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# An Exploration of Similarities between National and Regional Economic Activity in the Inland Northwest

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With this latest monograph from the Institute for Public Policy & Economic Analysis, I welcome you to Eastern Washington University. I hope this research will broaden your understanding of the Inland Northwest. Efforts like the Institute monograph series are manifestations of this university's commitment to serve the region. I applaud the initiative of my predecessor and of the current Board of Trustees to launch this Institute.

Teaching remains our core mission at Eastern Washington University. Increasingly, teaching and research are interwoven. Our faculty members keep professionally current when publishing in peer-reviewed journals. These achievements, in turn, allow them to better convey the evolving knowledge base of our academic disciplines.

Our students receive an enhanced education if their classroom experience is informed by the content and enthusiasm of their professor's research. Increasingly, we ask students to conduct research projects of their own. Whether conducting their own projects or assisting professors, our students acquire a richer learning experience through research.

Research for academic journals is not the only area our faculty members target, however. Our university asks its faculty to engage the communities and region from which we draw our students. This research provides a greater sense of place and a commitment by our faculty to it. It also translates academic methods and findings into a broader, and ultimately more relevant, arena: the lives of the citizens of the Inland Northwest.

The overarching goal of the Institute for Public Policy & Economic Analysis is to serve the region by translating knowledge. It does this through a variety of activities, including this series, annual economic forecasts, contract research and the Community Indicators Initiative. I invite you to explore its web site to learn more.

I come to Eastern with great hope that, together with our faculty, staff and partners, I can further anchor our institution to the daily course of life throughout the Inland Northwest. Our collective future depends on an educated and informed citizenry. Helping our region reach higher levels of knowledge is something this university can and will do.

My office and that of the Institute director welcome all comments on how we might better serve.

A handwritten signature in black ink that reads "Rodolfo Arévalo". The signature is written in a cursive, flowing style.

Rodolfo Arévalo, Ph.D.  
President

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## I. Executive Summary

This monograph examines the association between national economic activity and economic activity in the Inland Northwest. A common view is that the Inland Northwest does not follow the national economy very closely. However, most of the evidence put forth to support this view is largely anecdotal. Therefore, the purpose of this monograph is to examine whether or not this commonly held view is true.

This monograph's overriding conclusion is that regional economic activity, measured by the annual growth rate of real per capita personal income for eight Inland Northwest counties, has had a historically strong association with national economic activity. In other words, this study finds no compelling evidence that the behavior of the regional economy over the last three decades has been fundamentally divorced from the behavior of the national economy.

Using linear correlation and regression analysis, this study finds that:

- With the exception of Whitman and Lincoln Counties, there is a *statistically significant and positive* association between national and regional real personal income growth over a 33 year period, adjusted for transfer payments.
- In the case of Bonner and Pend Oreille Counties, the strength of their associations with the national economy saw a statistically significant decrease for the 1986–2002 period compared to the 1970–1985 period. This was not the case, however, for the other six counties
- Finally, with the exception of Lincoln and Whitman Counties, which have showed no significant correlation with the nation, the region has historically tracked the national economy *without* significant leads or lags measured in years.

## II. Introduction

This monograph examines the association between national economic activity and economic activity in the Inland Northwest. A common view is that the Inland Northwest does not follow the national economy very closely. However, most of the evidence put forth to support this view is largely anecdotal. Therefore, the purpose of this monograph is to examine whether or not this commonly held view is true.

Understanding the degree of association between national and regional economic activity is important for both public and private sector entities. In particular, it can give the region's key economic actors a more realistic perspective on the region's ability to share in national economic expansions or resist national contractions. In turn, this can mean more rational budgeting and hiring models based on forecasts of national economic activity. In a contrast, a poor understanding of the Inland Northwest's connection to the national economy means a greater likelihood that important economic decisions will be based upon unrealistic assumptions of the region's historical behavior over the business cycle.

For efficiency purposes, the geographic focus is on the region's most populous counties. These are: Lincoln, Pend Oreille, Spokane, Stevens, and Whitman counties in Washington; Bonner, Kootenai, and Latah Counties in Idaho.<sup>1</sup> The relevant data for this study are annual changes in real per capita personal income, less transfer payments. The choice of this series rests in the limited economic data that are comparable and have been collected consistently for both the nation and its counties.

Since changes in economic variables occur over time, time-series data is the primary focus of studies examining the short- and long-run behavior of economic activity. In fact, there are literally hundreds of studies examining the behavior of economic time-series. In the case of research into regional economies, economists started exploring regional cycles

following World War II when there were substantial improvements in the availability of regional time-series data. A brief discussion of this early work can be found in Vining (1947). As the length and quality of regional time-series increased, researchers began to apply more sophisticated types of analysis to uncover the extent to which regional economic activity differed from that observed at the national level.

Studies that are directly comparable to this analysis are McGee and Goodman (1965) and Cho and McDougall (1978). McGee and Goodman examine the Southeastern U.S. over the period 1945–1961; Cho and McDougall examine major urban areas in the United States over the period 1954–1975. Both studies, which focus primarily on employment, find that regional economies tend to follow the national economy and, where timing differences exist, the differences are not typically large. For example, Cho and McDougall find most urban areas lag the national economy over the business cycle, but the typical lag is only four months or less. Interestingly, for the study's time period, Seattle had one of the lowest overall correlations with national economy.

However, the sophistication of any time-series analysis is directly linked with a particular data series' length (total number of observations), which, in turn, is influenced by the frequency (daily, monthly, quarterly, yearly, etc.) at which the series is compiled. In the case of personal income, county data are reported annually, starting in 1969. As a result, the analysis here is limited to simple correlation and regression analysis due to the length of the series.

The rest of the monograph is organized as follows: Section III provides the analysis of real personal income growth; Section IV provides the overall conclusions of the analysis; and Appendix A briefly describes the applied statistical techniques.



