Peruvian economy like the restaurant and hospitality industry. However, like Nicaragua, Peru displays low relative size of backward linkages compared to Chile. A detailed analysis of the Chilean case in (Foster and Valdés, 2015), shows that the sector that has the highest value of backward links are agricultural support services industry. These sectors will likely develop in Peru as agriculture grows in value and sophistication.

Table 26. Value added of the sector (current prices) agriculture and its linkages in Peru, 1994 - 2007: value added as a share of national income

Year	Value-added agriculture %	Value of forward linkages %	Value of backward linkages %	Total %
1994	8.31	2.20	0.67	11.17
2007	6.51	2.95	0.29	9.74

Source: Calculated by the authors using data from INEI. The Peruvian intermediate use matrix for 2007 has not been prepared for national and imported inputs, so in that year we use for all sectors a constant for national share of inputs equal to the share of total supply that is national production. This choice likely leads to an underestimation of forward and backward linkages, because it is expected that the share of imported goods in final demand to be larger than in intermediate consumption. See formula details in Appendix I.

The relationship between the performance of agriculture and economic growth

In order to better understand the driving forces behind the patterns of development discussed above and in the previous chapter, we turn to an econometric investigation of the role of the agricultural sector in influencing the growth of the non-agricultural sector, and vice versa, using the WDI's sectoral value-added data for 24 countries in Latin America and the Caribbean since 1960. The measures of performance of both sectors are their incomes (value added), and in particular the question of interest is the relationship between sectoral income growth and the size of the two sectors. Do higher levels of one sector's income impact growth rates of the other sector, and if so, do they lead to faster or slower growth rates of the other sector? The econometric approach here follows the spirit of Granger causality tests (Granger, 1969)[2]: We posit a model where the growth rate of sector i (i = A for agriculture and N for non-agriculture) in country c in period t, $\Delta\ln V_{ict}$, is dependent on the lagged levels of both sectors' incomes, $\ln V_{Act-1}$ and $\ln V_{Nct-1}$. In addition, we add country and year dummies, X_{ct} , to account for country-specific effects and year-specific common shocks. The basic regression model is

$$\Delta\ln V_{ict} = \alpha + \beta_A \ln V_{Act-1} + \beta_N \ln V_{Nct-1} + \gamma_i X_{ct} + \epsilon_{ict} \quad i = A \text{ and } N$$

We are interested in the sign and statistical significance of the coefficients β_A and β_N. As in other dynamic growth models, due to the construction of the dynamic equation above, the endogeneity of the two explanatory variables of interest invites the use of instruments. As non-agricultural and agricultural value-added are national accounting constructs they are inevitably linked (endogenous to each other). Agricultural growth, through its input-output links pulls non-agricultural growth, and vice-versa. Also, the lag of the same variable, through standard time-series autocorrelation processes usually suffers from endogeneity. An instrumental variable approach, could be developed through a two-stage procedure by pre-estimating output, with a production function or another economic relationship. However, these are intensive in data that is not readily available, like capital stocks in agriculture. A different approach is to use the instruments that the time-series dataset offers. We adopt here the Arellano-Bond approach to dynamic panel-data using the GMM "system estimator" proposed in (Blundell and Bond, 1998), using lagged time-series information as instruments.[3]

[2] The traditional Granger causality test is performed with the level of a variable against the lags of the same variable and another variable which is being tested. Here we instead focus on the impacts of the lags of the tested variable on growth instead of the level.

[3] The system is estimated using the STATA command developed by (Roodman, 2009). The dataset is unbalanced due to some countries not having data for the entire period since 1960. In the case of the non-agricultural growth equation, auto-regressive tests of the errors led to adding three lags of the non-agricultural income variable. This significant lags indicate high persistence of non-agricultural growth rates, or stability of longer-term growth rates.

Before discussing the results of the econometric tests, it is important to clarify why the effects of agriculture on non-agricultural output and vice-versa are (after adequately controlling for endogeneity) unknown. When one sector grows there are at least two countervailing effects with respect to the other sector. In the first place there is a positive externality, a multiplier effect, as the growth of one sector also translates into higher demand of the other sector's output. However, there is a negative impact as well, sectors compete for non-sector-specific fixed (at least in the short term) factors that. This is most clearly the case with labor, a resource for which both sectors compete. Hence, *a priori*, one cannot determine if there is positive or negative causality of one sector on the performance of the other.

