Regional Business Cycle Synchronization in Chile

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Abstract

This paper studies the degree and causes of intranational synchronization in Chile, a country characterized by regions with high levels of specialization and concentration. Our results show that the degree of synchronization is low compared to other more developed countries and is even deeper when the economy suffers from exogenous shocks. Also, the econometric results reveal that the differences in production structures and the relative location of the regions, among others, have a significant impact on the degree of synchronization. As far as policy implications are concerned, under this scenario it is necessary to consider policies with a regional focus since with a low degree of synchronization a centralized policy is not warranted.

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1 Introduction

During the past 15 years there has been a notable increase in interest on the degree of business cycles synchronization across countries and their sources of fluctuations. Most studies examining this issue, usually aim to measure the degree of effectiveness and performance that has had the European Monetary Union (EMU) given its common currency policy (Fatas, 1997; Frankel and Rose, 1998; Glick and Rose, 2002; Darvas and Szapáry, 2008). Moreover, other studies have investigated whether the theory of optimum currency areas (OCA) has taken place in different economies and countries (Calderon et al., 2007; Volpe Martincus and Molinari, 2007; Fiess, 2007). Another set of studies have analyzed the possible channels through which the degree of synchronization is affected. Among these include the level of financial integration, the degree of trade between economies, and differences in industrial mix (Imbs, 2004, 2006).

Alongside to this, other researchers have changed their attention to the degree of business cycle synchronization across regions within countries (Wynne and Koo, 2000; Norman and Walker, 2007; Hall and McDermott, 2007; Poncet and Berthélemy, 2008; Artis and Okubo, 2008, 2010). This new area of research has the main advantage to provide a benchmark for the analysis of international business cycles. This is mainly because many of the models used to explain international fluctuations are based on unrealistic assumptions such as non-existence of barriers to factor mobility and financial flows. Nevertheless, under a regional approach, these assumptions are more plausible. This idea of using data for regions within a country as a natural experiment for interpreting for data across countries has generated a research agenda termed the intranational business cycle synchronization[1] (Hess and Shin, 1997) .

On the other hand, understanding the sources that produce differences in regional business cycles might help policy makers. For example, if regional GDP cycles are largely independent of other regions, a spatially targeted policy would be appropriate. However, if the regional business cycles show a low degree of discrepancy, a more centralized policy is warranted (Rissman, 1999).

Within this context, the case of Chile is interesting for several reasons. First, Chile is characterized

[1] Throughout this paper we use interchangeably the concepts of intranational business cycle synchronization, regional business cycle synchronization and co-movement

by regions with a high level of specialization, especially in the extreme regions where the main activity is the exploitation of natural resources. The central regions, especially the metropolitan region which is the capital and main decision-making center of the country, are characterized by a higher degree of diversification of their production structures. Consequently, it is likely that the Chilean regions present heterogeneous effects to exogenous or endogenous shocks given their differences in industrial mix and its relative geographical position.

The aim of this paper is twofold. First, we give evidence of the degree of intranational synchronization in Chile, with particular attention to the degree of regional business cycles synchronization with the national business cycle. Secondly, we give evidence of the potential sources that influence the degree of regional cycles synchronization using different econometric techniques applied in the empirical framework.

Our results show that the degree of synchronization of Chilean regions is very low compared to other more developed countries. This provides evidence that Chilean regions are not sufficiently integrated in order to form an optimal currency area. In addition, our econometric results reveal that differences in production structures, the size of the regions, the differences in private investment, the differences in public investment and the differences in the degree of integration with foreign markets have a significant impact on the intranational business cycle synchronization.

This paper is organized as follows. Section 2 provides some stylized facts on the intranational business cycle synchronization in Chile. Section 3 presents a review of the literature on the main sources of regional business cycles disparities. Section 4 presents the empirical methodology and the data used to investigate business cycle synchronization in Chile. Section 5 reports our main empirical findings on the determinants of business cycle co-movement between Chilean regions. Finally, the last section concludes our findings.

2 Degree of intranational business cycle synchronization in Chile

This section provides a general view regarding the degree of regional business cycle synchronization in Chile. Using annual series of regional GDP data for Chile over the period 1988-2005, we analyze the extent to which regional business cycles are synchronized with the national cycle and what is the degree of intranational synchronization.

We follow the framework proposed by Frankel and Rose (1998) to define synchronization. We first isolate the fluctuations at business cycles frequencies by filtering the regional GDP data through the Hodrick and Prescott (1997), henceforth HP, the band-pass filter proposed by Baxter and King (1999), henceforth BK, and the Christiano and Fitzgerald (2003) filter, henceforth CF[2]. In applying these filters, we choose the parameters recommended by Baxter and King (1999), i.e., for the BK filter we admit period components between two and eight years with a maximum length of three and we set the smoothing parameter of the HP filter (lambda) at ten. We also set the parameter of the HP filter at 6.25 as recommended by Ravn and Uhlig (2002) and we admit period components between two and eight years for the CK filter. Second, we measure the degree of business cycle synchronization using estimated correlation coefficients on the detrended (natural logarithm of) regional GDP. Formally, we define the degree of synchronization as:

$$\rho_{ij} = corr\left(y_i^c, y_j^c\right) = \frac{cov\left(y_i^c, y_j^c\right)}{\sigma\left(y_i^c\right)\sigma(y_j^c)}$$

where the cyclical components, on the variables in natural logarithm, of the regions i and j are y_i^c and y_j^c, respectively.

To illustrate the different outcomes of the filters using the Chilean database, Figure (1) proves a comparison of the different filtering techniques. Each of the filters is applied to the GDP series of every region. Then, correlations of the business cycles are calculated for all region-pairs that were filtered in the same way. The graph shows that there is little difference between the HP and BK filter. The largest deviation is produced between the CF and the others filter. Given this, we decided to report the results obtained using the HP filter with lambda setting at ten, which is the most used in the literature[3].

[2]Our regional GDP data is over the period 1985-2008, but detrending data with the BK filter implies losing the first and last three time period observation. Also, some authors recommend that these additional observations, obtained with the HP filter, are to be dropped (Baxter and King, 1999). For this reason we decided to work with the period 1988-2005.

[3]As a sensitivity check, we have also replicated all our calculations using detrended data after setting the lambda parameter of HP filter at 6.25 , and also the BK and the CF filter. The results are essentially the same, and can be obtained from the authors upon request.

