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This paper analyzes the effects of industry structure similarities, free trade agreements, and geographic borders on regional business cycle correlation, using fifty US states, 10 Canadian provinces, and 1 Canadian territory as a case study. Using two cross-sectional OLS regressions and one panel data OLS regression, this study finds that pair-wise gross territorial product growth correlation decreased significantly after NAFTA ratification for state-state, province-province, and state-province territorial pairs, contrary to previous literature's results. NAFTA effectively decoupled intra-national business cycles in the US and Canada while also desynchronizing cross-border pair-wise GSP growth correlation, but cross-border pair-wise GSP growth correlation was much less desynchronized post-NAFTA relative to intra-national pairs. These results indicate that NAFTA and the US-Canada border may produce two opposing forces that dampen each other's desynchronizing effects.

**Keywords**
free trade, free trade agreement, business cycle, industry structures, NAFTA

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This paper analyzes the effects of industry structure similarities, free trade agreements, and geographic borders on regional business cycle correlation, using fifty US states, 10 Canadian provinces, and 1 Canadian territory as a case study. Using two cross-sectional OLS regressions and one panel data OLS regression, this study finds that pair-wise gross territorial product growth correlation decreased significantly after NAFTA ratification for state-state, province-province, and state-province territorial pairs, contrary to previous literature's results. NAFTA effectively decoupled intra-national business cycles in the US and Canada while also desynchronizing cross-border pair-wise GSP growth correlation, but cross-border pair-wise GSP growth correlation was much less desynchronized post-NAFTA relative to intra-national pairs. These results indicate that NAFTA and the US-Canada border may produce two opposing forces that dampen each other's desynchronizing effects.

## Introduction

The United States and Canada have a unique economic relationship. Sharing the longest unfortified border in the world, similar cultures, and a common language, the two nations are each others' largest trading partners. US-Canada goods trade increased dramatically after 1988, when the Canada-United States Free Trade Agreement (CUSFTA) was ratified, eliminating tariffs on most trans-border goods trade. 1994 witnessed the ratification of the North American Free Trade Agreement (NAFTA), superseding CUSFTA. NAFTA's immediate effects were to reduce or eliminate the majority of remaining tariffs on motor vehicles, computers, textiles, agriculture, and other commodities between the US, Canada, and Mexico. With tariffs and barriers removed, goods trade in these sectors increased appreciably from 1994 to 2004, jumping 110.1% over a period of ten years. As of 2007, exports and imports to and from the US constitute 81% and 67% of total Canadian exports and imports, respectively, while exports and imports from Canada comprise 23% and 17% of total US exports and imports.

This astronomical rise in US-Canada goods trade, spurred by advances in North American economic integration, is hotly debated in Canadian policy circles. Opponents of the two trade agreements argue that further economic integration will tighten alignment of the Canadian business cycle with that of the US due to increased trans-border goods flows and bind growth in export-driven sectors of the Canadian economy to developments in American markets. Blayne Haggart, a research analyst reporting to Canadian Parliament, voiced concerns that "Greater economic integration will lead to the dissolution of Canada (2001)". The monetary economist Thomas Courchene also noted in his empirical research that "We are witnessing the rise of 'region-states', where geographic regions trade within their own area (2000)". This scenario culminates in Canada's economic degeneration into a market integrally linked to developments in US goods and asset markets.

Answering the question of whether trade agreements and industry structure similarity synchronize regional business cycles would determine whether North American trade integration is inextricably tying Canadian goods markets to those of the US. This paper analyzes the effects of industry structure similarity, the US-Canada border, and NAFTA ratification on synchronicity of regional US and Canadian economic growth from 1984 to 2004. The analysis finds that GDP growth correlation at the state and provincial level decreased significantly after NAFTA ratification. Agriculture and mining industry structure similarities were found to have strongly positive and statistically significant impacts on GSP growth correlation. Convergence of industry structure similarity in these two sectors increases predicted GSP growth correlation appreciably. Manufacturing industry structure similarity was not found to be a statistically significant determinant.

Prior to NAFTA ratification, the border weakened predicted cross-border pair-wise correlation by 31.4%. However, NAFTA and the border may have produced two opposing channels that served to dampen the desynchronizing effect. After NAFTA ratification, the border desynchronized cross-border pairs by only 13.7%. NAFTA's deregulatory effects may have spurred increases in intra-industry trade volume between states and provinces that were not possible between intra-national pairs.

Intra-nationally, NAFTA desynchronized state-state and province-province pairs by 24.1%. The border dampened NAFTA's desynchronizing effect to some extent, with cross-border pairs' predicted correlation coefficients reduced by only 6.4%. The geographic border and NAFTA ratification negate each other's desynchronizing forces to some extent, leaving post-NAFTA intra-national

business cycles much more strongly desynchronized than post-NAFTA cross-border business cycles. All regional business cycles were desynchronized, but NAFTA impacted intra-national pairs much more strongly than cross-border pairs.