The econometric results for both the level and the growth equations, for agriculture and non-agriculture, are presented in Table 23 (omitting the country- and year-specific dummies). The first two columns present a traditional Granger causality set-up. The table shows that agricultural value added "Granger causes", or precedes non-agricultural value added, but non-agricultural output does not "Granger cause" agricultural value added. The results show that in addition to a strong correlation from year-to-year in sectoral incomes, the size of agriculture in the previous period affects the current period's non-agricultural income, but not vice versa. In levels, the impact of agricultural income on non-agricultural income is relatively small (an elasticity of 0.005), but nevertheless positive and statistically significant. By contrast, the point-estimate of the impact of non-agricultural income on agricultural income is not only small and statistically insignificant, but negative. One drawback of these Granger causality tests performed in this GMM dynamic panel data setting is the risk of weak instrumentation in the presence of integrated series, such as the ones being inspected. This is why we consider as preferred the analysis performed on growth rates.

Table 27. Granger Tests: GMM System Estimates

	Levels		Growth Rates	
	$\ln \boldsymbol{V}_{Act}$	$\ln \boldsymbol{V}_{Nct}$	$\Delta\ln \boldsymbol{V}_{Act}$	$\Delta\ln \boldsymbol{V}_{Nct}$
$\ln V_{Act-1}$	1.008***	0.005**	0.010**	0.005**
	(0.004)	(0.002)	(0.004)	(0.002)
$\ln V_{Nct-1}$	-0.004	1.352***	-0.007*	0.357***
	(0.004)	(0.030)	(0.004)	(0.032)
$\ln V_{Nct-2}$		-0.356***		-0.375***
		(0.030)		(0.053)
$\ln V_{Nct-3}$				0.014
				(0.032)
Constant	-0.004	0.04	-0.065	0.047*
	(0.050)	(0.025)	(0.041)	(0.025)
Sargan Overidentifying Restrictions test (p-value)	0.448	0.109	0.825	0.122
Arellano Bond AR(1) Test in differences (p-value)	0	0	0	0
Arellano Bond AR(2) Test in differences (p-value)	0.38	0.212	0.259	0.238
Observations	948	948	996	948
Nr. of Countries	24	24	24	24

Note: Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01.

The results of the estimation of the regression for agricultural growth rates show that there is some evidence of Granger-causality non-farm to farm sector, at a p-value of 0.065. But the coefficient on the lagged level of non-agricultural income has a negative sign. This would imply that, at least in the Latin American context, higher value-added of the non-agricultural sector (lag log non-agricultural value added) is associated with lower growth rates of the agricultural sector. This would be consistent with non-agriculture pulling resources from agriculture. In contrast, the results of the estimation of the regression for non-agricultural growth rates show that there is stronger evidence of Granger-causality of the farm to the non-farm sector, at a p-value of 0.021. The coefficient on the lagged level of agricultural income is positive, implying that higher value-added of the agricultural sector (lag log agricultural value added) is associated with higher growth rates of the non-agricultural sector. This supports previous findings of (Bravo-Ortega and Lederman, 2005; de Ferranti et al., 2005) that have shown that a stronger agricultural sector in developing countries, and in Latin America in particular, tends to have net positive spillovers to the rest of the economy.

What is the relationship between farm labor demand and the performance of agriculture and non-agriculture?

Further to assess the importance of the agriculture's performance on national development we turn to an econometric analysis of the effects of the farm sector's value-added growth on employment for the three countries of focus in this study, Chile, Nicaragua and Peru. A positive shock that increases agricultural production would tend, all other things being equal, to enhance the demand for farm labor. Growth in the non-agricultural sector would likely increase the opportunity cost of farm laborers and decrease the labor supply to the farm sector. But agricultural income growth in Latin America has also been associated with incentive changes due to policy reforms, and subsequent shifts in technology, and the composition of production and the structure of farm sizes; and these changes in most cases have led to a simultaneous growth in farm sector incomes and a shedding of agricultural labor. Therefore, it is not obvious *a priori* how agriculture's performance would be related to the size of the farm labor force, and so we turn to the historical data to evaluate the effect of agriculture on farm employment.