As aforementioned in the introduction, a more centralized policy would be appropriate if the regional cycles followed a similar pattern. However, if the regional cycles present large discrepancies, a spatially targeted policy might be appropriate in order to offset the effects of national policies aimed to promote stability in the country as a whole. Under a scenario of low synchronization, these macroeconomic policies, which are spatially blind in design and impact, might have heterogeneous effects on those regions that are less synchronized with the national cycle and therefore might deepen undesirable regional disparities (Cho and McDougall, 1978; Hewings, 2009).

In Figure (3) we have graphed the degree of synchronization of output, considering the previous definition, of the thirteen regions of Chile with the national business cycle for the period 1988-2005[4]. It is evident that the Metropolitan Region is the most synchronized with the national business cycle, presenting a correlation of 0.97. This can be explained by two facts. First, the Metropolitan Region represents nearly 40% of national GDP wich might imply that the national business cycle is driven primarily by the cycle of this region. Second, this can be explained by the fact that many national policy decisions (monetary, fiscal and trade policies) are based solely on what occurs in this region or on measurements (such as inflation, employment and output) gathered mostly in this area[5]. As a result, a spatially blind policy such as monetary policy, might have the desired effect in both the country and this region[6]. On the other hand, there is a group of regions that are located on the periphery of the country, such as the XII, XI and I, whose correlations do not exceed 0.3. One implication of this is that, given a spatially blind policy, those regions that are far from the center might have different business cycle as compared to national business cycles. This reveals a spatial arrangement of regions characterized by a center-periphery pattern in relation to the configuration of the regional business cycles.

In recent research on business cycle synchronization, mobile windows have been used to observe the evolution of the correlation coefficients over time (Inklaar et al., 2008; Massmann and Mitchell, 2003). Figure (2) shows the evolution of average synchronization for 5-year mobile windows using

[4]This division does not consider the current administrative division. In 2007 two new regions were established, Los Rios Region (XIV) and the Region of Arica and Parinacota (XV).

[5]Until 2009, calculation of national inflation only considered a basket of goods, services and prices representative of Greater Santiago

[6]We understand the effect being sought as the acceleration or deceleration of the economy.

a smoothing parameter of 10 for the HP filter and the BK filter. First, it can be observed that average synchronization is not sensitive to the smoothing parameter, given that the two cases show very similar patterns. Secondly, average synchronization of regional cycles did not exceed an average correlation value of 0.3 which is quite low compared to more developed countries. For example, Kouparitsas (2002) and Carlino and Sill (1997) find that the business cycle correlation among regions of US range from 0.6 to 0.8. On the other hand, Barrios et al. (2003) find an average correlation coefficient among UK regions of 0.69. Finally, the degree of synchronization has considerably decreased since the beginning of 90's, reaching its lowest value after the Asian crisis (1998). However, in the last period from 2000 to 2005 the synchronization has increased progressively. These results show that the regional business cycles in Chile are poorly synchronized, and that the Asian crisis deepened this de-synchronization.

3 What factors influence the degree of regional synchronization?

This section provides a brief review of the main factors affecting the regional business cycles and the degree of synchronization. We are especially interested in learning about the factors that produce differences in regional cycles within a country. Hence, our aim is to adapt a proper structural model for the Chilean regional business cycle co-movement.

As mentioned above, the literature of international business cycle synchronization provides various determinants that may affect the degree of co-movement between countries. Among them are institutional factors; differences in macroeconomic policies, generally measured as differences in inflation, fiscal and exchange rate policy; trade frictions, such as tariffs and frictions in financial flows, etc. However, in a regional approach these variables become less important given the higher mobility of production factors and the absence of restrictions for trade. In view of the this, the theoretical framework developed in this section highlights the sources of regional cycles discrepancy found in the theoretical and empirical literature within the context of regional economics and international literature.

A basis for hypothesizing the existence of differentiated regional business cycles is found in the regional production structure. McLaughlin (1930) is the first in a long line of studies which highlights the industrial concentration as a source that affects the cyclical sensitivity of a region. McLaughlin's work stimulated a series of subsequent studies, both theoretical and empirical, which emphasize the degree of specialization or diversification of the regions. The pioneering theoretical model within this context was the export-base model developed by Vining (Vining, 1945, 1946a,b, 1949). One of the main conclusions of this model is that those regions with a preponderance of export commodities with high income elasticity of demand will be relatively less stable than those regions specializing in commodities with low income elasticity of demand. This interpretation is extended to the hypothesis that specialized regions in durable goods are relatively less stable than those not so specialized regions by recognizing that the durable nature of commodities is a key determinant of the income elasticity of demand. Several subsequent studies found empirical evidence of this fact by revealing a negative relationship between level of specialization of regions and cyclic stability (Neff and Weifenbach, 1949; Williams, 1950; Borts, 1960; Cho and McDougall, 1978).

The differences in production structures has also been studied in the international literature of the business cycles synchronization . Krugman (1993) stress that in the presence of industry-specific shocks a higher similarity in production structures across regions is likely to be associated with greater business cycle correlation, as two economies producing the same type of goods will be subject to similar stochastic developments. Empirical evidence of the positive relationship of structure similarity on business cycle synchronization is found by Clark and van Wincoop (2001), Barrios and Lucio (2003), Imbs (2004) among others.

The theoretical framework proposed by Vining to study regional business cycles is based essentially on the export-base theory. However, this model considers regions as isolated units that do not interact with each other. Recognition of this problem provides the basis for a new generation of models termed interregional business cycle models (Metzler, 1950; Airov, 1963; Van Duijn, 1973). An interregional model of economic fluctuations incorporates the links and feedbacks between regions. Regions within country are related primarily through their imports and exports to each other. This model indicates that an increase in spending or investment in a region generates multiplier effects in the other regions through the trade links among them. The stronger the trade ties, the greater the multiplier effects that are generated by the increased income of a region.

Due to the lack of trade data at the regional level, there is insufficient evidence on the effect of interregional trade on regional cycles. Nevertheless, the effect of international trade ties has been quite explored. The work of Frankel and Rose (1998) has been considered seminal for the analysis of trade and business cycles in potential optimum currency areas. They argued that one of the benefits of sharing the same currency is increased trade owing to reduced transaction costs. This increase in turn increases the correlation of business cycles, and strengthens the EMU. This result has been confirmed in the majority of subsequent studies that analyzed the determinants of synchronization of national cycles, independent of the manner in which this relationship is modeled.