## Literature Review

In a theoretical context, the impact of increased goods trade on business cycle synchronization is ambiguous. Assuming demand-side shocks drive business cycles, inter-industry trade increases between country pairs should channel the effects of these shocks from one country to another, leading to an increase in business cycle correlation as trade increases. For example, positive shocks to an economy could lead to increased income, subsequently increasing demand for imports from another economy, accelerating economic growth in the second country via export-led growth. The magnitude of the shock's transmission to the second economy would presumably be positively correlated with the level of trade between the two.

This conclusion rests on the assumption that the increases in trade are not intra-industrial, and that economies' production structures do not become more similar as a result. Krugman (1993) argues that as trade integration progresses, countries specialize in production of specific outputs. Therefore, trade integration that induces asymmetric industry specialization should desynchronize business cycles. We can alternatively assume that shocks are specific to distinct industries within the economy, which may have offsetting effects.

If increases in trade are intra-industrial, and economies' production structures become increasingly similar as trade increases, then with business cycles dominated by industry-specific shocks, trade integration that increases intra-industry trade should lead to increased synchronization of business cycles, due to the more symmetric response of economies to shocks. Frankel and Rose (1998) assert that the nature of trade integration and international trade can cause business cycles to converge or diverge. They argue that "closer international trade could result in tighter or looser correlations of national business cycles". Per the Ricardian theory of comparative advantage, closer inter-industry trade linkages could result in industry specialization, sensitizing economies to industry-specific shocks, thereby leading to more idiosyncratic business cycles. If intra-industry trade predominates, then industry-specific shocks will create identical responses within economies, synchronizing economic growth.

Preferential trade agreements' effect on business cycle correlation is a topic that has been explored extensively by European economists, in the wake of politicoeconomic integration on that continent. While this research has extensively studied the ramifications of trade agreements and currency unions for European and Asian markets, there is considerably less research detailing trade agreements' impact on US and Canadian goods markets. This paper fills that gap by studying the effect NAFTA has on state-level economic growth correlation and intra-industry goods trade.

Fiess (2007) employs OLS regression and spectral analysis to quantify the degree of business cycle correlation between Central American nations and the United States in the wake of the Dominican Republic-Central American Free Trade Agreement (DR-CAFTA). Using band-pass filtered annual data from 1965 to 2002 for 16 Central American nations, along with monthly data on Central American industrial production for 1995 to 2002 (due to a scarcity of reliable data for Central American economic activity), he determines the extent to which Central American economies are synchronized. Fiess discovers that Central American sensitivity to US economic activity has increased over time, while the period of relative tranquility in the 1990s increased synchronization within Central America. Using a cross-plot of bilateral exports to GDP ratios and business cycle coherence, there no evidence of a positive relationship between trade intensity and business cycle synchronization. Fiess's paper provides new information regarding the effects of free trade agreements on developing countries, specifically those in the Central American region. His OLS regression also provides a framework for analyzing the US economy's effect on other nations, and its effect on trade linkages between other country pairs.

Böwer and Guillemineau (2006) analyze the extent of business cycle correlation in the EU. Using extreme-bounds analysis (EBA), they examine the transmission mechanism for increased business cycle synchronization within the European Monetary Union. Using a vector of coefficients of bilateral business cycle correlations for twelve euro area countries, they regress this vector on an exogenous variable of interest with a varying set of 1-3 control variables, along with gravity theory model variables. From there, they identify extreme bounds by generating the lowest and highest values of confidence intervals for the estimated parameter on the exogenous variable of interest. If the low and high bounds on the interval have the same qualitative sign, and the parameter estimate is significant in all regressions, the variable is regarded as robust.

They find a positive correlation between bilateral trade and the vector of correlation coefficients, as well as for the bilateral trade to GDP ratio. Bilateral trade only explains approximately 10% of GDP correlation. Trade openness is found to have a positive but statistically insignificant effect on business cycle synchronization. Trade specialization also fails to qualify as robust for the 1980 to 1996 period, but becomes robust for 1997 to 2004. The majority of the impact on cycle synchronization appears to come from specialization in machinery and transport equipment. They also find a negative relationship between economic specialization and cycle correlation, but with a low $R^2$ of the regression, the authors conclude that similarity in relative shares of economic specialization says little about cycle correlation. Böwer and Guillemineau report that external trade is a key determinant of cycle synchronization for the euro zone. They find an endogeneity effect for optimal currency areas: If trade promotes co-movement of cycles, then a common currency that fosters trade leads to increasingly synchronized cycles within the monetary union. Increases in intra-industry trade also lead to increased synchronization, judging by its status as a robust determinant of cycle correlation in the 1997-2004 period for the extreme bounds analysis.

Chiquiar and Ramos-Francia (2005) analyze the effect of NAFTA on commercial integration of industrial and developing countries—in this case, the United States and Mexico. They analyze two components of this issue: First, whether NAFTA enhanced business cycle synchronization between Mexico and US, and second, whether increased competition from other countries (whose main advantage is an abundance of unskilled labor) undermined synchronicity of US and Mexican business cycles. The authors use spectral analysis, cointegration tests, and Granger causality tests to examine this. The spectral analysis focuses on manufacturing output behavior for the US and Mexico at business-cycle frequencies. Using differenced logs of quarterly manufacturing production indices for Mexico and the US from 1980 to 1993, they estimate the coherence between these differenced logs. The spectral analyses find statistically significant coherence estimates for bands of cycles with periods from two to eight years. This corresponds to the average length of business cycles. For 1996 to 2004, the coherence tests are run again, and coherences are significantly stronger for the post-NAFTA period, implying stronger US-Mexico business cycle correlation, and more cointegrated manufacturing production levels between the two nations.

