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Erniel B. Barrios[1] and Angela D. Nalica[2]

ABSTRACT

When the worst El Nino episode of the century happened in 1998, GVA of the rice sector declined by as much as 24% while other crops were able to keep the decline to within single digit level. While the world is focusing on productivity growth to fuel agricultural growth, the MTPDP 2004-2010 targets expansion of cultivation area as the source of agricultural growth for the Philippines. An assessment of the robustness of the agriculture sector to internal and external shocks can provide valuable inputs in planning the sector. We verify the convergence hypothesis focusing on rice production as well as the possible role of production area, corn as a substitute crop, and weather anomalies towards attainment of convergence. The spatial effect is incorporated into the model to verify the localization and/or universality of rice policy programs across the country in addition to the natural endowments of the provinces. Rice production among the Philippine provinces diverged in the period 1990-2002. The El Nino episode of 1998 pulled down rice yield by as much as 10% and further contributed in the divergence among provinces.

I. Introduction

In the Family Income and Expenditures Survey (FIES) of 2003, seventy nine percent of agricultural households fall among the four lowest income deciles (bottom 40% of the population). The non-agricultural households however, only have 30% in the bottom 40% of the population, emphasizing the greater vulnerability of those in the agriculture sector. More specifically, within the agriculture sector, those engaged in crops are more disadvantageous with average income in 2003 of PhP 59,999 compared to the rest in the agriculture sector with average income of PhP 68,703.

The worst El Nino episode of the century happened in 1998, expected to affect the agriculture sector the most. The marginalization of the grains farmers, specifically, those planting rice can be gauged from the GVA of the rice sector that declined by as much as 24% while other crops were able to keep the decline to within single digit level. Although majority of agricultural land devoted to rice farming is now reached by the irrigation systems, due to the often non-sustainable water source, rice farming still maintained the same marginalization due to the volatile weather conditions.

While the world is focusing on productivity growth to fuel agricultural growth, the Medium Term Philippine Development Plan 2004-2010 targets expansion of cultivation area

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as the source of agricultural growth for the Philippines. An assessment of the robustness of the agriculture sector to internal and external shocks can provide valuable inputs in planning the agriculture sector.

We verify the convergence hypothesis focusing on rice production as well as the possible role of production area, corn production, and weather anomalies towards attainment of convergence among Philippine provinces. We also assessed the structural effect of events associated to the 1998 El Nino episode towards rice production in the Philippines.

II. Convergence and Agricultural Growth

Initially sprouting from the Solow growth model, the concept of convergence has emerged from the literature for a relatively longer period now. As (Di Liberto 2005) puts it, the Solow model predicts that economies converge to a steady state, where the key force that underlies the convergence effect is diminishing returns to reproducible capital. Furthermore, steady state growth rate is explained by the model (zero) and it is only possible to obtain continued growth in output per head if there is exogenous technical progress.

Several convergence models appear in the literature. As discussed by (Barro and Sala-i-Martin, 1992) and (Sala-i-Martin, 1996), there are initially two types of convergence – unconditional or absolute ß-convergence and σ-convergence. If there is a tendency for poor economies to grow at a faster rate than the richer ones, then there is absolute ß-convergence. Specifically, if ß > 0 in the following regression equation $\gamma_{i,t,t+T} = \alpha - \beta \log(y_{i,t}) + \varepsilon_{i,t}$, where $\gamma_{i,t,t+T}$ is the annual growth rate of GDP of the i^{th} economy between time t and t + T and log $(y_{i,t})$ be the logarithm of the i^{th} economy's GDP per capita at time t, then there is absolute ß-convergence. On the other hand, if $s_{t+T} < s_t$, where s_t is the standard deviation at time t of $\log(y_{i,t})$ across all economies, then the economies are converging the sense of σ. Thus, σ-convergence implies a decreasing trend in the dispersion of per capita GDP or income over time. It refers to the inter-temporal gradual development of the dispersion of world income. These two kinds of convergence are in a way related. (Sala-i-Martin, 1996) remarks that ß-convergence is a necessary but insufficient condition for sustained σ-convergence. (De la Fuente, 2002) points out that convergence is necessary since the level of inequality will grow indefinitely when ß is negative (i.e. when richer economies grow faster than the poorer economies).

