REGIONAL CONVERGENCE ANALYSIS OF CHILEAN ECONOMY BETWEEN 1960 AND 1996

Patricio Aroca González[1]
Domingo Claps Arenas

There is a large literature concerning with the problem of economic growth. Specially in recent years these literature has been focusing on whether economies, both internationally and regionally speaking, are converging in the sense of diminishing the differences in per-capita Gross Domestic Product that characterize those economies.

We applied the neoclassical growth model to analyze the growth experience of Chilean regions along the last four decades based on the works of Barro and Sala-i-Martin (1992). In that work, the authors found evidence of conditional convergence among the economies of 98 countries including Chile. Now we tried to verify the convergence hypothesis inside the country implementing the same framework to the geopolitical subdivision of Chile.

The input of the model was data about per-capita Gross Domestic Product from the thirteen regions of Chile since 1960 until 1996.

The model

Neoclassical growth development models are based in the pioneer Solow´s work (1956) which established the principal features of modern development theory. Between the fifties and the eighties that model suffers different empirical defeats until Barro and Sala-i-Martin (1992), Sala-¬-Martin (1996),°King and Rebelo (1989),among others, in recent years confront the issue giving new insights on the problem originally proposed by Solow.

The neoclassical model suppose individuals which maximize certain utility functions with the following form:

$$U(\circ) = \int_0^\infty e^{-rt} u(c_t) L_t d_t$$

In this model agents could be households or dynasties. The consumption function takes the following form:

[1] Department of Economics and IDEAR of Universidad Católica del Norte, Antofagasta, Chile.

$$\frac{c_t^{1-q}-1}{1-q}$$

Where:

$q^{-1} \equiv willingness\ to\ substitute\ \text{int}\, ertemporally$

$C \equiv Consumption$

The budget constrain is given by:

$$\overset{\circ}{K} = F(K, L) - C - dK$$

Where

$K \equiv Capital$

$L \equiv Population$

$C \equiv Consumption$

$F(K, L) \equiv \Pr oduction\ \ function$

$d \equiv depreciation\ \ rate$

The production function is homogeneous and is represented by a Cobb-Douglas expression with constant returns.

The maximization problem of the households is obtained solving the Hamiltonian:

$$H(\circ) = e^{-(r-n)t}\left(\frac{c^{1-q}-1}{1-q}\right) + n(f(k) - c - hk - dk)$$

Where:

$f(k) \equiv \Pr oduction\ \ function\ \ in\ \ percapita\ \ terms$

$h \equiv rate\ of\ \ population\ \ growth$

From the first order conditions we establish the next equation:

$$\frac{\overset{\circ}{c}}{c} = q^{-1}(bAk^{b-1} - r - d)$$

This equation explains the consumption rate of growth. A combination of the last equation and the budget constrain in per-capita terms serves to quantify the transitional dynamics of the model. This quantification requires a log-linearization approximation which can be summarized in the following expression (see Xavier Sala-i-Martin, 1996):

$$\log(y(t)) = \log(y(0)) \bullet e^{-bt} + \log(y*) \bullet (1 - e^{-bt})$$

The β parameter drives the speed of convergence to the steady state. The **y** variable refers to the per-capita Gross Domestic Product (G P), and **y**$*$ represents the steady state value of GDP.

Rewriting the last equation in order to be regressed, we have:

$$\log(\frac{y_{it}}{y_{i,t-1}}) = a_i - (1 - e^{-b}) \bullet (\log(y_{i,t-1})) + u_{it}$$

We use non linear least squares to verify the convergence hypothesis. It is important to notice that (as other studies do) even though the βs could vary among different economies, we neglect that differences by supposing similar parameters of technology and preferences for Chilean regions, as well as, the same institutional framework among them.

The β parameter is given by the formula,

$$2b = \left\{ y^2 + 4\left(\frac{1-a}{q}\right) \bullet (r + ¶ + qy*) \bullet \left(\frac{r + ¶ + qy*}{a} - (h + ¶ + qy*)\right)\right\}^{\frac{1}{2}}$$

where,

$$y = r - h - (1-q)y* \rangle 0$$

$$a \equiv returns\ to\ capital$$

$$h \equiv average\ population\ rate\ of\ growth$$

As Barro and Sala-i-Martin (1992) established the magnitude of the β is related to the speed of convergence. For higher values we could expect faster convergence to the steady state. These authors also established that the neoclassical model, implies conditional convergence in the sense that the speed of convergence is supposed to be higher the lower the initial level of per-capita product.

