IS THERE A NORTH AMERICAN BUSINESS CYCLE?  
AN ANALYSIS OF THE PERIOD 1963-2002  

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Abstract
This paper investigates the business cycle linkages between Canada, Mexico, and the United States by examining the significant features of the three business cycles for the period 1963 to 2002. It analyzes the correlation between the cyclical fluctuations in these countries and tries to determine the existence of commonality and symmetry between the individual cycles. Using Markov-switching regimes in a multivariate framework and data on industrial production index and real GDP, we discover some synchronization of the business cycles in North America. Mexico and Canada individually share a common cycle with the U.S. but not with each other meaning there are key effects of increased integration between these countries.

JEL classification: E32, F43, F47, C32  
Keywords: North American Cycle, common cycle, Markov-switching, MS-VAR, time-series analysis

1. Introduction
The purpose of this paper is to determine how the business cycles of Canada, United States, and Mexico are linked to each other in order to inform whether a common business cycle really exists in North America. The paper therefore sets up the stage for broader studies on (1) monetary union between the three countries, as emphasized by Mundell (1961) and (2) the key effects of increased integration between these countries. The contention of this paper, however, is not to concentrate on whether a monetary union is feasible or not, but rather to assert whether there is a common unobserved component that governs the business cycles of the three countries similar to Artis et al. (2004). If such commonality exists then would increased integration between these countries result in increased correlations in consumption and/or investments?

A basic prerequisite of a probable monetary union is to first look at whether the countries are subjected to similar shocks, hence similar cycles, and then look at the possible mechanisms that could be put in place to deal with specific shocks. Our paper makes a valuable contribution to the literature on the first line of research by attempting to identifying a common business cycle component in North America. Following Krolzig (1997a), Artis, Krolzig, and Toro (2004), and Hamilton (1989), this paper uses Markov-switching vector autoregression (MS-VAR) technique to investigate the business cycle linkages between the three North American countries. The task is carried out in two phases. In the first phase, a generalization of the original Hamilton (1989) univariate Markov switching model is applied to uncover each country’s dynamic cycle on the basis of deepness (Sichel, 1993a, 1993b), steepness, and sharpness (McQueen and Thorley, 1993), and a cross-country comparison is made to highlight any

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similarities in the mean growth rate of output. In the second stage, the MS-VAR is estimated in order to identify and test for a common cycle in North America. The Markov switching models (univariate and multivariate) use quarterly data on industrial production index for the period 1963:3 - 2002:4 and on real gross domestic product (GDP) for the period 1980:1-2004:3, taken from IFS CD-ROM. The probability regimes are classified as: recession (or regime 1), normal growth (or regime 2), and high growth (or regime 3).

Results suggest synchronization of the business cycles in North America. A set of pairwise comparison tests of cycle regime changes demonstrates that Mexico and Canada each share a common cycle with the United States but not with each other. The multivariate analysis confirms the pairwise tests, but it also suggests that (a) Canada shares a common cycle with U.S. and Mexico combined; (b) U.S. shares a common cycle with Canada and Mexico combined; however, (c) Mexico does not share a common cycle with U.S. and Canada combined. This result supports a broader generalization that countries of the same degree of economic development tend to move according to the same wavelength.

Other relevant findings are that (a) the North American cycle affects the three countries in a similar fashion after the debt crisis in 1982; (b) the United States business cycle drives the North American cycle, from which one can infer that any time the U.S. is in recession there is a high probability that Canada and Mexico will also be in recession concurrently and an even higher probability that they will be in recession in the next quarter; and (c) impulse response analysis shows that North American recession or expansion has the same impact on each individual country, with Mexico showing the most erratic behavior. The rest of the paper is organized as follows. Section 2 briefly reviews the literature. Section 3 briefly highlights the Markov-switching methodology. Section 4 analyzes the data. Section 5 interprets the results. Finally, Section 6 concludes the paper.