# III. Measuring Regional Economic Connectivity to National Activity via Changes in Real Per Capita Personal Income

## Data and Analytical Techniques

The focus here is on the growth in real per capita personal income generated by employment, the provision of goods and services, and capital ownership. Nominal income data come from The Bureau of Economic Analysis (BEA); the BEA defines personal income (PI) as "...income that is received by persons from all sources. It is calculated as the sum of wage and salary disbursements, supplements to wages and salaries, proprietors' income with inventory valuation and capital consumption adjustments, rental income of persons with capital consumption adjustment, personal dividend income, personal interest income, and personal current transfer receipts, less contributions for government social insurance." PI is then calculated on a per capita basis (PPI) by dividing a region's total annual personal income by its population in the same year.<sup>2</sup>

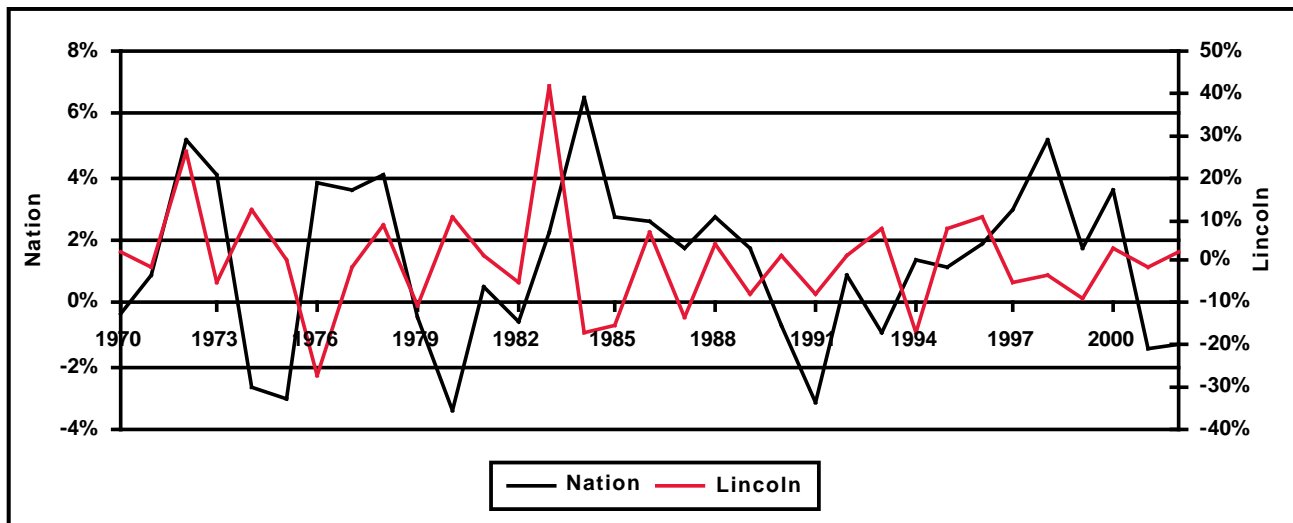
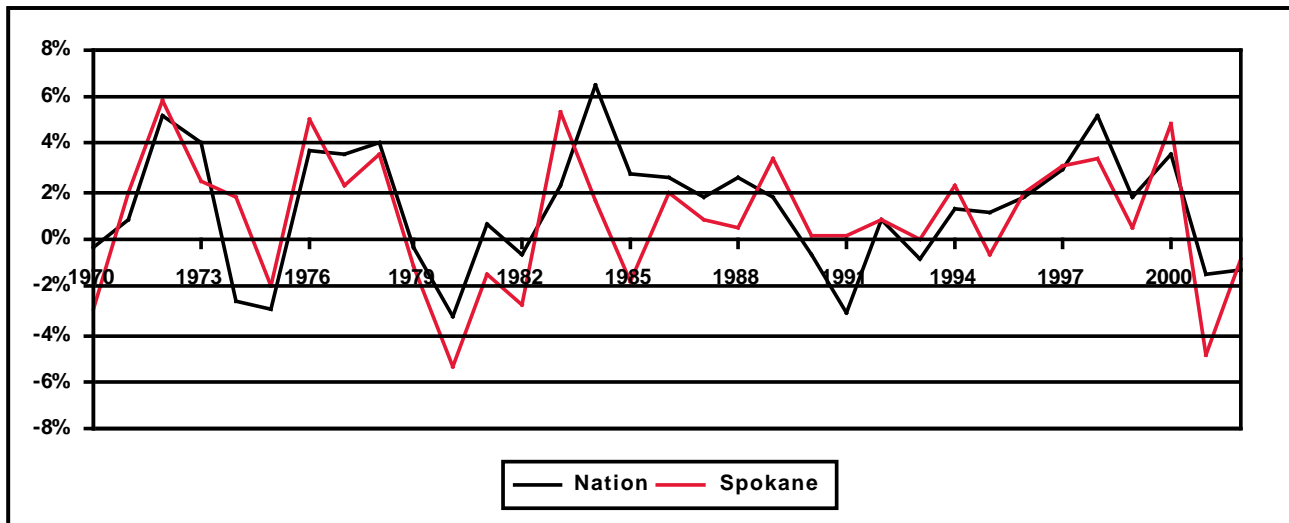
The measure of PPI used here is adjusted for transfer payments and changes in the price level. In particular, to reduce the impact of transfer payments and price changes on PPI, transfer payments are first subtracted out and then the data are "deflated" by the appropriate consumer price index.<sup>3</sup> This converts nominal PPI to transfer payment adjusted, real PPI (RPI) for the nation and the eight counties of interest.

Transfer payments, which reflect government payments in the absence of employment or the provision of services, are subtracted out because they are either unrelated to the business cycle or, as in the case of unemployment benefits, are designed to be counter-cyclical. According to the BEA, examples of transfer payments are "... retirement and disability insurance benefits,

medical payments (mainly Medicare and Medicaid), income maintenance benefits, unemployment insurance benefits, veterans benefits, and Federal grants and loans to students."<sup>4</sup> Compared to nominal income, real income is a better measure of economic activity since it reflects the value of income in terms of actual goods and services. In effect, deflating removes the distortions caused by persistent inflation.