From the last expression it is possible to check out that the higher willingness to substitute intertemporally (lower θ) the higher the speed of convergence. In other words, as households substitute future consumption for present consumption then the pace of transitional dynamics becomes higher. Otherwise, a low willingness to substitute intertemporally the more protracted the growth process (King and Rebelo,1989). The implication of such pattern of preferences is related to the financial system since it reflects a high level of the real interest rate. Then during periods of monetary contractions it is possible to expect an elongation of the transitional dynamics to the steady state. As could be seen the neoclassical model is supposed to converge under almost any circumstances.

The α parameter has an inverse relationship with the speed of convergence. Indeed, diminishing returns to capital is a necessary condition to achieve convergence : that is a key assumption of the neoclassical growth model, otherwise, GDP could never reach the steady-state level.

The average population growth also has an inverse relationship with the β parameter, that means high population growth requires strong effort of investment to maintain the speed of convergence, in order to have the share of capital to labor at least constant.

A convergence hypothesis implies that the poorer regions must be growing faster than the richer ones. We have to differentiate between β convergence and σ convergence, the former has to be with the fact of converging rates of growth among different economies while sigma convergence refers to diminishing dispersion of per-capita Gross Domestic Product over the economies in study. To verify sigma convergence we just analyze the relevant data as Barro and Sala-i-Martin (1992) did.

Data

Our data consists of GDP information from Chilean national accounts since 1960 until 1996 which were published by SUBDERE-Cieplan (1994) for the years 1960 to 1990, for the recent years (1992-1996) we use data estimated by Gemines (!996). It includes the countries totals and the regions GDP for each year at 1986 prices. The GDP were divided between nine different economic sectors: agriculture, fishing, mining, industry, services, communications, construction and public utilities. At the same time, we used estimation of population based on Census 1970, 1982 and 1992 from every region, in order to calculated the DGP per-capita.

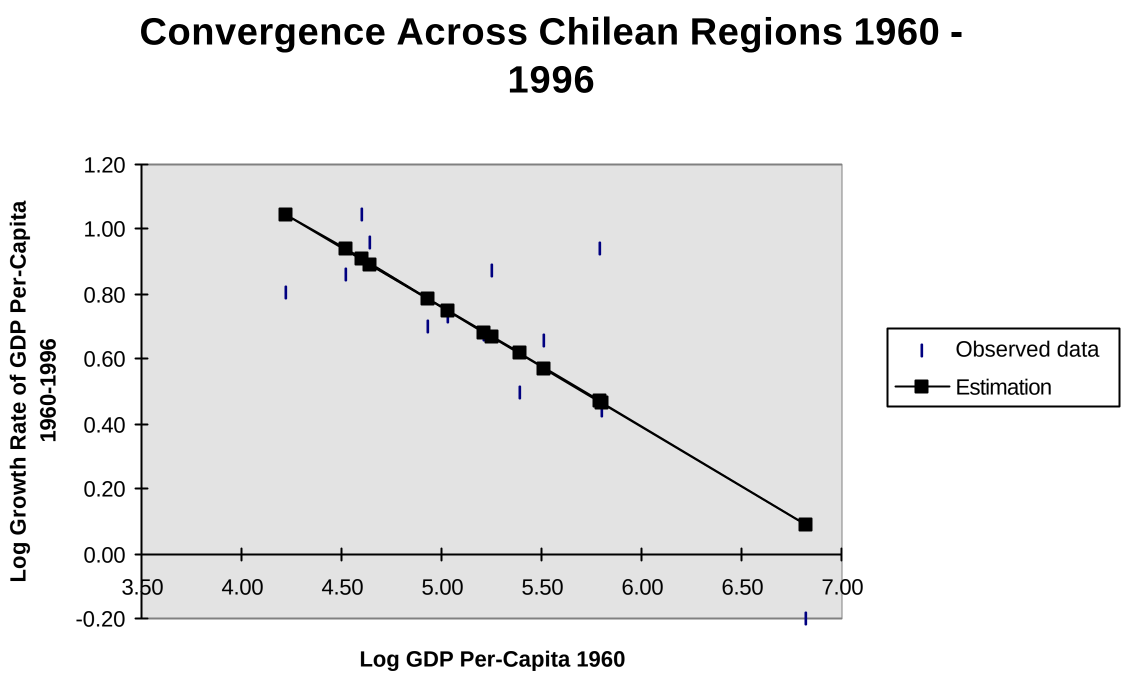
Results

The main results from the regression analysis for periods which consider 1960 as a baseline year are showed in **Table 1**. All the regressions gives the expected positive sign for the β´s. The regressions were run without considering any other variable.