Mexico-US cross correlation patterns in manufacturing output pre- and post-NAFTA are also analyzed. Tests indicate that before NAFTA

implementation, cyclical movements in US output lead Mexico's cycle by two years. After 1996, that lag period decreased, indicating a shift to a non-lagged contemporaneous correlation between manufacturing output cycles. The authors find no evidence of cointegration for the pre-NAFTA period, but do find evidence for cointegration in the NAFTA period. This suggests Mexican cointegration with US manufacturing industries in the wake of NAFTA implementation, leading to higher business cycle synchronization. Granger causality tests indicate causation is unidirectional from US manufacturing production to Mexico's. Instead of examining US-Mexican output correlation directly, Chiquiar and Ramos-Francia examine manufacturing synchronization, an industry comprising a significant share of output for both nations. By testing the extent of manufacturing industry correlation between nations, they can determine how manufacturing shocks affect cycle synchronization for both nations. Chiquiar's paper explains how trade agreements impact a sector of the intermediate goods market in North America. The methodology of this paper hinges on the assumption that industry-specific shocks (in this case, shocks to manufacturing) drive business cycle fluctuations. If cycle fluctuations are demand-driven rather than industry-driven, the usefulness of this analysis may be limited.

Cortinhas (2007) studies the effects of intra-industry trade and industry specialization on Southeast Asian business cycle synchronization. He uses annual data for real GDP of the five ASEAN nations from 1962 to 1996. Cortinhas excludes post-1997 data, to avoid the East Asian financial crisis's distorting effects on the data. Initial OLS and 2SLS empirical results suggest a positive correlation between intra-industry trade and cycle synchronization. Cortinhas runs a second OLS regression, this time regressing the gap in real output growth between country pairs on an index measuring intra-industry trade. The parameter on intra-industry trade becomes negative, indicating an increase in intra-industry trade will in fact reduce real output growth gaps between ASEAN nations. This estimate is consistent with the positive parameter on IIT in the first regression. Cortinhas then runs a second 2SLS to control for endogeneity, using the same instruments as before, and finds that the parameter on intra-industry trade is significant in synchronizing ASEAN business cycles at the 1% level. Ultimately, Cortinhas concludes that intra-industry trade is a significant, robust variable in determining ASEAN cycle correlation. He argues that the costs of joining a currency union in ASEAN decreases as intra-industry trade increases.

This paper uses OLS regression analysis to measure the effects of NAFTA on the correlation of state and provincial level economic growth. Instead of examining NAFTA's effects at a macro level, this analysis uses state and provincial data to capture the effects of physical distance, intra-industry trade in agriculture, manufacturing, and mining, and the geographic border at a microeconomic level. This model can be viewed as a variant of the gravity model of trade, since it incorporates control variables for physical distance and trade flows. The correlation coefficient of gross state product growth between two territories is calculated for all possible pairs of 50 states, 10 provinces, and 1 territory, generating 1,830 observations. This correlation coefficient is regressed on variables including state/province population levels, distance between most populous cities, exports as a share of gross state product, industry structure similarity within the mining, agriculture, and manufacturing sectors, and a set of dummies and interaction terms representing the geographic border and NAFTA ratification. This methodology allows us to measure the effects of NAFTA on not only state and provincial level economies, but also on sectors of the economy producing highly tradable output, an approach not utilized in the aggregate-level analyses of previous literature.

## Methodology

The regression equation appears below:

$$\rho_{I,J} = \beta_0 + \beta_1 \text{Agriculture Sector Similarity}_{I,J} + \beta_2 \text{Manufacturing Sector Similarity}_{I,J} + \beta_3 \text{Mining Sector Similarity}_{I,J} + \beta_4 \ln(\text{Population}_I) + \beta_5 \ln(\text{Population}_J) + \beta_6 \ln(\text{Distance}_{I,J}) + \beta_7 \text{Border}_{I,J} + \beta_8 \text{NAFTA}_t + \beta_9(\text{Exports/GSP}_I) + \beta_{10}(\text{Exports/GSP}_J) + \varepsilon_{I,J}$$

$\rho_{I,J}$ is a correlation coefficient measuring the degree of linear association between the GSP growth rate of state/province *I* and the GSP growth rate of state/province *J*. With this dependent variable, we can measure the synchronicity between territory *I*'s annual economic growth and that of all other territories. Data was taken from the Bureau of Economic Analysis and Statistics Canada. Provincial economic data is restricted to 1984 forward, so the scope of the analysis is limited to the years 1984 to 2004.