The size of the regions may also have an effect on the sensitivity of regional business cycles since as regions grow in population, their industrial base is more likely diversified. Empirical evidence of this fact is found by Clark and van Wincoop (2001) and Barrios and Lucio (2003). They point out that greater similarity in the regional business cycles is highly influenced by the size of the regions as large areas implies greater opportunities for diversification within regions.

The regional impacts of both national and regional policies have been extensively studied. One aspect of national policy is related to the regional impact of a change in monetary policy. The theoretical (Beare, 1976) and empirical evidence (Carlino and Defina, 1998) have found that this policy does not affect all regions of a country in the same way, leading to differences in regional business cycles. From a regional perspective, it is unlikely that the policy maker has some control over monetary policy or national government spending. However, the regional policy maker can exert some influence on the regional business cycle through the attraction of investment. Through differentiated tax policies, increased spending on infrastructure and industrial development districts private firms may be attracted to a particular locations.

Other researchers have also been interested in the geographical aspect of the regional cycles. They have highlighted fairly early that economic changes in one region are transmitted to other regions and that business cycles do not occur evenly over time and space (Jeffrey et al., 1969; Jeffrey, 1974; King et al., 1969; Jones, 1983). More recent studies have found empirical evidence of clusters of regions with similar cyclical patterns, which reveals the existence of a spatial phenomenon (Cromwell, 1992; Carlino and Sill, 1997). As stated by Hess and Shin (1997), if there are geographic externalities either side of the demand or supply, then one would expect that economic activity in neighboring regions were more highly correlated than those that are not.

4 Empirical Methodology

Given the theoretical and empirical evidence discussed above, we note that there are generally five major factors that could explain the discrepancy in the regional business cycles, and hence their degree of synchronization: the degree of differences in production structures, interregional trade, differences in private investment, regional policy and spatial aspects. However, Chile does not have long time series of regional data and also it does not exist interregional trade data. The available data between 1988 and 2005 allow us to evaluate the following structural model based on the literature reviewed above:

$$\rho_{ij} = f\,(space, dissimilarity, private\ investment, size) \tag{1}$$

Since 1990 both the regional public investment series and regional export series are available, which allows us to extend the previous structural model above to:

$$\rho_{ij} = f\,(space, dissimilarity, private\ investment, size, regional\ policy, openness) \tag{2}$$

In an effort to check the robustness of our results, we use econometric techniques usually used to analyze the international synchronization of business cycles, namely: cross-sectional analysis, panel data and system of equations.

4.1 Cross-sectional estimation

Using our database between 1988 and 2005, we estimate the model defined in (1) as:

$$\rho_{ij} = \beta_0 + \beta_1 RL_{ij} + \beta_2 Dissimilarity_{ij} + \beta_3 Size_{ij} + \beta_3 Dpinv_{ij} + \epsilon_{ij} \tag{3}$$

where ρ_{ij} is the synchronization measure defined in section 2 between region i and j; RL_{ij} is a variable that considers the effect of the relative location of the regions in space; $Dissimilarity_{ij}$ is a variable that measures the extent to which differences in production structures influence the degree of synchronization and $Dpinv_{ij}$ measures the effect that private investment might have on the regional business cycle synchronization. This models is estimated by OLS and, as suggested by Frankel and Rose (1998), the standard errors of the parameters are estimated using White (1980) correction for heteroskedasticity.

A drawback of the regular correlation measure is its confinement to values between -1 and 1. Thus, the dependent variable in this regression is restricted to this range of values, which implies the distribution of the errors is not Gaussian and this complicate reliable inference (Otto et al., 2001). Given this, in our estimations we used a Fisher's z transformation on the correlation coefficients recommended by Inklaar et al. (2008). The transformed correlations do not suffer from this problem, since the transformation ensures that they are normally distributed. Formally, the transformed correlations coefficients are calculated as:

$$z_{ij} = 0.5 \ln \left(\frac{1 + \rho_{ij}}{1 - \rho_{ij}} \right)$$

Let us now explain how the independent variables were calculated and the coefficient we expect for each of these. Our first interest is analyze the effect of relative geography location among the regions in the whole country, since as noted in Section 2, those regions located in the center or the periphery may have different degrees of synchronization (see Figure (3)). To build this variable we follow Aroca and Hewings (2002). This variable is based on a connectivity matrix, where 1 indicates contiguous regions and 0 otherwise. Each element of the principal eigenvector of this matrix is a measure of the relative location of each region to the center of the country and its connectivity. The size of ranges from 0 to 1, where values close to 0 mean that the region is far from the center and has low connectivity. Alternatively, values close to 1 imply high connectivity and closeness to the center of the country. With this information and following Aroca and Hewings (2002), our variable is defined as:

$$RL_{ij} = \left(\frac{|e_i - e_j|}{(e_i + e_j)} \right) \times 100$$

Consequently, RL_{ij} will be between 0 and 100. When it is near 0, it means that regions i and j have relatively similar locations, that is to say, both are central or peripheral, while values near 100 indicate that regions i and j are relatively far apart, that is, one is central and the other is peripheral[7]. We expect a negative coefficient on this variable, i.e., the greater dissimilarity in the

[7] We had also included a distance variable, but due to its collinearity we decided to drop it.

geography location of the regions, the lower degree of synchronization.

As noted in the review of the determinants of regional business cycles, one of the main determinants, of the disparities, is the differences in production structure. Moreover, as stressed by Krugman (1993), in the presence of industry-specific shocks, a higher degree of dissimilarity in production structures across regions is likely to be associated with more idiosyncratic business cycles. Most empirical analyses using both regional (Clark and van Wincoop, 2001; Barrios and Lucio, 2003; Barrios et al., 2003) and national data (Imbs, 2004; Calderon et al., 2007), as well as in single and multiple equation settings (Imbs, 2004; Herrero and Ruiz, 2008) find that production structure dissimilarities have a negative impact on the degree of business cycle synchronization. Consequently, we use a measure of structural dissimilarity proposed by Krugman (1993):

$$Dissimilarity_{ij} = \frac{1}{T}\sum_{t=1}^{T}\sum_{s=1}^{S}\left|\frac{y_{it}^{s}}{y_{it}} - \frac{y_{jt}^{s}}{y_{jt}}\right|$$

where y_{it}^{s} is the GDP of sector s in the region i in the year t. The index is minimal when the productive structures are similar in the two regions and its range fluctuates between 0 and 2. The available data allows for measuring this index for 12 sectors in the considered period. Given the theoretical and empirical base provided in section 3, it can be expected that an increase in this index reduces synchronization of regional cycles.