TABLE 1:	Non-Linear		
PERIOD	COEFFICIENT	T-STAT	R-SQUARED
1960-1996	0.01274	3.363	0.623
1960-1990	0.01085	3.414	0.596
1960-1985	0.00839	2.098	0.331
1960-1980	0.00987	2.234	0.356
1960-1975	0.02078	3.386	0.589
1960-1970	0.01412	2.061	0.308

The longest interval 1960-96 for the thirteen Chilean regions has a significant estimated β of around 0.013 and as a consequence we can say that there is evidence supporting the hypothesis of β convergence. **Figure 1** also shows the inverse relation between the average growth rate from 1960 to 1996 and per-capita Gross Domestic Product of 1960.

Figure 1



β of 0.0128 indicates a speed of convergence around a 1.3 percent a year for the Chilean regions between 1960 and 1996. It implies that regions which used to be poor in the former year tends to growth faster than wealthier ones. This β is about a half the one that Barro and Sala-i-Martin (1992) found for developed economies and is similar to the β found by Cavalcanti (1996) for the Brazilian states. In other words the Chilean regions converge to the steady state path of economic growth half the speed the economic regions of developed countries do.

If we consider the other periods it is possible to verify that the speed of convergence prevails around 1 per-cent a year even though the statistical significance of the β is not always as good as the long period from 1960 to 1996. However, in all regressions β convergence is verified. In addition we found the expected sign for β in all of them. Just for the period from 1960 to 1975 the β appears to be twice the value obtained for other periods. It is interesting to notice that after 1975 the speed of convergence for certain periods among Chilean regions not only decrease but also becomes negative as could be seen in **Table 2** where we replicate the previous estimations now for periods with a length of five or six years in order to verify the presence of β convergence at different periods of time instead of just adjust the length of the period, as we did in **Table 1**.

TABLE 2:	***Non-Linear***	***Estimation***		
PERIOD	***COEFFICIENT***	***STD.ERROR***	***T-STAT***	***R-SQUARED***
1960-1965	0.0005	0.0009	0.618	0.033
1965-1970	0.03115	0.015	2.068	0.25
1970-1975	0.03349	0.0109	3.05	0.5
1975-1980	-0.02067	0.0074	-2.76	0.38
1980-1985	0.00302	0.01	0.302	0.008
1985-1990	0.025	0.0094	2.81	0.45
1990-1996	0.025	0.0167	1.49	0.187

From **Table 2** it is possible to see that the speed of convergence is much higher for the periods 1965-75. Here the speed of convergence is greater than 3 percent a year. As could be noticed the speed of convergence over the periods in study shows instability (something similar found Barro and Sala-i-Martin when they tested β convergence in subperiods from a large period of time for the USA case). In that way the speed of convergence for the 1975-1980 subperiod declines to a negative value, the only unexpected sign we found for our regressions. It is remarkable that Barro and Sala-i-Martin got similar results for the subperiod 1975-81 in the sense that the speed of convergence showed an unexpected negative sign. These authors explained that phenomenon as a consequence of the oil crises that occurred during that time. For the period from 1980 to 1985 the speed of convergence becomes positive again but near zero and where the estimated parameter of β is statistically not significant from zero. IN addition, the adjustment of this regression is very low. During the first years of the eighties decade the Chilean economy suffered a significant financial crises (as almost all Latin American countries) which led to a higher intertemporal substitution of consumption and a more protracted path for the transitional dynamics of growth. The pattern of convergence recovers for the subperiod of five years beginning in 1985. Between 1985 and 1990 convergence speed rose to more than 2.5% percent a year, the highest speed since the subperiod 1970-75. Over that time, the prices of the main export products of Chile tended to have a good performance compared with previous years. The same pattern was verify for the subperiod 1990-96, where the speed of convergence prevails at 2.5% percent.