Absolute convergence can only be expected or anticipated exclusively among economies which are structurally homogenous – the only difference across economies is in their initial levels of capital. This insight is instrumental in the conception of conditional convergence. This model allows for the differential determinants of the steady state levels (e.g. technological level, propensity to save, or population growth rate) of the economies under study. To verify existence of conditional convergence, one has to estimate the equation

$$\gamma_{i,t,t+T} = a - b\log(y_{i,t}) + \psi X_{i,t} + \varepsilon_{i,t,t+T}$$

where $X_{i,t}$ is a vector of variables that hold constant the steady state of economy i, and $b = (1 - e^{-\beta T})/T$. If the resulting ß is positive for $X_{i,t}$ which is held constant, then there is conditional convergence. This seems to be a more realistic model since it possible for economies to differ in varying technological and behavioral parameters which in turn translates to different levels of equilibrium.

What then is the difference between absolute and conditional convergence? Absolute convergence implies a tendency for differences in per capita income to wear off within the sample over time. In the long run, expected per capita income is the same for all members of the group, independently of its initial value. As explained by (de la Fuente, 2002), this does not mean that inequality will disappear completely, for there will be random shocks with uneven effects on the differe nt territories. Such disturbances, however, will have only transitory effects, implying that, in the long run, we should observe a fluid distribution in which the relative positions of the different regions change rapidly. With conditional ß convergence, on the other hand, each economy converges only to its own steady state but these can be very different from each other. Hence, a high degree of inequality could persist, even in the long run, and we would also observe high persistence in the relative positions of the different economies. In other words, rich economies will generally remain rich while the poor continue to lag behind.

This brings us to another question – how to interpret the parameter ß from the two models. ß shows how fast the economies approach their steady state levels. It can help in the analysis of economic growth as it gives the rate or speed of convergence. As noted again by (De la Fuente, 2002), there is no contradiction between these estimates once it is recognized that they are measuring different things: while the unconditional parameter measures the overall intensity of a process of income convergence which may work in part through changes over time in various structural characteristics, the conditional parameter captures the speed at which the economy would be approaching a "pseudo steady state" whose location is determined by the current values of the conditioning variables.

II.1 Issues on Convergence

The convergence hypothesis, which makes predictions on the behavior of economies over time, provides the main building block for empirical tests on the fit of the model when confronted with data on groups of economies. It is some sort of an acid test to discriminate between exogenous and endogenous growth theories as remarked by (Di Liberto, 2005). (Durlauf, 1986) notes that convergence hypothesis asserts that differences in contemporaneous per capita income between any pair of economies will be transitory so long as factors which might be unique to an economy such as technologies, preferences and population growth rates are accounted for. He studied several works and papers that provide evidence of convergence and are found consistent with the neoclassical growth model and have been taken as evidence against a range of endogenous growth models. These papers show differing perspectives on convergence which may be explained by a combination of differences in definitions of convergence, class of theoretical growth models and econometric method used. (Bernard and Durlauf, 2001) provided a framework for testing the convergence hypothesis using cross section and time series data. This was largely brought about by diverse definitions and testing procedures as well as conflicting conclusions about convergence. They found out that cross section tests seem to place less stringent assumptions on the behavior of growth than the associated time series tests. Thus, results seem to be contradicting since the cross section tests verify convergence hypothesis for economies with varying long run steady states while time series tests suggest divergence which can be attributed to transition dynamics in the data. Their findings suggest that neither testing framework is likely to yield unambiguous conclusions with respect to competing growth models. Moreover, they noted that bulk of cross section evidence on convergence which has thus far appeared can be interpreted as consistent with some version of new growth theory.

In the analysis of a data set for 110 countries done by (Sala-i-Martin, 1996), the gap in per capita GDP across poor and rich countries did not narrow down over time. Thus, the data set exhibited ß-divergence. Moreover, the difference tends to increase over time which implies σ-divergence. This finding contradicts the neoclassical growth models. The model's inadequacy to explain absence of convergence provided the motivation to favor of endogenous model and against neoclassical growth. Endogenous models suggest that per capita income difference will persist across economies. Early endogenous growth models stress the presence of persistent differences in per capita income across countries: rich economies may retain a constant gap with poorer regions or may even increase it. (De la Fuente, 2005) noted that economic theory identifies forces with contrasting implications for income dynamics. The perceived failure of the optimistic convergence predictions has motivated the search for alternatives and contributed to the development of endogenous growth models.