Most of the literature finds that size contribute to explain within country business cycle correlations and has a positive impact on business cycles synchronization (Clark and van Wincoop, 2001; Barrios and Lucio, 2003; Barrios et al., 2003). On the other hand, size, which plays a central role in explaining bilateral trade flows in gravity models, can be seen as variable capturing the impact of trade on co-movement of economic activity. In our model $Size_{ij}$ is the natural logarithm of the combined population of regions i and j average in the time.

As multi-sector interregional models suggest (Van Duijn, 1973), the amount of investment in one region could have a significant influence on regional business cycles. Those regions with higher investment have more dynamic local economy which in turn generates multiplier effects throughout the economy. It is therefore hoped that, given the idiosyncratic elements in terms of multipliers and labor markets, each region responds differently to stimuli of investment. To analyze the influence of differences in private investment on the degree of synchronization we measured $Dpinv_{ij}$ as:

$$Dpinv_{ij} = \frac{1}{T} \sum_{t=1}^{T} \left| \frac{Pinv_{it}}{Pop_{it}} - \frac{Pinv_{jt}}{Pop_{jt}} \right|$$

where $Pinv_{it}$ and Pop_{it} are the private investment (measured as foreign direct investment) and the population, respectively, in region i in the year t. This index will be equal to zero when the two regions have the same level of per capita investment. Given the possible asymmetries in regional business cycles that can produce private investment, we expect a negative coefficient on this variable.

4.2 Panel data estimation

Other studies have considered a two-way error component model in order to study the degree of synchronization. This allows to distinguish between specific effects to certain regions-pairs or time periods. The inclusion of region-pair-specific effect serves two purposes. It allows to capture the time-invariant effects for each region-pair that might arise because omitted variables of the model. In this sense, region-pair-specific variable can capture issues such as synchronization due to strong bilateral trade ties that both region have.

A second argument in favor of including region-pair-specific effects is given by Glick and Rose (2002), who point out that the focus of the analysis should be on the time dimensions since the question of interest is whether, for example, the output correlation of a region pair decreases as dissimilarity in productive structure increase. With a cross-section approach it could be checked if region-pair with higher bilateral dissimilarity display lower output correlations than others. Nevertheless, it leaves out the development over time. Thus, our next step is to estimate the following two fixed effect models:

$$\rho_{ij,\tau} = \alpha_{ij} + \gamma X_{ij,\tau} + \epsilon_{ij,\tau} \quad (4)$$

$$\rho_{ij,\tau} = \alpha_{ij} + \beta_{\tau} + \gamma X_{ij,\tau} + \epsilon_{ij,\tau} \quad (5)$$

where α_{ij} is the region-pair-specific effect; β_{τ} is the time effect and $X_{ij,\tau}$ are the regressors explained in the previous section. We therefore split the sample in four subsamples in order to estimate models (4) and (5). These periods are: 1988-1992, 1993-1997, 1998-2002 and 2003-2005.

4.3 System of equation estimation

A more appropriate model should consider the different channels through which the variables can affect the degree of synchronization (Imbs, 2004; Herrero and Ruiz, 2008). On the other hand, our database has a greater number of available variables in the period 1990-2005 allowing us to enrich the model to be estimated and analyzed the effect of other variables on synchronization (see model 2). For example, we are interested in testing whether policies focused on regions have contributed to the regional business cycle synchronization. To incorporate the effect of regional policy, we proxy a similarity indicator using regional public investment, which we defined as:

$$Dpi_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{Pi_{it}}{Pop_{it}} - \frac{Pi_{jt}}{Pop_{jt}}\right|$$

where, Pi_{it} is public investment in region i in the period t.

Furthermore, as explained by the export-base models, the level of trade openness and integration that has a region is an important source of regional cycles. Moreover, as Poncet and Berthélemy (2008) point out, one would expect that a more similar intensity of international trade between regions may lead to greater synchronization business cycles, since they are exposed to similar international shocks. Under this scenario, similar levels of trade for regions would lead to similar cyclical patterns between them. To control this effect, we define *Open* as:

$$Open_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{Exp_{it}}{y_{it}} - \frac{Exp_{jt}}{y_{jt}}\right|$$

where Exp_{it} is the level of exports in the region i in the period t. This variable measures the similarity in the intensity of international trade between two regions.

Figure (4) shows the final theoretical model that considers two endogenous variables: differences in private investment per capita and public investment per capita; and a set of controls, or exogenous variables, for each equation. These two variables are considered endogenous because an increase in public investment, such as highways, bridges, sewer system, infrastructure, can be viewed as input in the production process of private industry which affects both the location of firms and investment decisions (Fisher and Turnovsky, 1998). On the other hand, those regions experiencing an increase in their level of private investment and do not have adequate infrastructure, requires local governments to invest in facilities to provide necessary conditions for industries.

We estimate this system of simultaneous equations using three stage least squares (3SLS). This method of estimation has two main advantages: first, it allows for the inclusion of multidirectional channels of influence in the estimation process of some of variables on the degree of synchronization, and thus obtain the direct and indirect effects (Imbs, 2004; Herrero and Ruiz, 2008). This avoids the problems of over- or under-estimation that can arise in the estimations of reduced form equations. It also allows for controlling some of the endogeneity of the independent variables. The 3SLS estimator combines the technique of instrumental variables and the generalized least squares method, obtaining consistency through the instrumentalization of endogenous variables and efficiency in the estimation of the variance-covariance matrix. Formally, we estimate the following system of equations:

$$\rho_{ij} = \alpha_0 + \alpha_1 \ln Dpi_{ij} + \alpha_2 \ln Dpinv_{ij} + \alpha_3 I_{1,ij} + \epsilon_{1,ij} \quad (6)$$

$$\ln Dpinv_{ij} = \gamma_0 + \gamma_1 \ln Dpi_{ij} + \gamma_2 I_{2,ij} + \epsilon_{2,ij} \quad (7)$$

$$\ln Dpi_{ij} = \beta_0 + \beta_1 \ln Dpinv_{ij} + \beta_2 I_{3,ij} + \epsilon_{3,ij} \quad (8)$$

where $Dpinv_{ij}$ and Dpi_{ij} capture the differentials in private investment and public investment, respectively, between pairs of regions. The vector $I_{n,ij}$ is a set of controls for equation n. For the identification of the system it is required that $I_{1,ij} \neq I_{2,ij} \neq I_{3,ij}$. In Equation (6) we include the main variables suggested by the empirical and theoretical literature as determinants of the degree of intra-national synchronization (ρ_{ij}). In Equation (7) we explain the differentials in private investment among the regions ($Dpinv_{ij}$) by means of the variables suggested by the theory of the gravitatory models. Finally in Equation (8) we contrast the determinants of the differentials of public investment (Dpi_{ij})[8].