The first three regressors are variables measuring the degree of industry structure similarity between territory *I* and all other states and provinces, in the agriculture, mining, and manufacturing sectors. Interstate export and import data is not collected by US statistical agencies, so direct measures of intra-national and intra-industry exports and imports as shares of states'

GSP are infeasible. Using BEA and Statistics Canada data, we instead measure industry structure similarities between territory pairs. For two given states *I* and *J*, agriculture, mining, and manufacturing as a share of each territory's GSP are taken, and averaged over the time period in question, giving us six separate values for states *I* and *J* containing their respective average shares of agriculture, mining, and manufacturing for the time period.

With these six separate values, the values representing state *J*'s GSP shares are subtracted from the values representing state *I*'s GSP shares, and then the absolute value is taken, giving us 3 variables measuring, as a share of GSP, the deviation in industry similarity between state *I* and state *J* for agriculture, mining, and manufacturing. This set of deviations is computed between state *I* and all 61 territories in the analysis. Trade theory states that as the deviation between two territories' industry as a share of GSP increases, their level of intra-industry trade should decrease. With lower levels of intra-industry trade, the two territories' responses to industry-driven economic shocks become increasingly asymmetrical. As a result, we expect the signs on these three intra-industry trade variables' coefficients to be negative.

Two population variables are also regressors. The first population variable corresponds to the log of territory *I*'s average population over the time period of the data set. The second population variable measures the log of territory *J*'s average population over the span of the data set. Previous literature on population's effect on cycle correlation is scarce, but if increases in consumer population generate higher demand for tradable output, intra-industry trade volume will inflate and synchronize pair-wise territories. Additionally, more populous territories should be more economically diversified, stabilizing yearly GSP growth. This may affect cycle correlation with other territories. Thus, the coefficients on the population vectors should be positive. The regression model includes a distance regressor, corresponding to the log of the distance between territory *I*'s most populous city, and the most populous city in territory *J*. The gravity model of trade states that as the distance between territories increases, the cost and time necessary to conduct goods trade increases, decreasing the predicted amount of total trade. Therefore, we expect the distance regressor's sign to be negative.

The border dummy quantifies the effect of the geographic border on business cycle correlation. Each entry in this variable corresponds to a pairing between territory *I* and all other territories, registering "0" for intra-national pairings, and "1" for pairings that cross the border. International finance theory argues that border barriers such as tariffs, customs checkpoints, and

trade restrictions reduce trans-border trade volume. With reduced levels of intra-industry goods trade, industry-driven shocks will trigger increasingly asymmetrical responses to state and province pairs. Thus, the coefficient on the border dummy should be negative.

Two export variables were included, to estimate the effects of export-dependent economies on GSP correlation. The first export variable measures international exports as a share of the first territory's gross state product. The second measures the same for the second territory's GSP. As international exports as a share of GSP increases, state and province-level economies' annual growth becomes increasingly variant, as fluctuations in the international goods market accelerates or depresses export-led growth. If exports as a share of gross state product increase, a state-level economy would become increasingly tied to developments in other territories' goods markets. Therefore, we expect the coefficient estimates on these variables to be positive. International export data for states was not recorded until 1999, so estimates for these variables are restricted to the post-NAFTA regression.

The NAFTA dummy registers "0" for observations measured in the 1984-1993 pre-NAFTA dataset, and "1" for observations taken in the 1994-2004 post-NAFTA dataset. NAFTA's primary effect was to eliminate all remaining tariffs on tradable output in several sectors of the Canadian and US economies. With intra-industry trade volume increasing in these newly deregulated sectors, and assuming macroeconomic shocks are industry specific, we expect NAFTA to increase pair-wise correlation coefficients.

These vectors are computed for every territory in the analysis, giving us 60 different sets of observations. These sets are then combined into one large set of observations, creating a final group of nine regressors with 1,830 entries each. See the following table for summary statistics of the variables.

| *Pre-NAFTA (1984-1993)* | | | | |
|---|---|---|---|---|
| **Variable** | **Mean** | **Std. Dev.** | **Min** | **Max** |
| Correlation i, J | 0.397845 | 0.354456 | -0.71519 | 0.981224 |
| Agriculture Similarity i, J | 0.026751 | 0.027623 | 1.85E-06 | 0.114372 |
| Mining Similarity i, J | 0.062572 | 0.085288 | 4.67E-06 | 0.348355 |
| Manufacturing Similarity i, J | 0.107517 | 0.113824 | 0.000192 | 0.780746 |
| Ln (Distance i, J) | 7.418351 | 0.775738 | 2.755334 | 9.142286 |
| Ln (Population i) | 3.571408 | 0.609343 | 2.679153 | 6.994147 |
| Ln (Population J) | 4.296975 | 1.31007 | 2.679153 | 6.994147 |
| *Post-NAFTA (1994-2004)* | | | | |
| **Variable** | **Mean** | **Std. Dev.** | **Min** | **Max** |
| Correlation i, J | 0.238658 | 0.360051 | -0.81859 | 0.995907 |
| Agriculture Similarity i, J | 0.021462 | 0.021531 | -0.00554 | 0.091592 |
| Mining Similarity i, J | 0.047482 | 0.066825 | -0.01866 | 0.238547 |
| Manufacturing Similarity i, J | 0.071065 | 0.052567 | -0.06749 | 0.290645 |
| Ln (Population i) | 3.623514 | 0.605917 | 2.687775 | 7.063507 |
| Ln (Population J) | 4.339703 | 1.307634 | 2.687775 | 7.063507 |
| (Exports/GSP i) | 0.065764 | 0.046117 | 0.010517 | 0.384355 |
| (Exports/GSP J) | 0.125679 | 0.105129 | 0.010517 | 0.384355 |
| *Pooled (1984-2004)* | | | | |
| **Variable** | **Mean** | **Std. Dev.** | **Min** | **Max** |
| Correlation i, J | 0.318252 | 0.365978 | -0.81859 | 0.995907 |
| Agriculture Similarity i, J | 0.024106 | 0.024903 | -0.00554 | 0.114372 |
| Mining Similarity i, J | 0.055027 | 0.076975 | -0.01866 | 0.348355 |
| Manufacturing Similarity i, J | 0.089291 | 0.090497 | -0.06749 | 0.780746 |
| Ln (Population i) | 3.597461 | 0.608108 | 2.679153 | 7.063507 |
| Ln (Population J) | 4.318339 | 1.308848 | 2.679153 | 7.063507 |