The annual growth of RPI over year  $t$ , abbreviated as  $g_t$ , is calculated as  $g_t = (RPI_t / RPI_{t-1}) - 1$ . For example, the growth rate for 1970 is  $g_{1970} = (RPI_{1970} / RPI_{1969}) - 1$ , the growth rate for 1971 is  $g_{1971} = (RPI_{1971} / RPI_{1970}) - 1$ , and so on. When this is done for both the national and county series, the result is a total of 33 observations for the nation and each county. For example, Figure 1 shows the time-series of the growth rate of RPI for the nation, Spokane County, and Lincoln County. Spokane County appeared to follow the national economy closely, with roughly the same highs and lows. In contrast, Lincoln County appeared to bear little resemblance to the national data.

**Figure 1: Selected Comparison of National and County Annual Growth Rates of Real Per Capita Income, 1970-2002**



Since the goal of the monograph is to more precisely characterize the relationship between the national and regional economies, the remainder of this section focuses on correlation and regression analysis. Appendix A provides a more detailed explanation of these techniques. However, before proceeding, it is crucial to understand that the statistical methods used here are *not* proof of cause and effect relationships in the traditional sense. Generally, it is very difficult, if not impossible, to use traditional statistical methods to generate iron-clad proof of causal relationships between complicated economic events. In other words, because

real-world economic outcomes are not generated in a controlled laboratory setting, cause and effect relationships cannot be carefully isolated. Therefore, it is best to consider these methods as establishing evidence of *statistical associations* between economic variables that are testable for statistical significance.

## Analysis of Changes in Growth Rates of Real Per Capita Personal Income

Table 1 gives the average and standard deviation of  $g_t$  for each of the eight Inland Northwest counties and the U.S. The standard deviation is a statistic that measures the dispersion, or volatility, of a random variable around its average value. The larger a series' standard deviation, the more volatile it is.

**Table 1: Descriptive Statistics for the Annual Growth Rate of Real Per Capita Income 1970-2002**

Region	Arithmetic Average	Standard Deviation	Volatility F-test
Nation	1.32%	0.06%	-
Lincoln	0.04%	1.61%*	25.02
Whitman	0.24%	0.64%*	9.95
Stevens	0.39%	0.28%*	4.36
Pend Oreille	0.95%	0.27%*	4.24
Kootenai	1.40%	0.27%*	4.15
Latah	1.56%	0.26%*	4.08
Bonner	1.01%	0.16%*	2.50
Spokane	0.90%	0.08%	1.20

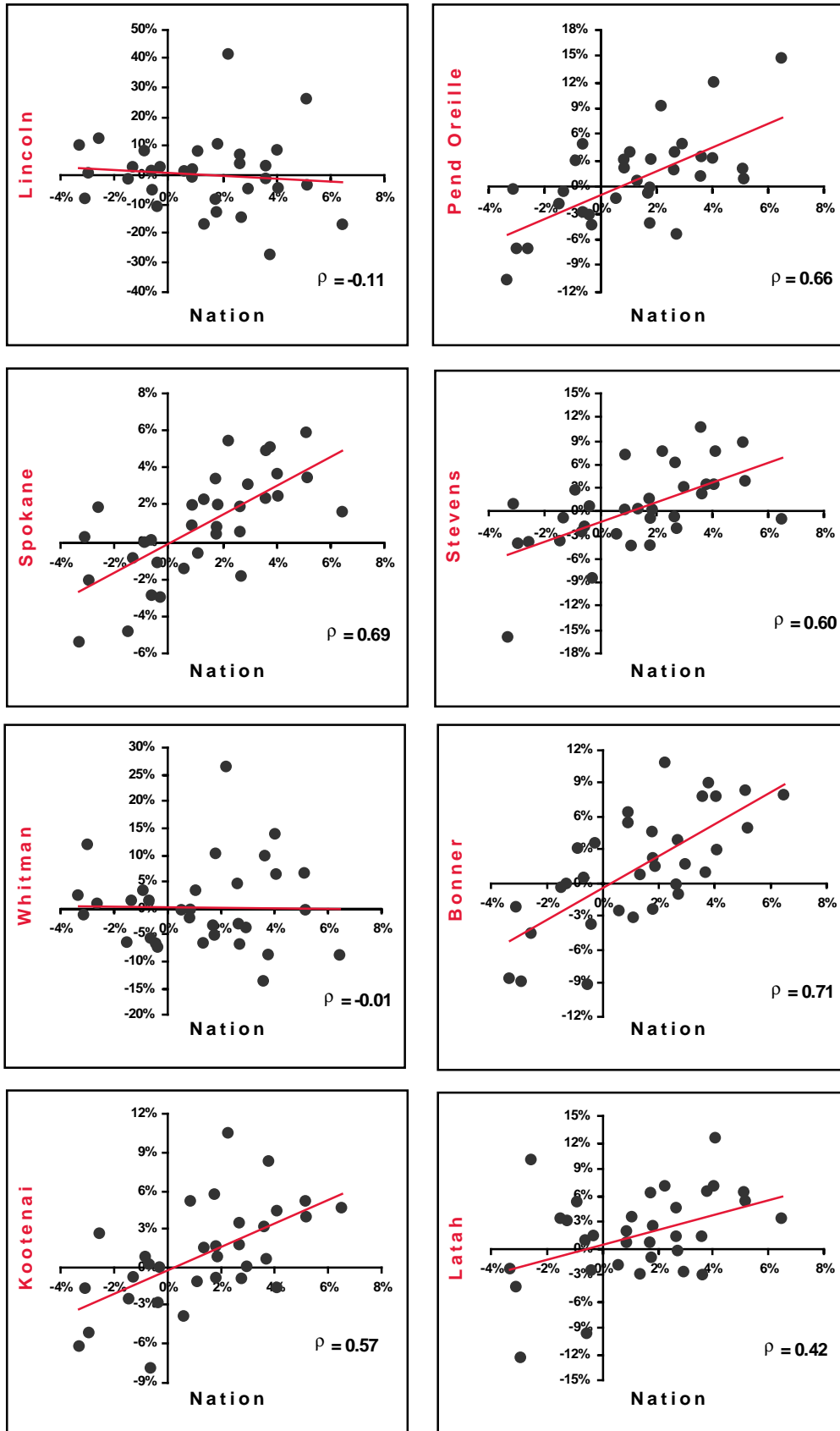
Note: \* indicates that the standard deviation is statistically larger than the national data at the 5% level based on a difference in variance F-test. This test is conducted by dividing the square of a county's standard deviation by the square of the nation's standard deviation; this ratio is compared to a statistical table calculated for the F-test.