As mentioned previously, the estimation of this system of equations allows estimating direct and indirect effects of each variable, getting also their net effects. In this way, the net effect of the

[8] Controls for equations are described in appendix

variable $Dpinv_{ij}$ is given by:

$$\begin{aligned}\frac{d\hat{\rho}_{ij}}{d\hat{Dpinv}_{ij}} &= \frac{\partial\hat{\rho}_{ij}}{\partial \hat{Dpinv}_{ij}} + \frac{\partial\hat{\rho}_{ij}}{\partial \hat{Dpi}_{ij}}\frac{d\hat{Dpi}_{ij}}{d\hat{Dpinv}_{ij}} \\ &= \alpha_2 + \alpha_1\beta_1 \end{aligned} \tag{9}$$

While, the net effect of the variable Dpi_{ij} is given by:

$$\begin{aligned}\frac{d\hat{\rho}_{ij}}{d\hat{Dpi}_{ij}} &= \frac{\partial\hat{\rho}_{ij}}{\partial \hat{Dpi}_{ij}} + \frac{\partial\hat{\rho}_{ij}}{\partial \hat{Dpinv}_{ij}}\frac{d\hat{Dpinv}_{ij}}{d\hat{Dpi}_{ij}} \\ &= \alpha_1 + \alpha_2\gamma_1 \end{aligned} \tag{10}$$

Following Imbs (2004), the coefficients of (9) and (10) are estimated by the delta method, which allows for estimating the variance of an estimator generated from the transformation of one or more random variables.

5 Results

As a first approximation, we drew a scatter plot for our measure of synchronization against regressors. Figure (5) shows that the synchronization has a negative relationship with relative location *RL*, the logarithm of *Dissimilarity* and the logarithm of *Dpinv*, while this is positive with the logarithm *Size*. The next step is to verify to what extent these relationships are consistent when we control for all of them.

Table 1 reports the results when estimating model (3) by OLS with HP ($\lambda = 10$) over the whole sample period 1988-2005[9]. Column one shows that variable *RL* is negative and significant, confirming the result shown in Figure (5). This result has two interesting implications. First, this result promotes the idea that space measured by the relative location of the regions in Chile plays an important role in the degree of synchronization. Second, it reveals that the peripheral regions follow a synchronization pattern different from the central regions of the country.

In column two, we evaluate the impact of *LR* controlling for *Size*. The coefficient on *RL* holds negative and significant, and the coefficient on *Size* is significantly different from zero and, as

[9]Estimation results using data detrended with the two alternative methods, HP ($\lambda = 6.25$) and BK, are essentially the same, and can be obtained from authors upon request

expected, positive. That is, the larger the regions the greater their degree of synchronization.

As mentioned earlier, the productive specialization of regions plays an important role on the degree of synchronization. In column three, we measure the effect of RL when we additionally control for $Size$ and $Dissimilarity$. As expected from theory, regions with less similar production structures have more asymmetric business cycles. This is, ceteribus paribus, an increase in $Dissimilarity$ has a negative and significant effect on the degree of synchronization. It is worth noting that RL and $Size$ maintain their sign and significance after controlling for $Dissimilarity$.

The Chilean regions are characterized by a very heterogeneous spatial distribution of private investment which could result in volatile and asymmetric business cycles. In the fourth column we estimate model (3) where we control for $Dpinv$. This variable presents a negative sign but is not significant, while the other variables maintain their sign and significance.

The next step is to improve the baseline regression by looking at region-pair specific and time effects for the periods 1988-1992, 1993-1997, 1998-2002 and 2003-2005. Table (2) reports the results for the panel data approach. The first column shows the OLS estimates for the pooled data; the second and third columns show the one-way fixed and random effect estimates (model (4)), respectively; and the fourth and fifth columns show the two-way fixed and random effect estimates (model (5)), respectively. Furthermore, we have carried out a Hausman test over FE and RE models for both one-way and two-way. In both case, this leads to no rejection of the null hypothesis that RE provides consistent estimates, this is, the region-pair-specific effects do not appear to be correlated with the regressors. Therefore, our analysis is based on RE models. The coefficients on RL, $Dissimilarity$ and $Size$ are significant in both one-way and two-way model and with the expected sign. This confirms the previous results and shows the robustness of these variables even controlling for region-pair-specific and time effect.

Table (3) shows the estimations for the system of equations (6), (7) and (8), using 3SLS. The first column is the estimation for the first period 1990-1997 (pre Asian crisis); the second column corresponds to the period 1998-2005 (post Asian crisis) and the third column correspond to the whole subsample period 1990-2005. The variable RL is negative and significant for the first period and for the whole sample, which indicate that relative location was a important factor in the pre-crisis period. *Size* presents a similar result. Our variable measuring differences in production structures *Dissimilarity* retains its sign and significance in the second period and over the whole subsample period.

The differences in sensitivity to external shocks are captured by the variable *Open*. The direct impact of this variable on the degree of synchronization is positive for the post-crisis period. This indicates that the higher degree of trade openness of some regions in the period 1998-2005 resulted in these regions having more homogeneous business cycles. In effect, international integration acts as a stabilizing force and facilitates regional adjustments to idiosyncratic shocks (Poncet and Berthélemy, 2008). For private investment, the variable *Dpinv* has a negative and significant sign for the second period confirming that private investment has heterogeneous effects on regional business cycles, promoting desynchronization (Van Duijn, 1973). It is also worth noting that considering all the channels through which the variable *Dpinv* can influence synchronization, it presents a negative and significant sign for the second period.