2. Literature Review

Research on business cycle linkages between North American countries can be categorized as follows: 1) those that examine Canada jointly with the United States along with other developed countries and 2) those that match Mexico with other Latin American countries using the U.S. taken as the reference country. The sensitivity of the Canadian economy to business cycles in the United States has been investigated by many authors. Early contributions by Rosenbluth (1957), Chambers (1958), and Hay (1966) relied on spectral techniques to analyze macroeconomic variables in order to determine whether there are any similarities between the phases of the business cycles across the two countries. By simply comparing peaks and troughs between U.S. and Canada, these studies left out all the relevant aspects of economic dependence ‘over cycles of all length’ Bonomo and Tanner (1972). Bonomo and Tanner (1972) combined the spectral method with a comparison of the relationship between the two countries over all lengths of cycles. Their study of industrial production for the period 1919-1967 shows that the two economies are subject to similar cycles but the duration of Canadian cycles is smaller than that of the United States. Most importantly, these authors also found that 1) Canadian cycles tend to lag less than one month behind those of the U.S. for cycles less than 50 months long; 2) the sensitivity of Canada’s economy to economic cycles in the
U.S. has not changed in a systematic way, despite the adoption of the flexible exchange rate by Canada in the 1950s.

A study by Phillips (1991) partly confirms the findings of Bonomo and Tanner (1972). In fact, Phillips evaluates the transmission of business cycles for the period 1961:1-1989:3 between United States and Canada, Germany, and the United Kingdom by using a two-country business cycle model, which is considered by many as the first attempt at a generalization of the univariate two-regime Markov-switching model of Hamilton (1989) [see Filardo and Gordon (1994) and Krolzig (1997a)]. Based on seasonally adjusted data on industrial production, Phillips arrives at the conclusion that both countries ‘move into and out [of] recessions simultaneously’ without either having to lead the other. However, his findings are in agreement with Bonomo and Tanner that shocks to U.S. growth rates are transmitted to Canada after a one-period lag. It is worth noting that Phillips’ study does not take into consideration any transmission of cycles that might occur between large industrial nations and less developed countries [such as Mexico-U.S. and Canada-Mexico] and further asserts that the transmission of cycles across developed countries is negligible. Krolzig (1997a, b) has reached a similar conclusion in his international business cycle analysis of developed nations. He found that the synchronization of these economies’ cycles is mostly due to common world-wide shocks that have occurred since the first oil shock in 1973.

Backus and Kehoe (1992) looks at evidence of an international business cycle by analyzing annual national accounting data for a set of ten countries, including Canada and the United States. Their study extends over a period of 100 years and contrasts properties of GNP, investment, government purchases, net exports, inflation and money stock by using generalized method-of-moments. Of relevance for this paper is their finding that contemporaneous correlation of output fluctuations (a feature of the business cycle) between the two countries was 0.49, 0.91, and 0.64 during the Prewar, Interwar, and Postwar periods, respectively. This finding led them to conclude that Canada and the United States are subject to common external shocks that give rise to a certain conformity of the cycles.

Further research by Gregory, Head, and Raynault (1997) have found that little of the fluctuation in GDP in Canada and the U.S. can be accounted for by the world business cycle. They conclude that internal shocks to these economies are the main sources of their business cycles.

Thus far, the literature has sent a mixed signal as to the relationship between business cycles across the two developed countries. Nothing can be said from the literature about the association of Mexico’s business cycle regimes with Canada and little vis-à-vis the United States. To our knowledge, the only study that deals with this issue is Mejia-Reyes (1999), using the classical business cycles approach. He relies on yearly data on real GDP per capita for the period 1950-1995 to date turning points across major economies in Latin America and the United States. He used a methodology proposed by Artis, Kontolemis, and Osborn (1997) that is based on Pearson’s corrected contingency coefficient (CCcorr), a measure of correlation. In Mejia-Reyes’s view, a CCcorr greater than 60% is an indication of “strong” correlation, between 40 and 60% is considered “mild”, and less than 40% is portrayed as a clear sign of “low” association of the cycles. Having found a CCcorr around 20% for Mexico and the United States, he then concludes that the business cycles of the two countries produce dissimilar turning points. Using standard techniques in the literature, our study contributes to the existing literature by
showing just the opposite: The turning points are similar across the three countries’ cycles but the speed from peak to trough (going into recession) is different from that of trough to peak (recovery).

The various studies in the literature that investigate international business cycles have either focused on co-movement of economic variables or asymmetry of the business cycles but not on both. Artis et al. (2004) takes Diebold and Rudebusch’s (1996) into consideration in their study of the ‘European Business Cycle’ by analyzing both aspects of the business cycles. This paper follows a similar approach by providing a global analysis of the ‘North American Business Cycle’. We investigate not only the commonality of the cycles across the three countries for monetary union purpose, but also which country drives the common cycle, and whether the common cycle is driven by common exogenous shocks.