The county standard deviations show that the Inland Northwest's annual growth rate of RPI was significantly more volatile relative to the nation over this period. In particular, with the exception of Spokane County, the counties' standard deviations were statistically higher than the nation's. Spokane County's behavior likely reflects its metropolitan status, which is more representative of the national economy than the more rural counties. Generally, however, the volatility pattern in Table 1 indicates that income growth in the Inland Northwest can vary strongly year-to-year.

Figure 2 shows a series of scatter plots where the annual growth rate of RPI of the nation ( $g_{t,n}$ ) lies on the horizontal axis and that of a given county ( $g_{t,c}$ ) lies on the vertical axis. This means a given point on any graph

represents the combination ( $g_{t,n}, g_{t,c}$ ) for  $t = 1970, 1971, \dots, 2002$ . Each plot also shows the estimated correlation coefficient ( $\rho$ ) and the estimated regression line based on the simple linear regression model  $g_{t,c} = A + B(g_{t,n}) + \epsilon_t$  (see appendix A). The estimates of A and B, defined as  $\alpha$  and  $\beta$ , are summarized in Table 2, where the counties are arranged by highest to lowest  $\rho$ -value over the 1970-2002 period.<sup>5</sup> The  $\rho$  and  $\beta$  estimates that are statistically different from zero are noted by an asterisk.

**Figure 2: Scatter Plots of Annual Growth Rates for Real Per Capita Income for 8 Inland Northwest Counties vs. Nation, 1970-2002**



**Table 2: Results of the Regression and Correlation Analysis on Annual Growth Rates of Real Per Capita Income**

Time Period	1970–2002			1970–1985	1986–2002
County:	$\alpha$	$\beta$	$\rho$	$\beta_1$	$\beta_2$
Bonner	-0.0051†	1.4420*	0.71*	1.7918‡	0.7253‡
Spokane	-0.0010†	0.7593*	0.69*	0.7390	0.8009
Pend Oreille	-0.0085†	1.3588*	0.66*	1.6934‡	0.6734‡
Stevens	-0.0127†	1.2545*	0.60*	1.5164	0.7178
Kootenai	-0.0019†	0.9079*	0.57*	1.0105	0.6977
Latah	0.0045†	0.8433*	0.42*	1.0190	0.4833
Whitman	0.0029†	-0.0405†	-0.01†	-0.1706	0.2262
Lincoln	0.0074†	-0.5257†	-0.11†	-0.5762	-0.4221

Note: † indicates that a value is not statistically different from zero at the 5% level. \* indicates that a value is statistically different from zero at the 5% level; ‡ indicates that the change in slope is statistically significant at the 5% level.

For purposes of interpretation, the closer the  $\rho$ -value is to one, the closer the point groupings around the regression lines in Figure 2. The higher the value of  $\beta$ , the steeper the estimated regression line. In this respect,  $\beta$  can be thought of as a county's historical "beta-sensitivity" to changes in the national growth rate.<sup>6</sup> For example, a beta-sensitivity greater than one ( $\beta > 1$ ) means that for every 1% point change in  $g_{t,n}$  (i.e.,  $g_{t+1,n} - g_{t,n} = \pm 1\%$ ),  $g_{t,c}$  will change by more than 1% in absolute value. The opposite would be true for a beta-sensitivity between zero and one ( $0 < \beta < 1$ ).

Figure 2 and Table 2 demonstrate that with the exception of Whitman and Lincoln Counties, there is a statistically significant, positive association between the national growth rate of RPI and each county's growth rate of RPI over the 33 year period. This means that six of the eight counties have tended to track the national economy through the business cycle, as measured by changes in income growth. In turn, this suggests that the Inland Northwest's economic performance is not as divorced from the national economy as previously thought.

However, the values of  $\rho$  and  $\beta$  do vary between counties. For example, in the case

of Bonner County, historically a 1% point increase in the national growth rate was associated with a 1.442% point increase in the county's growth rate. In other words, on average over the 33 year period, the Bonner County's beta-sensitivity was greater than one. On the other hand, Latah County's beta-sensitivity was 0.8433%, or less than one.

In this context, it is interesting to note that Spokane County has the lowest statistically significant beta-sensitivity in Table 2. This may reflect the historical importance of government employment related to national defense and education. More specifically, if public sector employment, compared to private sector employment, is less sensitive to business cycle fluctuations, then this could be working to dampen Spokane County's beta-sensitivity to the national economy. Finally, for Whitman and Lincoln Counties, it is worth emphasizing their beta-sensitivities *are not* statistically different from zero. Therefore, it is concluded that over the period of interest, these two counties experienced no significant correlation with the national growth rate of RPI (positive or negative).

So far, the evidence suggests that a significant historical association exists

between six counties in the Inland Northwest and the nation, in terms of the growth rate of RPI. However, there are two important issues that need to be explored. The first is the *timing* between the national and regional economies. The second issue is one of *structural change*.

### Are There Leads or Lags in this Relationship?

Consider again Figure 1. Sometimes Spokane’s RPI growth was synchronized with the national economy, as in the 1979–1982 contraction; sometimes it was leading, as in the 1982–1984 expansion; and at other times it was lagging, as in the 1987 to 1990 expansion. If a county is consistently out-of-sync with the national economy,

statistically different from zero. This means that the county growth rate of RPI is typically reaching its cyclical peaks or troughs a year *before* the national economy. On the other hand, if  $\rho_{+1} > \rho$ , then a county has the tendency to lag the nation, reaching its cyclical peaks or troughs a year *after* the national economy.