It was of interest to us to determine whether or not policies at the regional level has promoted synchronization. To accomplish this, we have added the variable *Dpi* which represents the differences in per capita regional public investment. Public investment in Chile is oriented to promote economic growth and regional social development. To achieve these objectives, regional public investment has been oriented mainly to the construction of infrastructure and social investment, influencing the openness of economic activities in support of private investment and attention to the basic needs of the population. In the 1990s, public investment had the objective of reducing the gap between the existing levels of infrastructure and maintaining social equity in regional terms.

It can be observed in Table (3) that public investment has contributed to the synchronization of regional cycles in both pre and post-crisis period. It can also be observed that public investment has promoted private investment, given the positive and significant sign that it presents in Equation (7). But this indirectly implies that public investment has a negative effect on synchronization. As well, considering all the channels through which this variable can influence synchronization, it can be observed that its effect is negative and significant for the second period. This is, considering its effect through *Dpinv* its net effect on the synchronization is negative.

6 Conclusion

The first objective of this study is to analyze the level of intranational synchronization in Chile, a country characterized by regions with a high level of specialization and high concentration of population, economic activity and national policy decision-making in the Metropolitan Region.

Using the correlation of regional business cycles regarding the national business cycle, we show that exists a spatial pattern wherein the peripheral regions follow a pattern different from the more central regions. For instance, the Metropolitan Region, which is the nation's capital, shows a greater degree of synchronization with the national cycle in comparison to regions that are located geographically in the periphery of the country. This is due to two possible factors: its large share of product compared to the national product and the fact that national policies are tailored based on measurements building just for this region. This implies that a spatially blind policy might deepen regional inequalities, affecting negatively to regions at geographic extremes and benefiting the Metropolitan Region and those regions that follow the national cycle.

Moreover, we found a low degree of synchronization between the Chilean regions in contrast to the case of more developed countries such as UK, USA and China which show a higher degree of synchronization. We also found that the trend has been towards further cyclical divergence rather convergence between the Chilean regions in the nineties, especially after the Asian crisis. These results show that there is a low level of interregional integration and, therefore, little evidence that the Chilean regions are an optimum currency area. As indicated by Rissman (1999), under this scenario it is necessary to consider policies with a regional focus, since with a low degree of synchronization a centralized policy is not warranted.

Our second objective was to develop an econometric model that allowed us to identify the observed co-fluctuation patterns. Using various econometric techniques to test the robustness of our results, we found that regions with similar production structures, size, and spatial patterns have higher degree of synchronization. These results, on the one hand, are consistent with those previously found in the literature. On the other hand, these finds are important from the perspective of economic policy. Because it is likely that more diversified and larger regions react similarly to a national policy, it is necessary to promote policy focused on the regions that are not, especially in the periphery regions which might be in other stage of the cycle. In this way, the possible negative effects of spatially blind policies might be offset or mitigated. Within this context, our results show that policies aimed specifically at regions such as public investment have promoted the synchronization level and have helped to stabilize fluctuations in product. But, the differentials in private investment have the opposite effect.

Finally, the results also show that the synchronization of the regional cycles in Chile is lower in recession time, therefore policy with regional focus should be taylored especially when the economy is going down.

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A Data Base

The following table shows the variables used in this work and its source.

Variable	Definition	Data source
Regional GDP	Regional GDP in millions $2003	Banco Central
Population	Regional Population	INE
FDI	Foreign domestic Investment. Millions of Chilean pesos	Comité de inversiones extranjeras
Public Investment	Effective regional public investment. Millions of Chilean pesos	Ministerio de Planificación
Public Expenditure	Regional public social expenditure. Millions of Chilean pesos	Ministerio de Planificación
Export	Total exports in the region. Millions of Chilean pesos	Ministerio de Planificación
Infrastructure	Regional expenditures made in paving. Thousands of Chilean pesos	Ministerio de Planificación
Distance	Distance in kilometers between the centroids of the regions.	Geoda

B Controls for the system of equations.

1. Controls equation (7)

   (a) To control for the fact that the northern regions, which are purely mine, receive a greater volume of private investment in relative terms, we add the variable Ady that takes the value 1 when two regions have a common border and 0 otherwise. Also, we add the distance between the centroids of the regions.

   (b) To control for differences in regional infrastructure, we define the variable $Infras$ as:

   $$Infras_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{Pav_{it}}{Pop_{it}} - \frac{Pav_{jt}}{Pop_{jt}}\right|$$

   where Pav_{it} is the spending on paving in the region i in the year t.

   (c) We added a variable to indicate the differences in terms of market across regions. We define $Dpop$ as:

   $$Dpop_{ij} = \frac{1}{T}\sum_{t=1}^{T}|Pob_i - Pob_j|$$

2. Controls equation (8)

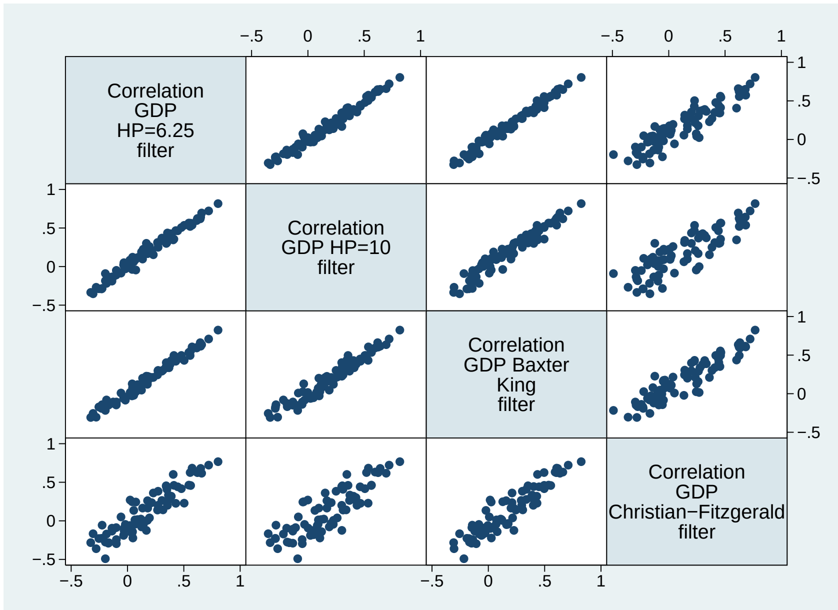
   (a) For this equation we use as a control variable $Dpop_{ij}$, since it is expected that larger regions receive more public investment. Also add a variable that indicates the differences in public spending, which we define as:

   $$Dse_{ij} = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{Se_{it}}{Pop_{it}} - \frac{Se_{jt}}{Pop_{jt}}\right|$$

   where, Se_{it} is the social spending in the region i in period t.