**Table 1. Summary statistics for the variables in the OLS analyses.**

Conventional standard errors are insufficient for this type of regression analysis. Heteroskedasticity in the error term is typical for cross-sectional regressions dealing with state-level economic data. Additionally, autocorrelation in the error term is a likely problem. Typically, serial correlation is not a problem for cross-sectional data, as there exists no temporal pattern within the residuals. However, spatial autocorrelation may be at work in the residuals. If there is an economic component unique to a single state affecting its GSP growth, all observations including that territory within the pair will suffer from correlation of the residual term. Thus, spatial autocorrelation is likely present. To simultaneously correct for heteroskedasticity and spatial autocorrelation in the error term, heteroskedasticity and autocorrelation consistent standard errors were employed.

Three separate versions of the regression were run. The first regression dropped the entries with a "1" for the NAFTA dummy, giving us coefficient estimates for the model prior to NAFTA ratification. The second excluded all pre-NAFTA observations, giving the sample regression function for the post-NAFTA era. Finally, a panel data regression was run, with all entries included, allowing us to see the coefficient estimates for the overall time period of 1984 to 2004. With variation in the NAFTA dummy, the pooled regression allowed estimation of the NAFTA dummy coefficient, quantifying NAFTA's synchronizing or desynchronizing effects on state-level business cycle synchronization. To capture the effect of the border pre- and post-NAFTA, the NAFTA and border dummies were interacted with each other, and included in the pooled cross-sectional regression, creating the below regression model:

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$$\rho_{I,J\,t} = \beta_0 + \beta_1 \text{Agriculture Sector Similarity}_{I,J\,t} + \beta_2 \text{Manufacturing Sector Similarity}_{I,J\,t} + \beta_3 \text{Mining Sector Similarity}_{I,J\,t} + \beta_4 \ln(\text{Population}_{I\,t}) + \beta_5 \ln(\text{Population}_{J\,t}) + \beta_6 \ln(\text{Distance}_{I,J}) + \beta_7 \text{Border}_{I,J} + \beta_8 \text{NAFTA}_{t} + \beta_9(\text{NAFTA}_{t} * \text{Border}_{I,J}) + \varepsilon_{I,J\,t}$$

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## Empirical Results and Discussion

| *Regressor* | *n = 1,830 Pre-NAFTA Coefficient* | *n = 1,830 Post-NAFTA Coefficient* | *n = 3,660 Panel Coefficient* |
|---|---|---|---|
| Agriculture Industry Similarity | -1.546*** (0.304) | -0.849** (0.360) | -1.165*** (0.245) |
| Manufacturing Industry Similarity | 0.121* (0.069) | -0.990*** (0.201) | -0.093 (0.077) |
| Mining Industry Similarity | -0.802*** (0.123) | -0.674*** (0.155) | -0.719*** (0.091) |
| Distance between most populous cities | -0.139*** (0.015) | -0.027** (0.013) | -0.084*** (0.010) |
| Population of territory i | 0.107*** (0.018) | 0.044* (0.026) | 0.097*** (0.015) |
| Population of territory j | 0.0489*** (0.0144) | 0.104*** (0.019) | 0.084*** (0.011) |
| Border | -0.205*** (0.0474) | -0.184*** (0.054) | -0.314*** (0.042) |
| International exports/GSP for territory i | N/A | 1.081*** (0.414) | N/A |
| International exports/GSP for territory j | N/A | -0.118 (0.143) | N/A |
| NAFTA | N/A | N/A | -0.241*** (0.013) |
| NAFTA * Border | N/A | N/A | 0.177*** (0.049) |
| Intercept | 0.976*** (0.1074) | -0.056 (0.140) | 0.492*** (0.091) |
| Adjusted $R^2$ | 0.296 | 0.161 | 0.236 |
| Standard error of regression | 0.297 | 0.330 | 0.320 |
| F-test p-value | 0.00 | 0.00 | 0.00 |
| Durbin-Watson statistic | 1.434 | 1.617 | 1.524 |
| White test with cross terms LM statistic | 293.402 | 204.842 | 406.665 |
| White test p-value | 0.00 | 0.00 | 0.00 |
| White test F statistic | 10.081 | 4.224 | 9.404 |