The modeling approach here is simple: We posit a model where the size of the agricultural labor force (in natural logs) in period t, $\ln L_{At}$, is dependent on the lagged level of the log of the total number of adults in the working-age population (the 15 – 64 years cohort from demographic censuses), $\ln L_{Tt-1}$, and the lagged levels of the logs of both sectors' incomes, $\ln V_{At-1}$ and $\ln V_{Nt-1}$. The working-age population is added to control for labor-force changes related to longer-run demographic trends rather than to the performance of the farm and non-farm sectors. The basic regression model is

$$\ln L_{At} = \alpha + \beta_A \ln V_{At-1} + \beta_N \ln V_{Nt-1} + \gamma_i \ln L_{Tt} + \epsilon_t$$

We estimate the model for each country individually and as a group. The expected signs of the coefficients are positive in the case of agricultural value added and negative for non-agriculture. We make use of lagged values of the explanatory variables to avoid possible estimation problems associated with contemporaneous shocks that might affect the size of the agricultural labor force and sectoral incomes.

Table 28 Accounting of agricultural and non-agricultural employment growth: Fixed-Effects Approach

	Agricultural Employment	Non-Agricultural Employment
$\ln V_{At-1}$	0.185	-0.013
	(0.169)	(0.119)
$\ln V_{Nt-1}$	-0.253**	0.232***
	(0.105)	(0.074)
$\ln L_{Tt}$	0.672***	0.793***
	(0.126)	(0.089)
Constant	5.398***	-2.614***
	(0.797)	(0.561)
F test p-value	0	0
Adjusted R2	0.729	0.945
Obs.	84	84

Note: Standard errors in parentheses, * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

Table 24 shows the basic regression results, using the data for all three countries together, for the regression of the farm labor force as a function of the working-age population and the lags of agricultural and non-agricultural value added, estimated by fixed effects. Note that the estimated coefficients associated with the explanatory variables are directly interpretable as elasticities. The statistical results show that for the three countries considered together, the farm labor force is more sensitive to non-farm income growth than to farm sector income growth. An increase of 10 percent of real non-farm growth is associated with a reduction in the farm labor force of about 2.5 percent. The point estimate of the elasticity of farm labor to farm value added is smaller, on the order of 2/3 of that of non-farm value added, and moreover its p-value would not reject a null hypothesis that the elasticity is zero. From these results it appears that the size of farm labor force is positively affected by the demographic factors driving the size of the working-age population – a positive supply-side effect – and negatively affected by the performance of the non-agricultural sector – also a supply-side effect. On the demand side, however, for these data, *ceteris paribus*, the performance of the agricultural sector appears not to affect the size of the farm labor force.

Inspecting individual-country regressions, shown in Table 25, demonstrates some interesting differences. In the case of Chile, a country which as an aging farm labor force, both farmers and salaried workers, and a relatively slow growth in population, there is no apparent relation between the working-age population and the number of employed in farming. But there is a strong negative and statistically significant effect of the non-farm sector's performance on the size of the farm labor force. Chile's agricultural value-added appears to increase labor demand, with an elasticity of 0.25, all else constant, much smaller than the negative impact of non-agricultural income. In the case of Peru, the value-added performances of neither sector appear to influence the size of the farm labor force, controlling for the working-age population, which has a strong positive and statistically significant impact. To understand these differences that demography has on employment between Chile and Peru, consider that in 1982 Chile had a demographic labor force of 7 million persons while Peru had a demographic labor force of 5.9 million persons. Thirty years later, in 2012, Peru's demographic labor force was much larger than Chile's 15.6 against 11.4 million. This high growth rate of the demographic labor force in Peru, or equivalently its delayed demographic transition, explains the high elasticity that the labor force has on farm employment in Peru. The coefficient on the working age population is interpretable as an elasticity; with a value of approximately 0.6, the implication is that for each say 5 percentage increase in the Peruvian working-age population, the farm work force increases by slightly more than 3 percent. Demography appears to be driving agricultural employment growth in Peru, and indeed Peru is the only country in Latin America with higher growth in farm employment than non-farm employment. The usual net effect of the non-farm sector's performance on the agricultural labor force is not observable. By contrast to both Chile and Peru, the results of the individual regression for Nicaragua show no statistically significant effects on the agricultural labor force either of the performances of both sector appears, or of the working-age population.