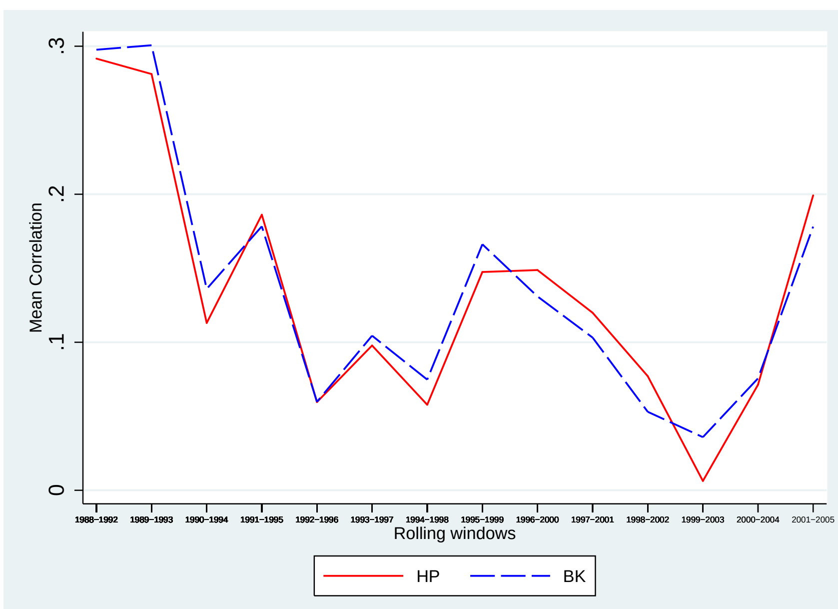
C Figures and Tables

Figure 1: Comparison of Filters (1988-2005)



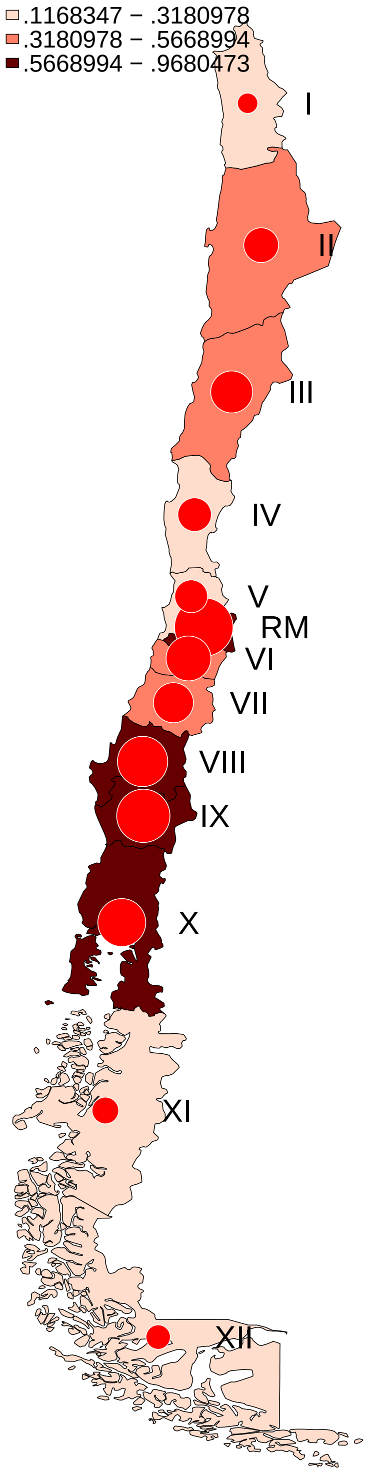
Source: Authors

Figure 2: Average of Bilateral Business Cycle Correlation, 5-year moving windows, 1988-2005



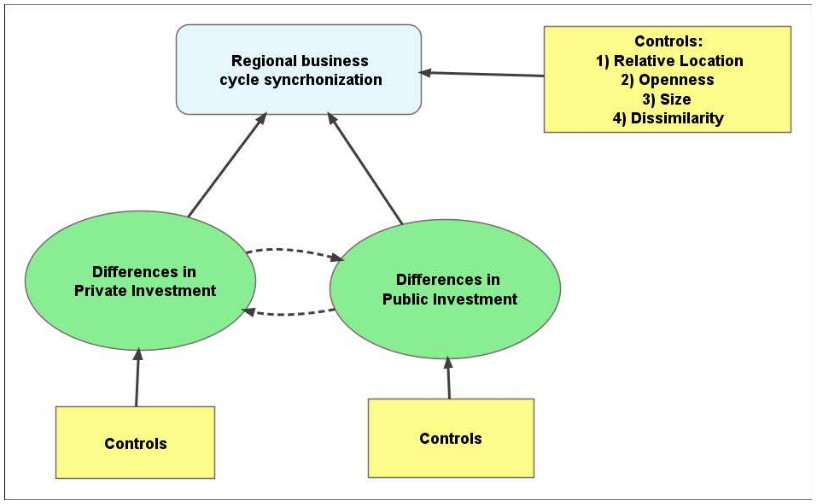
Source: Authors

Figure 3: Synchronization of Regional Cycles in Relation to the National Cycle, 1988-2005