**Table 2. Regression results for the pre-NAFTA, post-NAFTA and panel data models, with Newey-West standard errors. 1, 2, or 3 stars next to the estimate represent statistical significance at the 10%, 5%, and 1% level, respectively.**

For the pre-NAFTA sample regression function, all parameters are statistically significant at the 10% level, and all but manufacturing are statistically significant at the 1% level. All parameter estimates, minus manufacturing, take signs consistent with a priori expectations. The model explains a statistically significant portion of the variation in GSP correlation, with variation in the regressors explaining approximately 30% of the variation in GSP growth correlation. The Durbin-Watson statistic for the pre-NAFTA OLS estimates is calculated at 1.434. At n = 1,830 and with 8 regressors, we reject the null of no autocorrelation in the residual term, indicating that the residuals may follow an AR(1) process. The White test with cross terms confirms the presence of heteroskedasticity in the residual terms. The LM statistic equals 293.402, well past the critical value necessary to confirm unequal error variance. Since these tests show that heteroskedasticity and autocorrelation are present with conventional standard errors, the Newey-West standard errors resolve this issue.

The empirical results for the regression model following NAFTA implementation change drastically relative to the pre-NAFTA estimates. The sample regression function explains a statistically significant portion of the variation in GSP growth correlation at the 1% level, with variation in the regressors accounting for approximately 16.1% of the variation in GSP growth correlation. The adjusted $R^2$ of this model is considerably less than the 0.30 adjusted $R^2$ for the pre-NAFTA regression. The post-NAFTA regression's Durbin-Watson test produces a d-statistic of 1.617. As before, the presence of an AR(1) process in the residual term is suggested, justifying use of the Newey-West HAC covariance matrix. Inequality in the residual terms again seems likely, as the LG test value is 204.842, well past the critical value necessary to confirm heteroskedasticity in the original OLS residuals. The pooled model explains approximately 23% of the variation in GSP pair-wise correlation, and its Durbin-Watson and White test results again confirm the necessity of using Newey-West standard errors in the panel data regression.

Agricultural sector similarity is the strongest trade determinant of pre-NAFTA cycle correlation, with a 1% difference in the agriculture share of GSP between two territories weakening predicted cycle correlation by 1.55%. In the post-NAFTA regression, agriculture industry similarity weakens as a strong determinant of correlation, with the parameter estimate decreasing from -1.546 to -0.849. The estimate remains statistically significant at the 5% level. Agriculture structure similarity remains the strongest determinant of business cycle correlation in the panel model as well, with a parameter estimate of

-1.163. This estimate has a smaller magnitude than the pre-NAFTA estimate, but remains larger than the post-NAFTA estimate.

Prior to NAFTA, mining industry similarity has a sizable effect on cycle correlation, with a 1% increase in mining sector dissimilarity lowering predicted growth correlation by 0.8%. Mining similarity weakens as a determinant of correlation after NAFTA ratification, with the parameter estimate shifting from -0.802 to -0.675, but remains statistically significant at the 1% level. The panel data model's mining similarity parameter estimate increases to -0.720, compared to the post-NAFTA model's estimate of -0.675.

Based solely on the pre- and post-NAFTA regression models, following NAFTA ratification, industry structure similarities in agriculture and mining weakened as determinants of state and provincial business cycle correlation. Additionally, manufacturing became a statistically significant determinant of cycle correlation in the post-NAFTA era. One possible explanation for the reduction in agriculture and mining similarity's effects on business cycle correlation is that with increased economic integration between the US and Canada in the form of reduced trade barriers and tariffs, the transmission of industry-specific shocks was muted. Integration of goods and asset markets may create a more effective shock transmission mechanism, allowing a more complete dispersal of industry-specific shocks throughout all state-level economies, regardless of the level of industry structure similarity. Therefore, differences in agricultural and mining industry structure may not impact GSP growth correlation as strongly.

Manufacturing similarity has a statistically significant and synchronizing effect on states' growth correlation. A 1% increase in the difference between manufacturing as share of two states' GSP increases the predicted value of growth correlation by 0.12%. After NAFTA ratification, the parameter estimate on manufacturing takes the expected negative sign, and becomes strongly negative, with a 1% increase in manufacturing sector dissimilarity weakening predicted synchronization by 0.9%. The manufacturing variable's parameter estimate decreases drastically from -0.990 in the post-NAFTA regression, to a statistically insignificant -0.093 in the panel data model. The small magnitude of the pre-NAFTA and panel estimates may indicate substantial market segmentation in manufactures trade prior to NAFTA, if dissimilarity in this sector only weakly impacts cycle synchronization.