Although focus is given to the more recent literature on growth which exhibits absence of convergence among countries, this does not provide compelling reason to shift to endogenous models. Neoclassical models have been demonstrated to predict conditional convergence. This type of convergence addresses the economies' differences in technological and behavioral parameters. Moreover, as can be seen in the work of Durlauf (1996), recent endogenous growth models predicts the possibility of convergence across economies. While there is divergence of perspectives on convergence, both theories of exogenous and endogenous growth models predict that a mechanism of convergence is possible. (Di Liberto, 2005) remarked both theories are currently able to explain the observed convergence among groups of homogeneous countries and the absence of convergence when introduced to a large and heterogeneous data set. He further noted that simple convergence tests cannot be considered fully supportive of one theory against the other.

II.2 Agricultural Growth

Agriculture has a vital role to play in contributing to an economy's development. An implication of the model on structural transformation (i.e., a declining role for agriculture) by (Gollin et al 2002) is that agricultural growth is central to development. The model actually shows a connection of agricultural growth to industrial development. Those countries which are experiencing increases in agricultural productivity will have a shift of workers from the agricultural to nonagricultural sector. They concluded in their paper that low agricultural productivity can substantially delay industrialization. This delay might result into low per capita income of the country compared to that of the leader. They further noted that a greater understanding of the determinants of agricultural productivity will improve our understanding of the development process among poor nations.

(Ruttan 2002) cited that increases in agricultural production, both from crops and animals, initially were attributed to increases in the area cultivated but towards the end of the twentieth century, growth is coming from increases in land productivity – in output per acre or hectare. Growth in total factor productivity in agriculture has made an important contribution to economic growth – within rural areas, this has led to poverty reduction. (Timmer, 2004) remarks that at least in most of Asia, agricultural growth has tended to be much pro-poor than growth in the modern industrial or service sectors. There are several constraints on agricultural productivity: resource and environmental, scientific and technical, institutional constraints. These will have differential effects on the economies having such constraints. Thus, specific actions can be taken on to facilitate growth in the economy.

III. Modeling Issues

The paper uses rice production data aggregated at the provincial level for the period 1990 to 2002. The data is collected quarterly from sample farming households by the Bureau of Agricultural Statistics (BAS) of the Department of Agriculture. Rice production is characterized by pronounced seasonality, having only two complete production cycle within a year.

Following the definition of conditional convergence by (Barro and Sala-i-Martin, 1992) and (Sala-i-Martin, 1996), a spatial-temporal growth model is postulated as follows:

$$\Delta p_{it} = b_0 + b_1 \log(y_{it}) + b_2 \log(a_{it}) + b_3 \log(c_{it})$$

$$+ d\left(\Delta p_{it} - b_0 - b_1 \log(y_{it}) - b_2 \log(a_{it}) - b_3 \log(c_{it})\right) D_{it} + u_i + e_{it}$$

$$e_{it} = r e_{it-1} + z_{it}$$

Where Δp_{it} is the growth rate in quarterly yield of rice, computed both from the original and the deseasonalized data. y_{it} is the yield of rice, a_{it} is the harvest area for rice, c_{it} is the harvest area for corn, D_{it} a sparse spatial autoregression indicator ($1/m$ if the provinces are 'neighbors', in our case happen if they come from the same region, 0 otherwise), m is the number of provinces in a region, u_i a random effect component, e_{it} the autocorrelated error term, and $z_{it} \sim N(0, s^2)$. The effect of D_{it} is to average initial residuals of provinces in the same region. The residuals after accounting for the covariates are attributed to the spatial externalities common among provinces in the same region. The spatial externalities can serve as aggregate proximate indicators of the viability of the area in growing the crop as well as policies and programs supporting the sector.

The model is estimated using a generalized least squares procedure in two backfitting steps. Step 1 considers a simple linear model to compute the initial residuals.

The residuals are then aggregated with D_{it} before the second generalized least squares is applied to the whole model with estimated residuals from Step 1.