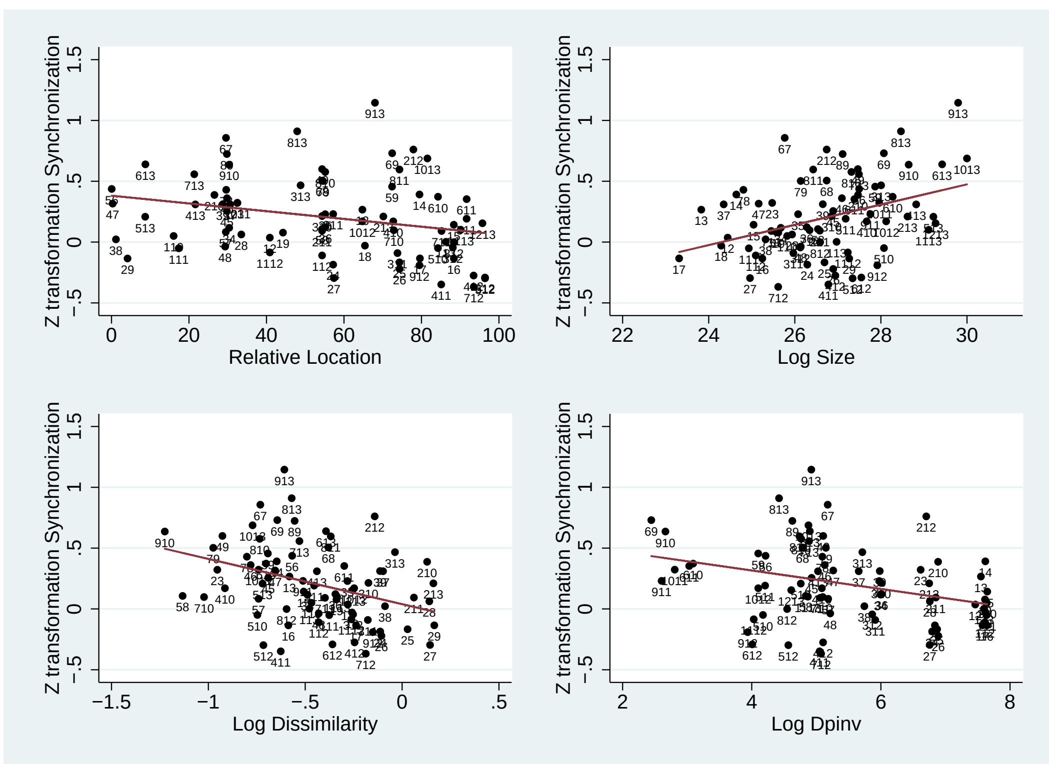
Source: Authors. The size of the bubbles represents the relative value of the regions.

Figure 4: Theoretical Model



Source: Authors

Figure 5: Scatter Plot for Variables on the Degree of Synchronization, (1988-2005)



Source: Authors

Table 1: Cross-Section Estimations, Full Sample (1988-2005)

	(1)	(2)	(3)	(4)
RL	-0.003***	-0.004***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Size		0.088***	0.079***	0.078**
		(0.024)	(0.022)	(0.031)
Dissimilarity			-0.317***	-0.315***
			(0.088)	(0.101)
Dpinv				-0.001
				(0.032)
Constant	0.382***	-1.961***	-1.860***	-1.838*
	(0.071)	(0.634)	(0.585)	(0.984)
N	78	78	78	78
R^2	0.074	0.229	0.323	0.323

Robust standard errors in parentheses
All variables in log, except *RL* and the depedent variable
Dependent Variable: z's transformation on correlations
Filter: HP with $\lambda = 10$
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Panel Data Estimations

	(1) OLS	(2) FE One Way	(3) RE One Way	(4) FE Two Way	(5) RE Two Way
RL	-0.004**		-0.004**		-0.004**
	(0.00)		(0.00)		(0.00)
Dissimilarity	-0.609***	-1.159**	-0.609***	-1.123**	-0.672***
	(0.15)	(0.47)	(0.16)	(0.48)	(0.17)
Size	0.117***	0.162	0.117***	0.990	0.147***
	(0.04)	(0.36)	(0.04)	(1.57)	(0.04)
Dpinv	-0.038	-0.113*	-0.038	0.007	0.009
	(0.03)	(0.06)	(0.04)	(0.08)	(0.04)
Constant	-2.677**	-3.978	-2.677**	-26.405	-3.583***
	(1.18)	(9.64)	(1.27)	(41.71)	(1.30)
Time dummies	No	No	No	Yes	Yes
N	312	312	312	312	312
Husmann χ			3.545		1.459
P-value			0.315		0.692

Robust standard errors in parentheses
All variables in log, except *RL* and the depedent variable
Dependent Variable: z's transformation on correlations
Filter: HP with $\lambda = 10$
Hausmann Test H_0: RE is consistent
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: System of Equation Estimation

	1990-1997			1998-2005			1990-2005		
	z	*Dpinv*	*Dpi*	z	*Dpinv*	*Dpi*	z	*Dpinv*	*Dpi*
Dpinv	-0.009		0.559***	-0.458***		0.834***	-0.082		0.614***
	(0.08)		(0.05)	(0.15)		(0.10)	(0.08)		(0.07)
Dpi	0.170**	1.782***		0.229***	0.985***		0.106**	1.664***	
	(0.08)	(0.17)		(0.08)	(0.16)		(0.05)	(0.20)	
Dissimilarity	-0.290			-0.370*			-0.281*		
	(0.22)			(0.20)			(0.16)		
Size	0.095*			0.037			0.087**		
	(0.05)			(0.06)			(0.04)		
Open	0.044	0.236***		0.170**	0.103		0.081	0.194**	
	(0.06)	(0.08)		(0.07)	(0.08)		(0.05)	(0.08)	
RL	-0.006***			-0.001			-0.003***		
	(0.00)			(0.00)			(0.00)		
Infras		-0.730***			-0.179			-0.903***	
		(0.17)			(0.16)			(0.22)	
Adyacency		0.515*			0.081			0.116	
		(0.30)			(0.26)			(0.26)	
Dpop		-0.303***	0.166***		-0.224**	0.206***		-0.366***	0.178***
		(0.10)	(0.06)		(0.10)	(0.07)		(0.10)	(0.06)
Distance		0.396***			0.093			0.149	
		(0.14)			(0.14)			(0.13)	
Dse			0.318***			0.241***			0.355***
			(0.05)			(0.05)			(0.05)
Constant	-2.315	8.355***	-4.277***	1.051	5.977**	-5.177***	-1.793	11.842***	-4.571***
	(1.77)	(2.29)	(0.88)	(2.09)	(2.54)	(1.09)	(1.37)	(2.76)	(0.89)
N	78			78			78		
R^2	0.202	0.569	0.677	-0.182	0.461	0.497	0.372	0.615	0.710
NE *Dpinv*	0.085			-0.267**			-0.017		
t	1.394			-2.523			-0.282		
NE *Dip*	0.153			-0.222*			-0.031		
t	1.410			-1.915			-0.304		

Robust standard errors in parentheses
All variables in log, except *RL*, *Adyacency* and the synchronization measure
Filter: HP with $\lambda = 10$
Dependent Variable: z's transformation on correlations
NE: Net effect
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$