More importantly, however, with the exception of  $\rho_{-1}$  for Bonner County, none of the lag/lead  $\rho$ -values are statistically different from zero. Therefore, with the exception of Lincoln and Whitman Counties, which show no significant correlation values, we conclude that the region has historically tracked national income growth without significant leads or lags measured in years.

**Table 3: Relationships between Inland NW Counties and the US, via Correlation Coefficients of Real Per Capital Income Growth**

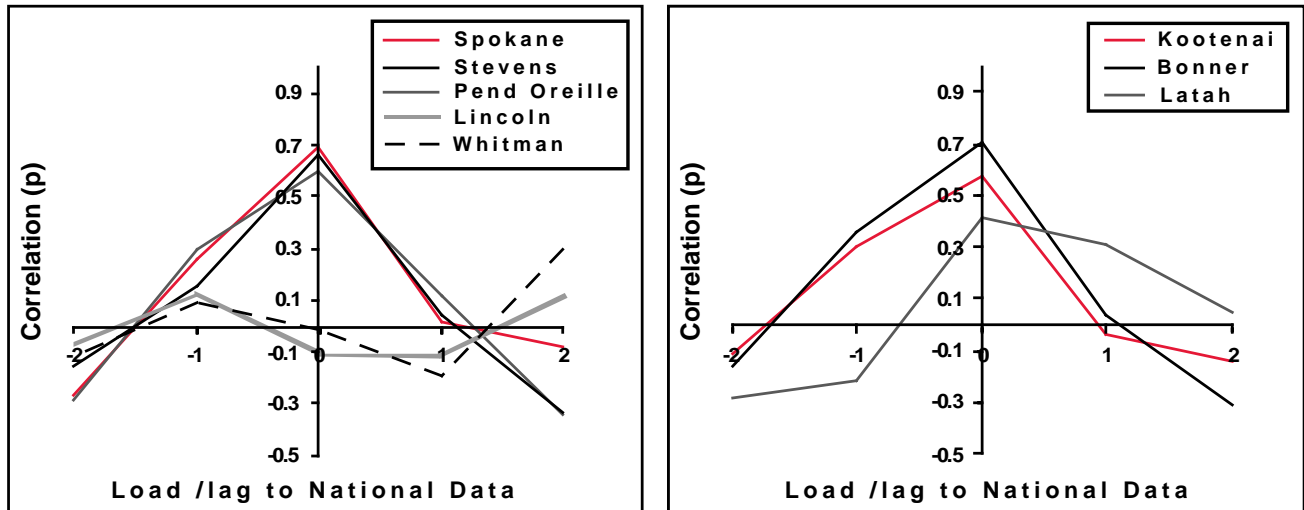
Correlation Outcome	Interpretation
$\rho_{-2} > \rho$	County has led nation by two years.
$\rho_{-1} > \rho$	County has led nation by one year.
$\rho_{+1} > \rho$	County has lagged nation by one year.
$\rho_{+2} > \rho$	County has lagged nation by two years.

then, when calculated at different leads or lags to the national economy, the correlation coefficient for that lead or lag should be higher than the contemporaneous  $\rho$ -values shown in Table 2.

To investigate this, correlation coefficients are calculated for leads and lags of  $\pm 2$  years so that  $\rho_{-2} = \rho(g_{n,t}, g_{c,t-2})$ ;  $\rho_{-1} = \rho(g_{n,t}, g_{c,t-1})$ ;  $\rho_{+1} = \rho(g_{n,t}, g_{c,t+1})$ ; and  $\rho_{+2} = \rho(g_{n,t}, g_{c,t+2})$ . If  $\rho_{-2}$  or  $\rho_{-1}$  is positive and larger than  $\rho$ , then a county has historically *led* the nation in changes in RPI. On the other hand, if  $\rho_{+2}$  or  $\rho_{+1}$  is positive and larger than  $\rho$ , then a county has historically *lagged* the nation. The table below summarizes these relationships.

For example, assume for the moment that  $\rho_{-1} > \rho$ , and that  $\rho_{-1}$  is positive and

**Figure 3: Lagged, Leading, and Contemporaneous Correlations of Annual Growth Rates of Real Per Capita Income, 1970-2002**



Lead/Lag	Lincoln	Pend O.	Spokane	Stevens	Whitman	Bonner	Kootenai	Latah
-2 yrs.	-0.06	-0.16	-0.27	-0.29	-0.12	-0.16	-0.11	-0.28
-1 yr.	0.13	0.16	0.26	0.30	0.09	0.36*	0.30	-0.22
0	-0.11	0.66*	0.69*	0.60*	-0.01	0.71*	0.57*	0.42*
+1 yr.	-0.11	0.04	0.02	0.12	-0.20	0.03	-0.04	0.31
+2 yrs.	0.12	-0.33	-0.08	-0.34	0.29	-0.31	-0.14	0.05

Note: \* indicates that a value is statistically different from zero at the 5% level.

Figure 3 plots and lists these  $\rho$ -values for each of the eight counties. Note that the absolute size of the  $\rho$ -values for different leads and lags are, with exceptions for Lincoln and Whitman Counties, noticeably less than the size of the contemporaneous  $\rho$ -values.

### Did the Relationship between the Inland Northwest and the U.S. Change over Time?

Structural change refers to significant changes in the statistical behavior of economic data over time. In the case of the growth rate of RPI, this could be due to changes in the mix of industries nationally or regionally, such as shifts away from manufacturing in favor of services. Alternatively, significant changes in the nation's macroeconomic performance, such as a permanent reduction in the