NAFTA's elimination of tariffs on motor vehicles, electronic products, and textiles led to an appreciable increase in intra-manufacturing trade between 1994 and 2004. As the US and Canada witnessed a huge increase in trade

volume in these outputs, it is reasonable to argue that the once-segmented manufacturing sector became highly integrated, with substantial differences in manufacturing industry structure now strongly impacting GSP growth correlation. This would explain the shift in statistical significance and parameter signage in the pre- and post-NAFTA model, as well as the negative parameter estimate in the panel model.

Distance between the most populous cities has the expected substantial effect on correlation, with a 1% increase in distance between largest cities by territory weakening predicted correlation by 14%. Post NAFTA, the coefficient estimate on the distance variable decreases in magnitude, shifting upwards to -0.027. Following NAFTA ratification, physical distance between territories within the US and Canada weakens substantially as a desynchronizer of business cycle correlation. In the panel data model, the distance variable remains a strong determinant of cycle correlation, with a coefficient estimate of -0.084 significant at the 1% level. With the technology boom of the 1990s, advances in telecommunications and transportation technologies enabled cheaper and faster transportation of tradable commodities, perhaps weakening distance's effect on business cycle correlation.

Prior to NAFTA ratification, both population variables are statistically significant and positive at the 1% level as determinants of GSP growth correlation. After 1993, the population parameters shift in value considerably. The coefficient estimate on the population of territory *I* remains positive, but decreases from 0.107 to 0.044, and is now statistically significant only at the 10% level. Territory *J*'s population strengthens as a determinant of business cycle correlation, increasing to 0.104, and remains statistically significant at the 1% level. Within the pooled regression, the two population variables' coefficient estimates are statistically significant at the 1% level, with correct signage and estimates close in value to those of the post-NAFTA estimates. Additionally, their coefficient values lie within .01 units of each other, unlike the previous regressions' distance variables' coefficients.

The post-NAFTA export variables produce contrasting results. Exports as a share of GSP for state *I* were a statistically significant determinant of business cycle correlation at the 1% level, with a 1% increase in exports as a share of state *I*'s GSP increasing cycle correlation by 1.1%. However, exports as a share of GSP for territory *J* was statistically insignificant at and beyond the 10% level. The coefficient on this variable was -0.118, indicating that for a 1% increase in exports as a share of territory *J*'s GSP, business cycle correlation between the two territories weakens by 0.12%. These estimates imply that a state's own exports

as a share of GSP is more important in terms of its pair-wise synchronization with other territories, relative to other territories' exports as a share of GSP.

The pre-NAFTA border has a statistically significant and strong desynchronizing effect on state and provincial level cycle correlation. The border weakens the estimated value of pair-wise business cycle correlation by 20.5% in the pre-NAFTA time period. The border dummy remains statistically significant at the 1% level in the post-NAFTA segment, and decreases in negativity to -0.18. Following NAFTA ratification, the geographical border weakens slightly in its capacity as a state-level desynchronizer. The panel model's border coefficient is the largest of all three border estimates. All regressors held constant, the correlation of GDP growth between a province and a state is 31.4% weaker than the correlation of GDP growth between two provinces or two states. The negative parameter estimate on the NAFTA dummy indicates that post-NAFTA, GSP growth correlation between all territory pairings, intra- and international, decreases by 24.1%. Contrary to established literature, this analysis argues that NAFTA had a significantly disaggregating effect on regional economies.

Interacting the border dummy with the NAFTA dummy produces a term with a coefficient estimate of 0.177, statistically significant at the 1% level. Multivariate calculus reveals how this interaction term affects the economic interpretation of the border and NAFTA dummies. The partial derivative of the sample regression function with respect to the border is:

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$$\delta \rho_{i,j} / \delta \text{Border}_{i,j} = -0.314 + (\text{NAFTA} * 0.177)$$

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Prior to NAFTA ratification, the correlation of GSP growth between a province and a state is weakened by 31.4%, relative to an intra-national territory pair. After NAFTA ratification, state-province GSP growth correlation weakens by only 13.7%. NAFTA ratification mitigates the desynchronizing force of the geographic border to some extent.

The partial derivative of the SRF with respect to NAFTA is:

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$$\delta \rho_{i,j} / \delta \text{NAFTA}_{i,j} = -0.241 + (0.177 * \text{Border})$$

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NAFTA weakens intra-national pairs' GSP growth correlation by 24.1%. For state-province pairs, NAFTA weakens GSP growth correlation by only 6.4%. While NAFTA had a highly desynchronizing effect on intra-national pairs, its

effect is much weaker on state-province pairs. One valid argument against this analysis is the question of whether a similarly important economic event in the 1990s strongly impacted US-Canada goods trade, and the NAFTA and border dummies are simply absorbing that event's effects into their estimates. While the possibility exists that other events occurring from 1984 to 2004 impacted pair-wise GSP growth correlation, the likelihood is that inter-territorial trade is the main explanatory variable influencing pair-wise GSP growth correlation. The scatter-grams on the following page corroborate this assertion. Within these graphs, we clearly see a positive relationship between exports as a share of GSP and business cycle correlation.