The effect of El Nino episode of 1998 is assessed by including a dummy variable in the model above, both as a location and scale parameter.

IV. Convergence in Rice Yield

The random effect model with temporal and spatial autoregression for both the original data and the deseasonalized rice yield data significantly fits the provincial data (see Tables 1 and 2). Parameter estimates for both growth equations (original and deseasonalized) are similar. The possible effect of deseasonalization can be observed only in the magnitude of the spatial parameter.

Adjusting for spatial effect of the regions, the provinces failed to exhibit convergence in rice yield. This is can be interpreted in two ways. First, the natural endowments of the provinces are distinctly varied, so that even with interventions in farming systems and technological innovations, yield still vary significantly. This means that the zoning provision of the Agricultural and Fisheries Modernization Act (AFMA) is an important strategy towards in the identification of optimal production areas for certain crops, rice most specially. An intensive advocacy campaign among farmers to consider a crop more suitable to their soil is needed, rice is not really ideal for all provinces. The second interpretation of divergence is that, it is possible that the agricultural interventions are not really tailor-fitted to the needs of the provinces.

The negative effect of area on growth in yield is an indication that the newly developed production areas are not necessarily optimal for rice production. While many arable lands are still available in various parts of the country, it cannot be allocated for rice production. At least for the rice sector, expansion of harvest area seems not to provide support for growth. Corn production area does not significantly contribute to yield of rice. This means that either there is not enough crop rotation between rice and corn, or that rice production does not benefit from this crop rotation at least with corn.

Table 1: Convergence in Quarterly Growth in Yield of Rice

Classical Model for the Verification of Convergence Hypothesis (Random Effect Model)				
Overall Fit p-value	0.0000	Determinant	Coefficient	p-value
ρ	0.1014	Constant	-0.0462	0.166
s_u	0.0327	Log(Yield)	0.1889	0.000
s_e	0.2243	Log(Area)	-0.0107	0.001
$s_u/(s_u+s_e)$	0.0208	Log(CornArea)	-0.0010	0.652
Classical Model for the Verification of Convergence Hypothesis (Random Effect Model) Adjusted for Spatial Effect				
Overall Fit p-value	0.0000	Determinant	Coefficient	p-value
ρ	0.1014	Constant	-0.0503	0.134
s_u	0.0347	Log(Yield)	0.2629	0.000
s_e	0.2216	Log(Area)	-0.0102	0.002
$s_u/(s_u+s_e)$	0.0239	Log(CornArea)	-0.0018	0.439
		Spatial Neighborhood	-1.6889	0.000

The autoregression parameter estimate is only 0.1014. This means that random shocks in yield in the previous quarter influences only about 10% of the random shocks in yield for the present quarter. This can mean that rice farming has become more intensive, that the present random shocks like technology application dominated soil and weather endowments usually inherited across neighboring quarters.

The random effect due to the provinces accounts for a little more 2% of the aggregate of spatial and temporal variance (excluding the effect of the spatial parameter). This is an indication that spatial dependency is better accounted by the spatial autoregression component than by simply postulating a random component for the provinces. If the average residuals in a neighborhood are positive, then that is deducted (negative sign of coefficient) from the prediction of yield indicating that spatial externalities contributed negatively to yield. On the other hand, if the average initial residuals is negative, then the spatial externalities are meant to contribute positively to yield, hence the spatial effect is added accordingly.

The spatial externalities associated with a region includes, but not limited to, natural endowments due to weather and soil fertility and well as implementation of programs geared towards enhancing agricultural productivity. Majority of the regions yield positive effect for spatial externalities with Central Luzon and Davao regions benefiting the most from spatial externalities. Davao region is one region that benefit from almost uniform distribution of rainfall throughout the year, in addition to the good quality of soil suited for grains production. Central Luzon on the other hand, includes the most fertile land ideal for crop production (including rice). There are also the most advanced irrigation systems in the region, in addition to several demonstration farms of different agricultural research institutions. In 2002, of the 16 rice-producing regions, Central Luzon produced 17% of total rice production in the country. Three regions yield negative effect of spatial externalities, including ARMM, Central Visayas, and Eastern Visayas, where some of the lowest rice production can be observed in the period 1990-2002.