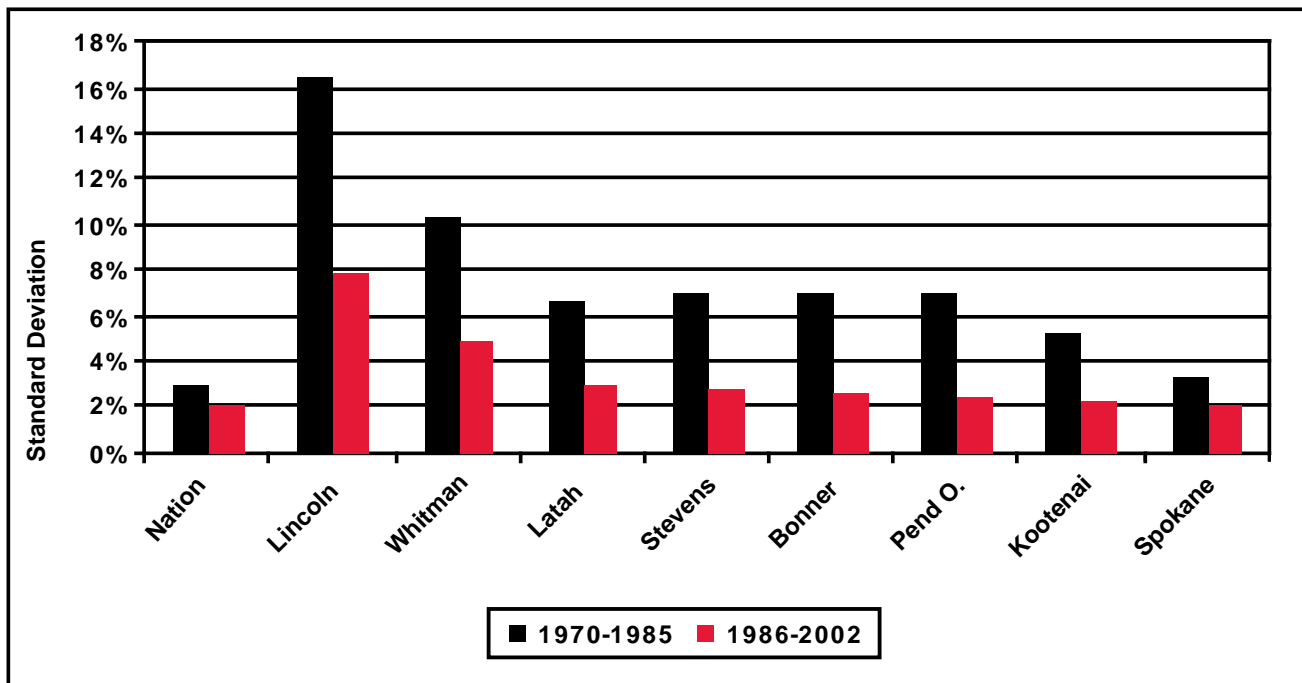
inflation rate or changes in the behavior of the business cycle, could also create structural change in the economy. Signs of structural change in a data series include significant changes in the series' volatility (as measured by standard deviation) or its historic correlations with other variables.

Consider Figures 4 and 5. Figure 4 shows the standard deviation of RPI growth for the periods 1970 to 1985 and 1986 to 2002.

Figure 5 shows the rolling 10-year  $\rho$ -value between the nation and each of the counties starting in 1979. The division of the data in Figure 4 reflects several important changes in the national economy following the mid 1980s. One was the transition from a high- to a low-inflation environment. This transition was due in part to changes in Federal Reserve monetary policies in the 1980s and long-term reductions in real oil and



**Figure 4: Standard Deviations of Annual Growth Rates of Real Per Capita Income over two Different Periods, 1970-2002**



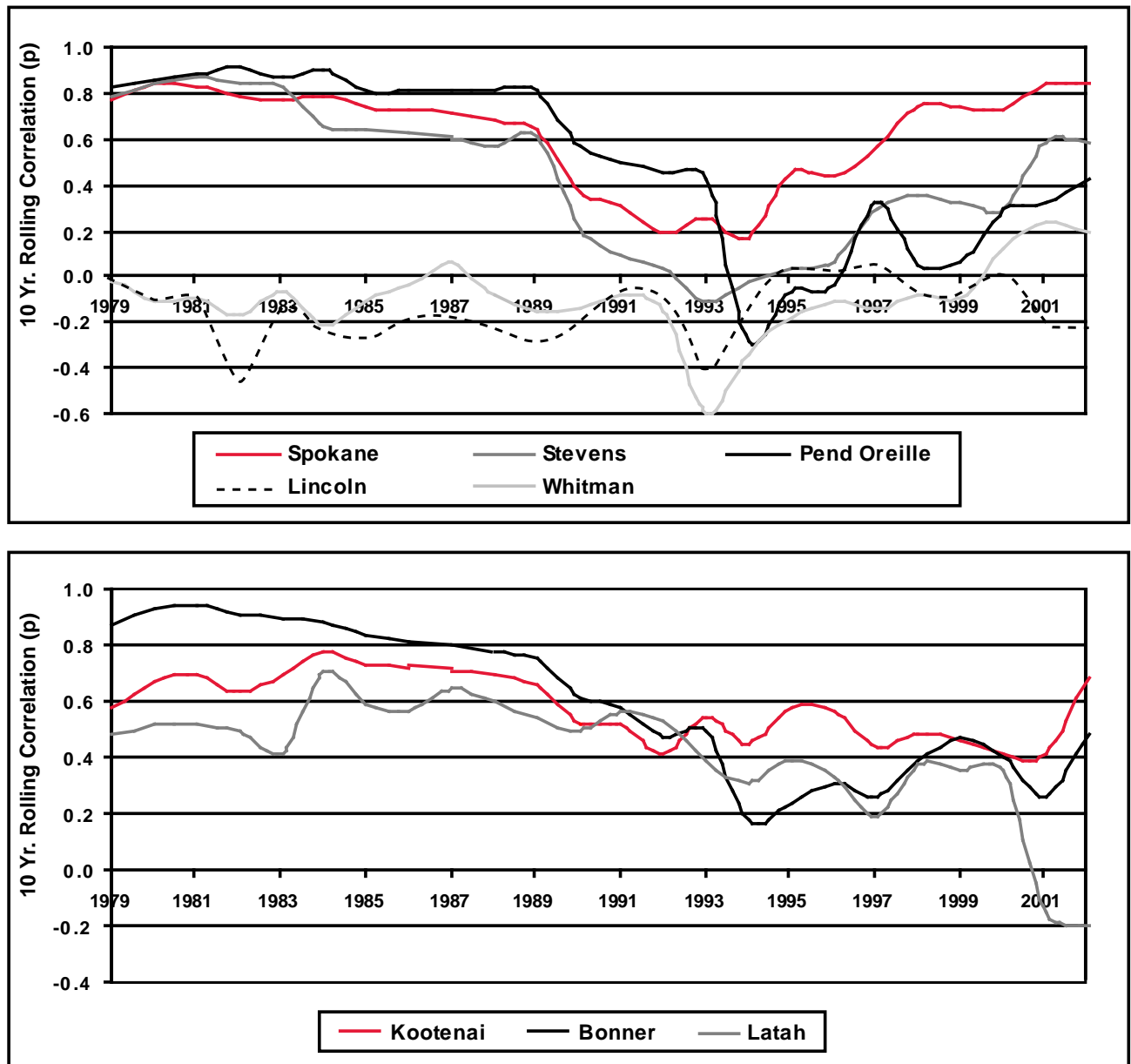
gas prices following the price shocks of the 1970s and early 1980s. Another was the passage of the 1986 Tax Reform Act, which resulted in long-term reductions in the top marginal tax rates for income earners and corporations. In the case of Figure 5, a 10-year rolling period is applied to smooth over data volatility that might mask long-term correlation trends.