**Figure 1. Scatter-plot of exports as a share of state *I*'s GSP in relation to GSP growth correlation. Note the positive trend in the scatter-plot.**

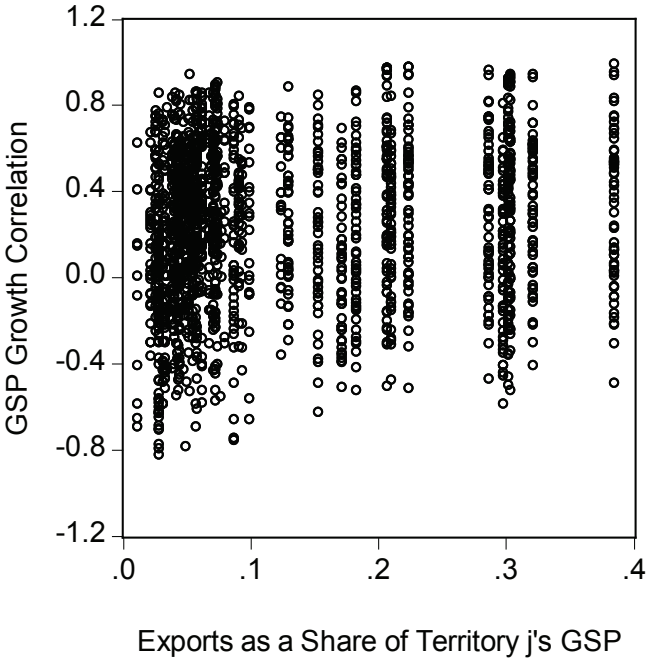


**Figure 2. Scatter-plot of exports as a share of territory *J*'s GSP in relation to GSP growth correlation. Here the trend is less clear, but there remains a positive trend between the two variables.**

## Conclusions

The border reduces cross-border pairs' GSP growth correlation by anywhere from 18% to 31%. Despite substantial trade integration, state and province pairs' GSP growth remains strongly desynchronized. Disparities in taxation and trade regulations may remain, functioning as a disincentive for trans-border goods trade. Home market bias may also influence US and Canadian firms' decisions to trade. The border's geographic and legal effects remain an obstacle to business cycle synchronization. Yet in relation to NAFTA, the border had a synchronizing effect. Via partial derivative analysis, the border increases the predicted level of cross-border pairs' GSP growth correlation, reducing NAFTA's strongly desynchronizing effects. With the elimination of virtually all economic barriers to cross-border trade, it is reasonable to conclude that the doubling of goods trade between states and provinces over a ten-year

period reduced NAFTA's impact on business cycle correlation between states and provinces. GSP growth correlation between cross-border pairs weakens by 31.4%, prior to NAFTA ratification. Post-NAFTA, GSP growth correlation between cross-border pairs weakens by only 13.7%. While NAFTA may have desynchronized intra-national pairs, its effect is much weaker in international pairings.

In the panel data regression, NAFTA alone was found to desynchronize territory pairings by 24.1%. In a vacuum, this might be used as evidence to argue the notion that free trade agreements are inherently desynchronizing. The trade agreement may have had a desynchronizing effect by inducing states and provinces to specialize in specific industries, per the Ricardian theory of comparative advantage. With different territories specializing in different industries, industry-specific shocks would no longer produce symmetrical responses within state-level economies. It appears that NAFTA's primary effect was to generate simultaneous business cycle desynchronization between state-province pairs, state-state pairs, and province-province pairs. Though NAFTA had the synchronizing effect of integrating multiple sectors of the goods market of both nations, its desynchronizing effect also decoupled domestic economies from within. NAFTA was ratified at the same time the border's relevance as a desynchronizing force was reduced, due to tariffs and trade barriers, coupled with advances in transportation and telecommunications technology. These two events opened up new markets for states and provinces with economies centered on industries producing tradable output. As a consequence of the Ricardian law of comparative advantage, states found themselves trading more with provinces whose economic structures matched their own, and thus the desynchronizing effects of NAFTA were reduced to some effect, although not completely negated. This reinforces the notion that business cycle shocks are industry driven, as opposed to demand driven.

One theory to explain the mechanisms of the post-NAFTA environment is the following: NAFTA ratification lowered barriers to increased goods trade, inducing territories to specialize in differing industries. As a result, the NAFTA induced desynchronization between territory pairs. However, those states specializing in identical industries witnessed such an increase in intra-industrial trade that a net synchronization was created in those pairs. Cycles may be becoming more industry-driven, and what is being witnessed post-NAFTA is the generation of industry cycles that territories are tied to. This theory accounts for the regression results and the positive trend between exports as a share of GSP and business cycle synchronization. At an aggregate level, NAFTA

can desynchronize pairs by spurring trade specialization, but also induce trade creation that creates industry-driven business cycle synchronization, partially negating the decoupling. Post-NAFTA, GSP growth correlation both intra-nationally and internationally has decoupled. Further empirical work is forthcoming. Gravity model variables will be added, including transportation expenditures as a share of two territories' combined gross product. With this, we can determine the effect transportation technology has on synchronizing economic growth. More sectors of the economy producing tradable output will be also be considered.

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