The results showed in **Table 2** are more volatile than those presented in **Table 1**. However, its importance is embedded in the study of short periods of time where transcendental economical changes take place. In that sense, shorter periods take account of economic reforms, the constant swallowing of primary prices and change in the preferences and technological parameters.

The speed of convergence performance through short periods of time is quiet different from the one faced for larger periods. Here shocks plays a significant role because they affect in different form economies which otherwise would always be on the convergence path. For shorter periods it is easier to measure the effect of a sudden change in certain economic variables like prices. Barro and Sala-i-Martin (1992) established a new variable in order to keep those shocks inside the relevant economies and not widespread among all the economies in study. For example, a sudden upraise of a primary price is isolated in order to just impact the economies for which that product represents a high proportion of the income. To do that the authors constructed a variable according to the following expression:

$$S_t = \sum_{j=1}^{J} W_{ij} * \log\left(\frac{y_{j,t+T}}{y_{jt}}\right)$$

Where $\mathbf{W}_{ij}$ represents the share of the sector j GDP on the regional GDP, and $\mathbf{y}_{jt}$ represents the national GDP of sector j at time t, t+T implies a certain period of time of length T.

In **Table 3**, we show the results of a regression analysis considering the same variable that Barro and Sala-i-Martin (1992) considered in their study to isolate the effect of certain shocks. For the case of Chile we worked with nine sectors: agriculture, fishing, mining, industry, services, communications, construction and public utilities. The regression equation implemented was:

$$\log(\frac{y_{it}}{y_{i,t-1}}) = a_i - (1-e^{-bT}) \bullet (\log(y_{i,t-1})) + f_i s_t + v_{it}$$

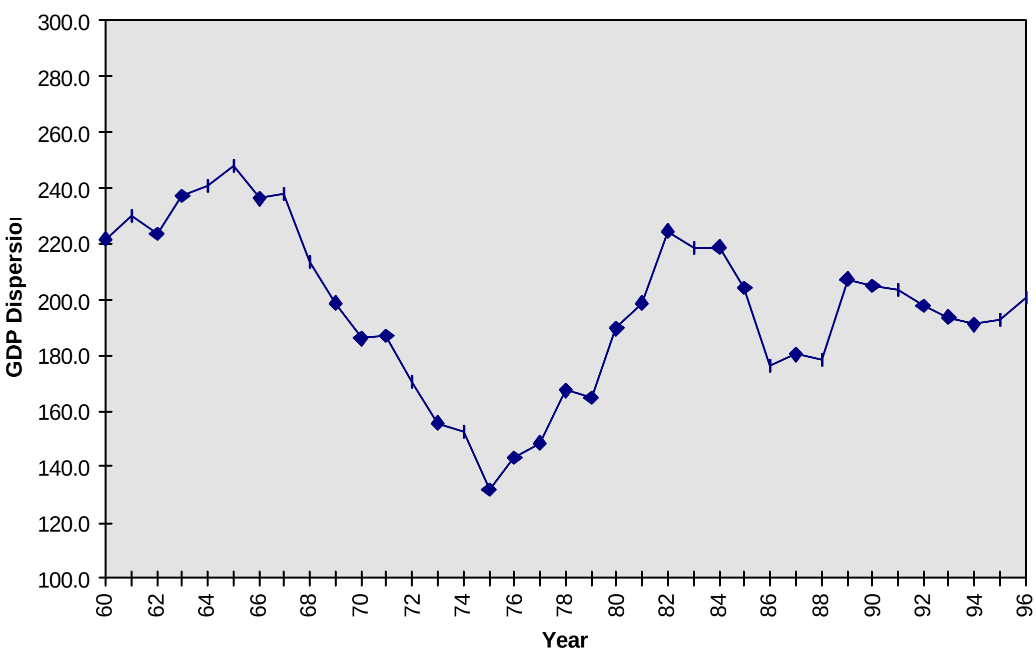
Where **f** indicates the coefficient of the $\mathbf{s}_t$ variable. In this equation, it is assumed that the there are shocks that affect in different way to different regions. To capture this effect the original error term was split in two part : one similar to the original (v_{it}) and the other part ($f_i\ s_t$) was introduced to control by shocks that affect regions growth heterogenously.