Figure 4 clearly shows that nationally and regionally, there is a noticeable reduction in the volatility of RPI growth in the 1986–2002 period. In Figure 5, from the late 1980s to mid 1990s,  $\rho$  declines for most counties and then, by the late 1990s,  $\rho$  stabilizes or starts to rise again. However, in the case of Pend Oreille, Bonner, and Latah, the overall decline in  $\rho$  since the 1970s is fairly significant. In effect, both graphs suggest that some structural change may have occurred over the 33 year period. If there have been significant structural changes in the historical association between the regional and national economies, then the counties’

beta-sensitivities should be statistically different for the two different time periods in Figure 4. The last two columns in Table 2 show estimates of  $\beta$ -values for the periods 1970–1985 ( $\beta_1$ ) and 1986–2002 ( $\beta_2$ ).<sup>7</sup>



**Figure 5: Rolling 10-Year Correlations to the U.S. of Annual Growth Rates of Real Per Capita Income, 1970-2002**



Although Table 2 shows a decrease in the estimated size of the beta-sensitivity for most counties, only in the case of Bonner and Pend Oreille Counties is the decrease statistically significant. This does not mean that the other six counties did not experience some structural change; rather, it means the estimated sizes of the change cannot be easily distinguished from zero. In turn, this suggests that structural change has been more acute in Bonner and Pend Oreille than the other six counties.

This may reflect the declining importance of the Inland Northwest's natural resource based industries, which were important employers in counties like Bonner and Pend Oreille prior to the 1990s. Therefore, it's possible that this decline has caused the decline in their beta-sensitivities to the broader economy.

## IV. Conclusions

The overriding conclusion of this study is that regional economic activity, measured by the annual growth rate in real per capita personal income for eight Inland Northwest counties, has had a historically strong association with national economic activity measured by the same income variable. In other words, this study finds *no* compelling evidence that the behavior of the regional economy over the last three decades has been fundamentally divorced from the behavior of the national economy.

Using linear correlation and regression analysis, this study finds that, with the exception of Whitman and Lincoln Counties, there is a statistically significant and positive association between national and regional personal income growth over a 33 year period, adjusted for transfer payments. In the case of Bonner and Pend Oreille Counties, the strength of this relationship, in a slope or sensitivity sense, saw a statistically significant decrease for the 1986–2002 period compared to the 1970–1985 period. For most other counties, the relationship remained statistically stable over the 33 year period. Finally, with the exception of Lincoln and Whitman Counties, which show no significant correlation values, the region has historically tracked the national economy without significant leads or lags measured in years.

Given these conclusions, it is important to state again that the statistical methods used here are *not* proof of cause and effect relationships in the traditional sense. Therefore, it is best to consider the methods used here as establishing evidence of *statistical associations* between economic variables that are testable for statistical significance.

Since income is not the only measure of economic activity, future Institute research on this topic will also use measures of

employment. However, existing employment measures pose some challenges. In particular, the U.S. Bureau of Labor Statistics has been collecting county data that are comparable to the national data only since the early 1990s. In addition, the frequency of the data is monthly. This means, compared to the BEA's income data, the county data have a higher frequency over a shorter period of time.

This introduces two complications. The first is a high degree of seasonality that can be difficult to model using more traditional correlation and regression methods. The second is that the data's time period only encompasses two recessionary periods and two expansionary periods. This means, relative to the RPI series, there are fewer major business cycle events that can be used to characterize the Inland Northwest's response relative to the nation's response. For this type of data series, Fourier analysis, sometimes called spectral analysis or harmonic analysis, offers an alternative approach to the methods used in this monograph. Since the 1960s, Fourier analysis has been widely applied by economists trying to better understand the underlying cyclical nature of many economic time-series.

# Appendix A:

## A Brief Primer on Correlation and Regression Analysis

Given the limited number of observations, simple linear correlation and regression analysis are the best methods to analyze the national and county growth rates of RPI. In addition to being suitable for smaller data sets, the statistical results, compared to other methods, are easier to interpret.

Consider two variables  $y$  and  $x$  that are observed over time, such that we have  $x_t$  and  $y_t$  for  $t = 1, 2, 3, \dots, N$  observations (i.e., the number of  $x$  values is equal to the number of  $y$  values). Assume  $x$  and  $y$  can take on both positive and negative values. Correlation analysis allows us to test the degree of historical association between  $x$  and  $y$  over time by computing the statistic of linear correlation,  $\rho = \rho(x_t, y_t)$ . By construction,  $\rho$  is bounded by  $-1$  and  $1$ .