Table 29. Accounting of agricultural and non-agricultural employment growth

	Agricultural Employment			**Non-Agricultural Employment**		
	Chile	**Nicaragua**	**Peru**	**Chile**	**Nicaragua**	**Peru**
$\ln V_{At-1}$	0.252*	-0.447	0.026	0.183	0.212	0.2
	(0.127)	(0.705)	(0.187)	(0.112)	(0.320)	(0.218)
$\ln V_{Nt-1}$	-0.411***	-0.392	0.149	0.107	0.631*	0.221
	(0.136)	(0.728)	(0.114)	(0.120)	(0.331)	(0.133)
$\ln L_{Tt}$	0.694	1.199	0.642***	0.909	0.2	0.549***
	(0.677)	(1.097)	(0.136)	(0.596)	(0.499)	(0.158)
Constant	0.383	13.293***	-0.112	-12.859**	-7.299***	-2.842***
	(5.769)	(3.909)	(0.876)	(5.085)	(1.777)	(1.023)
F test p-value	0.001	0.438	0	0	0	0
Adjusted R2	0.421	-0.007	0.961	0.981	0.959	0.964
Obs.	27	20	32	27	20	32

Note: Standard errors in parentheses, * *p*<0.10, ** *p*<0.05, *** *p*<0.01.

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Appendix I. Forward and Backward Linkages Methodology[4]

We use the following formulae to estimate the value of the primary agricultural sector's forward and backward linkages with the value added (VA) of other sectors.

Forward: Addition to the primary sector arising in sector :

$$\left[\frac{X_{Sj}^{T}}{\sum_{k} X_{kj}^{T}}\right] \cdot \left[\frac{X_{Sj}^{N}}{X_{Sj}^{T}}\right] \cdot VA_{j}$$

Where X_{Sj}^{T} represents the value of the intermediate inputs used in activity j from all sources, domestic and imported, coming from the primary sector (S, agriculture, fruit, etc.). The term X_{kj}^{T} represents the value of the intermediate inputs from any sector k used by sector j. The sum across all inputs k represents the total costs of intermediate inputs used by activity j. The superscript T represents the total amount of an input from all sources, domestic or imported, and the superscript N indicates domestic inputs. The term VA_j represents the value added attributable to sector j. Equation (2) measures the value of forward linkages of agriculture as a proportion of the value added of sector *j,* which is equal to the fraction of total costs due to domestic agricultural and livestock inputs.

Backward: Addition to the primary sector arising in sector j =

$$\left[\frac{X_{jS}^{T}}{\sum_{k} X_{jk}^{T}}\right] \cdot \left[\frac{X_{jS}^{N}}{X_{jS}^{T}}\right] \cdot \left[\frac{\sum_{k} X_{jk}^{N}}{TVO_{j}^{N}}\right] \cdot VA_{j}$$

where X_{jS}^{T} represents the value of the products sold by sector *j* for use by the primary sector S (agriculture, etc.), and X_{jS}^{N} represents the value of sector *j*'s products used by the domestic S sector. The term TVO represents the total value of output of the domestic sector *j.* The share of the value added of sector *j* considered in the backward linkages is given by the product of two elements: the proportion of domestic intermediate demand arising in the primary sector for the products sector *j* and the proportion of intermediate demand for sector *j* products of the total value of output of sector *j.* This measurement of backward linkage makes clear the importance of both the demand of the primary sector

[4] Taken from page 25 of Foster and Valdés (2015).

relative to the overall intermediate demand, and the relative importance of intermediate demand in the total value of output. There is the possibility that the domestic agricultural sector is the only user of an input, in which case the first two terms would be equal to 1.0. If there are exports of these inputs, the third term would be less than 1.0, perhaps significantly so, as in the case of nitrates sold as fertilizer but also exported.