TABLE 3:	Non-Linear	Estimation			
PERIOD	*COEFFICIENT*	*T-STAT*	*S-COEFFICIENT*	*T-STAT*	*R-SQUARED*
1960-1965	-0.001	-0.19	0.47	0.84	0.007
1965-1970	0.03	1.99	1.19	0.28	0.31
1970-1975	0.03	3.01	0.36	0.71	0.52
1975-1980	-0.016	-1.95	0.63	0.97	0.43
1980-1985	0.01	1.11	1.41	2.19	0.33
1985-1990	0.03	2.28	-0.69	0.66	0.47
1990-1996	0.02	1.38	0.24	0.19	0.18

It is remarkable that the periods starting in 1965 until 1975 shows the greatest speed of convergence of all the estimations we have presented, that is an speed of over 3 percent per year. After those ten years the convergence seems to decrease dramatically as we already have seen in **table 2** . Now the parameter is less negative but still less than zero. The pace of convergence appears to recover after 1985 however the speed is less than the speed that characterize the Chilean economy during the later sixties and earlier seventies.

Figure 2

Dispersion of GDP Per-Capita Among Regions 1960 - 96



The coefficients associated to the s_t variable do not help as much as we thought to explain the sign and level of the coefficients estimated for the period 1975-1985 (compare **tables 2** and **3**).

In order to verify the presence of sigma convergence we just estimated the dispersion in annual per-capita Gross Domestic Product among Chilean regions. That dispersion is plotted in Figure 2.

We can see that GDP dispersion was decreasing until 1975, the same period where the convergence rate was over 3 percent per year. After that, the dispersion goes up until 1982, where it start going down slower than the previous period 1965 - 1975.

Conclusions

We verified the presence of β convergence among the Chilean regions between 1960 and 1996. The pace of that convergence is around 1 percent, similar to the Cavalcanti's results for the Brazilian case. In that sense the process of convergence in Chile is half the speed of some developed countries along similar periods of time, situation that could be explained by the differences of certain parameters prevailing in both types of economies.

When we divided the period 1960-96 into six different subperiods the regression analysis did not change essentially: the expected sign prevails (except for the subperiod 1975-80), and the adjustment continues being acceptable in most of the cases. However the pace of convergence appears to be volatile a characteristic that Barro and Sala-i-Martin verified in their study for developed countries.

The period of 1965 to 1975 appears to be where the convergence is faster than any other period under analysis, over 3 percent per year. The next ten years (1975 to 1985), which were characterized by deep structural change in the Chilean economy, appear as there is not convergence. The estimate of β is negative in the first five years and later is not different from zero, which means that in that period the differences among regions were growing or at least they remained constant.

When a variable, to take account for the effect of heterogeneous shock over the regions, was introduced in the model, there was not a significant improvements in the results. Therefore, this variable, that is suggested by Barro and Sala-i-Martin (1992), was not capable to capture the effects of possible shocks that affect the regions heterogeneously.

On the other hand, there was not evidence supporting the hypothesis of σ convergence. Even though, the methodology still needs further empirical effort for the Chilean case. We hope that in a future research the σ convergence could be clearly tested for the Chilean regions.

Finally, we only work with series of product and not with those referent to income data. This is a weakness of our work, because it is important that we find convergence among income per-capita more than product per-capita, given that the first is close related to the welfare of the people. However, it is well known the high correlation between income and product per-capita, therefore this study could be a good approximation that what could be occurring with regional income per-capita.

Another weakness of our work is that we face a lack for Chile of estimation for certain parameters described in the presentation of the model. Knowing estimation of the steady state value of per-capita Gross Domestic Product, the magnitude of returns to capital input, the intertemporal rate of substitute consumption could allow us to have some estimation of β that could be used to test the results that we obtain.

References

Barro, Robert; Sala-i-Martin, Xavier: "Convergence". Journal of Political Economy, 1992, vol.100, no.2.

Cavalcanti, Pedro; de Goes, Roberto: "Convergencia entre a renda per-capita dos Estados Brasileiros". Revista de Econometria, v.16, no.1, Abril 1996.

King, Robert; Rebelo, Sergio: "Transitional Dynamics and Economic Growth in the Neoclassical Model". Working Paper no. 3185. National Bureau of Economic Research, November 1989.

Sala-i-Martin, Xavier: "Apuntes de Crecimiento Económico". Antoni Bosch, Editor. Octubre 1994.

SUBDERE-Cieplan **:**"Evolución del Producto Por Regiones 1960 -1992", Ministerio de Interior, Subsecretaría de Desarrollo Regional y Administrativo, Santiago, Chile.