Consider the extremes of  $-1$  and  $1$ . If  $\rho = 1$  then the series are perfectly, positively correlated, and a standard  $x$ - $y$  graph would appear as a series of points lying on a linear line with an upward slope. More generally, if  $\rho > 0$ , then as  $x$  increases in size,  $y$  has the tendency to do the same; similarly, as  $x$  decreases in size,  $y$  has the tendency to do the same. If  $\rho = -1$ , then the series are perfectly, negatively correlated, and a standard  $x$ - $y$  graph would appear as a series of points lying on a linear line with a negative slope. More generally, if  $\rho < 0$ , then as  $x$  increases in size,  $y$  has the tendency to do the opposite; similarly, as  $x$  decreases in size,  $y$  has the tendency to do the opposite. In contrast, if  $\rho = 0$ , then the  $x$ - $y$  graph would appear as a series of points on a horizontal line. That is, if  $\rho = 0$ , then no slope-relationship, positive or negative, exists between  $x$  and  $y$ .

With real world economic time-series it is rare to find a situation where  $\rho$  is exactly equal to  $-1$ ,  $1$ , or zero. As a practical matter,  $\rho$  will usually be *between*  $-1$  and  $1$ , and never exactly zero. Therefore, what researchers are typically interested in is whether or not  $\rho$  can be shown to

be *statistically different* from zero. In other words, is the absolute value of  $\rho$  large enough (i.e., non-trivial in size in the positive or negative direction) that it can be distinguished from a value of zero? In this case, the advantage of  $\rho$  as a measure of association is that it can be subjected to statistical tests to determine the likelihood that it is not equal to zero.

Although the correlation statistic is very useful in describing the overall association between two data series, it has one important limitation in this respect: it is not a direct measure of the slope relationship between series. In other words, if  $\rho > 0$ , then a positive slope relationship exists between  $x$  and  $y$ ; however,  $\rho > 0$  does not directly describe the numerical *sensitivity* of the association. That is, given a change in  $x$  over time ( $\Delta x = x_{t+1} - x_t$ ),  $\rho$  does not tell us what, on average, has been the associated historical change in  $y$  ( $\Delta y = y_{t+1} - y_t$ ).

Via a tool called linear regression analysis, a function that approximates the average historical relationship between  $x$  and  $y$  can be estimated from a hypothesized relationship taking the form  $y_t = A + B(x_t) + \epsilon_t$ , where  $\epsilon_t$  is assumed to be a normally distributed random error term with a zero mean. In effect, regression analysis generates statistical estimates of  $A$  and  $B$  so that a “best fit” regression line of the form  $y_t^e = \alpha + \beta(x_t)$  results. Therefore,  $\alpha$ , often called the “intercept value”, is the expected (i.e., predicted) value of  $y$  ( $y^e$ ) if  $x$  equals zero, and  $\beta$  is the estimated “slope value” of the regression line.

In other words,  $\beta$  measures the *average* historical sensitivity of  $y$  to changes in  $x$ . More generally, the larger  $\beta$  is in absolute terms, the more sensitive  $y$  is to changes in  $x$ . Like correlation,  $\alpha$  and  $\beta$  can also be tested to determine if they are statistically different from zero. Note also that there is a connection between  $\rho$  and  $\beta$ : if  $\rho$  is positive, then  $\beta$  should also be positive and visa versa; if  $\rho$  cannot be distinguished from a value of zero, then the same will hold true for  $\beta$ .

## Endnotes

- <sup>1</sup> Although there is no single geographic definition of the Inland Northwest, it is generally thought to include the counties in northeastern Washington and the northern “panhandle region” of Idaho.
- <sup>2</sup> PPI estimates are available annually from the BEA at [www.bea.gov](http://www.bea.gov). BEA data for the Inland Northwest is also available from the Northwest Income Indicators Project (NIIP) at <http://niip.wsu.edu>. NIIP is sponsored by Washington State University and run by Dr. Gary W. Smith.
- <sup>3</sup> National PPI was deflated using the national consumer price index for urban consumers; county PPI was deflated using the Western States’ consumer price index for urban consumers.
- <sup>4</sup> For an analysis of transfer payments in Spokane and Kootenai Counties, see Geddes (2004).
- <sup>5</sup> A simple linear regression model may not always be sufficient for describing the relationships between data series; therefore, the models  $g_{t,c} = A + B_1(g_{t,n}) + B_2(g_{t,n})^2 + \epsilon_t$  and  $g_{t,c} = A + B_1(g_{t,n}) + B_2(g_{t,n})^2 + B_3(g_{t,n})^3 + \epsilon_t$  were also tested. However, for all counties the statistical significance of  $\beta_2$  and  $\beta_3$  were generally substantially below the 5% level. In addition, several tests were run on the estimated error terms generated by the simple linear model. The Durbin–Watson test was used to test for error term autocorrelation out to five lags; the test indicated no significant autocorrelation for the regressions in Table 2 where  $\beta$  is significantly different from zero. Multiple tests for error term normality were also run and, where  $\beta$  is significantly different from zero, the tests failed to reject the assumption of normality. As a result, the simple linear model appears sufficient for modeling the data’s behavior. For additional detail, see also Appendix A.
- <sup>6</sup> For those familiar with the Capital Asset Pricing Model (CAPM), the  $\beta$  here is similar in concept to the share  $\beta$ ; a share  $\beta$  measures the historical sensitivity of an individual stock’s rate of return to changes in the overall market’s rate of return.
- <sup>7</sup> Here the regression model takes the form  $g_{t,c} = A + B(g_{t,n}) + \Phi(d_t * g_{t,n}) + \epsilon_t$ , where  $d_t$  is a variable that takes on the value of zero for the 1970–1985 period and a value of one for the 1986–2002 period;  $\Phi$  is the “shift value” associated with the second time period when  $d_t = 1$ . That is, if  $d_t = 0$ , then  $g_{t,c} = A + B(g_{t,n}) + \epsilon_t$ . if  $d_t = 1$ , then  $g_{t,c} = A + (B + \Phi)(g_{t,n}) + \epsilon_t$ . In Table 2,  $\beta_1$  is the regression estimate for the 1970–1985 period and  $\beta_2 = (\beta + \varphi)$  is the estimate for the 1986–2002 period, where  $\varphi$  is the regression estimate of  $\Phi$ . If  $\varphi$  is statistically different from zero, then the structural change is of statistical significance. The Chow test for structural change was also applied to the data; this test confirmed the results in Table 2.

## References

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