3. Methodology

The methodology of this paper is based on the original contribution of Hamilton (1989), who considers a univariate Markov switching univariate Markov-Switching Autoregression (MS-AR) model with two regimes: recession and expansion, which captures the changes in time series that can occur due to continuous shocks. The Hamilton model has become one of the standard tools in time-series econometrics and has been widely used in the literature. This model has been extended to accommodate duration dependence in the transition probabilities (Durland and McCurdy 1994; Pelagatti 2005), three regimes: recession, normal growth, and high growth, and regime shifts in intercepts (I), autoregressive parameters, and covariance matrix (H) (see Hamilton and Raj 2002) for more advances in the field]. A substantial contribution is the generalization to multivariate analysis, namely, MS-VAR or MS-VECM, which includes the works of Krolzig (1997a, 1997b, 1998), Krolzig and Sensier (2000), Kim and Piger (2000), Clements and Krolzig (2002, 2003, 2004). This paper follows the MSVAR generalization by Krolzig (1997) and Artis et al. (2004), as found in the appendix.

4. Data and Data Analysis

The quarterly data used in this study are the seasonally adjusted industrial production indexes for Canada, United States, and Mexico. They were taken from the CD-ROM of the International Financial Statistics (IFS) of the International Monetary Fund (IMF) and cover the period 1963:3 - 2002:4. The growth rates of the industrial production shows a large positive outlier for Canada and a large negative outlier for the U.S.. The TRAMO/SEATS procedure of Gomez-Maravall (1992) is used to remove the effects of these outliers from the data. The series were then tested for stationarity by using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. It shows results consistent with a trend and an intercept term underlying the data. Both tests concur that the growth rate variables are I(0) and the levels of the variables are I(1) at the 1% level of significance.

Further analysis of the data displays facts that are summarily important in a preliminary assessment of business cycle linkages between Canada, Mexico, and the United States. The data show that all three countries have experienced positive growth in each of the last four decades, despite major historical economic events such as oil shocks,
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debt crisis, and international conflicts. Each country also achieved its highest mean growth rate in the 1960s, a possible reason for this being the payoff from post-war economic efforts. Finally, both U.S. and Mexico have recorded their lowest performances in the 1980s (0.50 and 0.690 percent, respectively, possibly due to the debt crisis) while Canada has seen its worst in the 1990s by averaging 0.51 percent. The U.S. has been the least volatile economy of all three countries, as measured by a standard deviation of 0.805, and Mexico is the most volatile. The contemporaneous correlation coefficients show a strong positive correlation of the growth rate of output between Canada and the United States over all the periods but the 1960s. The average is 0.61. The correlations between Mexico - Canada and Mexico - United States are weak and positive on average (0.16 and 0.26) but close to zero for the 1960s.

5. Empirical Results

Studies on business cycle in general consider three major aspects in the dynamic of output: 1) Concurrency in the turning points to determine whether periods of recession and growth coincide across countries; 2) Speed of adjustments from trough to peak or vice versa; and 3) Durations of economic states. This paper follows a similar approach by looking for similarities across the three North American countries as three separate entities (the Univariate approach) and by considering them as if they were one single block (the Multivariate analysis).

a) Results of the Univariate MSAR Models. The generalized Hamilton model used for each country is chosen on the basis of the Akaike, Hannan-Quinn, and Schwartz information criteria. A Markov-switching-intercept-heteroskedastic model with 3 regimes and 4 lags [MSIH(3)-AR(4)] is the best representation for the Canadian business cycle, whereas a Markov-switching-mean heteroskedastic model with 3 regimes and 3 (4) lags [MSMH(3)-AR(3), -AR(4)] is proven to be a better approximation for the Mexican (U.S.) business cycle. The three regimes considered are recession (regime 1), normal growth (regime 2), and high growth (regime 3). The features of the business cycle of the three countries show that the models adopted are capable of not only capturing most of the recession and expansion periods established by NBER and ECRI but also those contractions that have occurred in the early 2000s.