Table 2: Convergence in Quarterly Growth in Deseasonalized Yield of Rice

Classical Model for the Verification of Convergence Hypothesis (Random Effect Model)				
Overall Fit p-value	0.0000	Determinant	Coefficient	p-value
ρ	-0.1557	Constant	-0.1376	0.000
s_u	0.0294	Log(Yield)	0.2649	0.000
s_e	0.2108	Log(Area)	-0.0137	0.000
$s_u/(s_u+s_e)$	0.0190	Log(CornArea)	0.0022	0.341
Classical Model for the Verification of Convergence Hypothesis (Random Effect Model) Adjusted for Spatial Effect				
Overall Fit p-value	0.0000	Determinant	Coefficient	p-value
ρ	-0.1557	Constant	-0.1766	0.000
s_u	0.0290	Log(Yield)	0.3285	0.000
s_e	0.2079	Log(Area)	-0.0130	0.000
$s_u/(s_u+s_e)$	0.0190	Log(CornArea)	0.0022	0.318
		Spatial Neighborhood	-1.3433	0.000

V. The Effect of the 1998 El Nino on Convergence

Expectedly, the 1998 El Nino episode contributed further in the divergence in rice yield among the provinces. The extent of the effect of the drought varies across the provinces. The coping mechanism adopted by the farmers to positively mitigate the ill-effects of the weather anomaly also varies across the provinces, further spreading away rice yield. Provinces across the country generally experienced 10% reduction in yield as an effect of the drought.

The El Nino episode of 1998 does not contributed significantly to the temporal variation and well as the provincial random effects.

Table 3: Convergence in Quarterly Growth in Yield of Rice (Effect of El Nino 98)

Classical Model for the Verification of Convergence Hypothesis (Random Effect Model)				
Overall Fit p-value	0.0000	Determinant	Coefficient	p-value
ρ	0.1009	Constant	-0.0203	0.555
s_u	0.0310	Y98	-0.0946	0.291
s_e	0.2230	Y98* Log(Yield)	0.1011	0.025
$s_u/(s_u + s_e)$	0.0190	Y98*Log(Area)	-0.0191	0.053
		Y98*Log(Corn Area)	0.0109	0.103
		Log(Yield)	0.1684	0.000
		Log(Area)	-0.0093	0.007
		Log(Corn Area)	-0.0024	0.304
Classical Model for the Verification of Convergence Hypothesis (Random Effect Model) Adjusted for Spatial Effect				
Overall Fit p-value	0.0000	Determinant	Coefficient	p-value
ρ	0.1009	Constant	-0.0160	0.644
s_u	0.0331	Y98	-0.1097	0.216
s_e	0.2205	Y98* Log(Yield)	0.0974	0.029
$s_u/(s_u + s_e)$	0.0220	Y98*Log(Area)	-0.0102	0.107
		Y98*Log(Corn Area)	0.0102	0.124
		Log(Yield)	0.2414	0.000
		Log(Area)	-0.0094	0.007
		Log(Corn Area)	-0.0033	0.172
		Spatial Effect	-1.7289	0.000

VI. Conclusions

A sparse spatial autoregression model with random provincial effect is postulated to explain rice production in the Philippines. Growth rate in rice production is computed both from the original yield data as well as from the deseasonalized yield data. Parameter estimates for both growth equations (original and deseasonalized) are similar and the possible effect of deaseasonalization can be observed only in the magnitude of the spatial parameter.

Adjusting for spatial effect of the regions, the provinces failed to exhibit convergence in rice yield. The negative effect of area on growth in yield is an indication that the newly developed production areas are not necessarily optimal for rice production. While many arable lands are still available in various parts of the country, it cannot be allocated for rice production. At least for the rice sector, expansion of harvest area seems not to provide support for growth. Rice farming has become more intensive, that the present random shocks possibly caused by technology application dominated soil and weather endowments usually inherited across neighboring quarters.

The 1998 El Nino episode contributed further in the divergence in rice yield among the provinces. The extent of the effect of the drought varies across the provinces. The coping mechanism adopted by the farmers to positively mitigate the ill-effects of the weather anomaly also varies across the provinces, further spreading away rice yield. Provinces across the country generally experienced 10% reduction in yield as an effect of the drought.

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