The duration of Canadian cycles is shorter than that of the United States. In Canada and in the United States normal growth prevails for approximately 16 and 11 quarters, respectively. The shortest duration is for high growth in both Canada and Mexico and for recession in the United States. This finding confirms Bonomo and Tanner (1972). The probability of being in a normal growth regime is 57.4% for the U.S., 88% for Canada, and 46% for Mexico. The standard errors of each regime show Mexico’s economy to be volatile than the U.S. but less volatile than Canada in periods of normal growth. The most volatile regime for each country has been recession for the United States, high growth for Mexico, and normal growth for Canada.

In order to uncover the link between the business cycles of the three countries, the paper compares the recession dates inferred by the smoothed probabilities of being in recession. Figure 1 shows that the three countries have experienced recession concurrently during three episodes: after the first oil shock in the mid 1970s, after the
second oil shock or during the debt crisis in the early 1980s, and in the early 2000s. This finding confirms Krolzig (1997a,b) that worldwide shocks are partly responsible for the co-movement of output growth at the international level. Canada and the United States share most of the recession periods. In other words, Canada and the U.S. are more closely related to each other than either is related to Mexico.

![Figure 1. Probabilities of a Recession (Comparison of Recession periods)](image)

Further analysis of the link between the countries leads to consider the pattern of the transition probabilities. That is, the probability that regime j will materialize in period t+1 given the fact that regime i prevails in period t. The regimes can also be the same in both periods, in which case their probability will indicate the persistence of that episode. Contractions and normal growth are quite likely to persist in all three countries. By relative persistence we mean for some regimes the probability is above 70 percent while for others it is between 50 and 60 percent. Only in the United States is high growth persistent. In Canada, transition back to normal growth is almost inevitable; most of the probabilities of transition from high growth regime to recession are very close to zero in all three countries. Probabilities of transition from normal growth to recession are also low for all three countries. Mexico has the highest probability, around 13%. Transition from recession to normal growth varies much more, from zero in Mexico to 34% in Canada. In sum, the smoothed transition probabilities suggest that the turning points of the business cycles are more inclined towards symmetry than asymmetry.

We further test for symmetry in the business cycle in accordance to the three cycle features of sharpness, deepness, and steepness (the null hypotheses being absence of each feature). For all three countries, the null hypotheses of non-sharpness and non-deepness are “accepted”, so the turning points of the business cycle in each country are similar and symmetric in that respect. The data suggest steepness for U.S. and Canada, but not for Mexico.
The univariate exercises have demonstrated that there is a fairly apparent synchronization of the individual business cycles across the three North American countries. But the MS-AR models are not capable of establishing whether there is an unobserved component behind these concurrent ups and downs in the level of economic activity of these three countries. Hence, we cannot rely on these models to investigate the co-movement among the IIP series. There are, however, a number of insights gathered from the univariate models that motivate our undertaking of a Markov-switching vector autoregression to uncover the existence of a common cycle. First, the major exogenous shocks such as oil crisis, debt crisis, and high tech burst have similar effects on the three countries. Second, if we were to sum up graphically the features (deepness, steepness, and sharpness) of the business cycle of each of the countries, we could easily show that Canada and the United States cycles are mostly similar. Finally, the degree of concordance of the cycles is highest for US and Canada (around 57%), which reinforces our second point above. One plausible conclusion is that Canada and the United States are most likely to share a common cycle. A conclusion that requires further confirmation from an MS-VAR model approach.

b) Results of the Multivariate Model. We decomposed the data series on IP (and GDP) into Gaussian and non-Gaussian components. The Gaussian component has a zero mean and deals with the individual country shocks while the non-Gaussian component shows the role of the common cycle in determining the individual cycles. The latter component can be construed as the unobserved component that drives the common cycle. The cointegration test for uncovering long-run relationships between the level of industrial production indexes of Canada, Mexico and the United States was carried out with four lags, a trend, and an intercept term. The Trace and Maximum-eigenvalue tests reject the null hypothesis of cointegration at both the 5 and 1 percent levels. Therefore, the model under consideration is of MS-VAR type instead of MS-VECM. The multivariate generalization model chosen on the basis of AIC, HQ and SC is MSIH(1)-VARX(1). The model contains an exogenous dummy variable to capture the shift from the Gold Standard era to a period of dirty floating regimes in North America (takes on value of 1 from 1963:3 - 1972:4).

The estimated parameters of the MS-VAR model using quarterly data for the period 1963:3-2002:4 are shown in Table 1. The different regimes are well marked by the direction and the magnitude of the intercept terms. Recessions appear with a negative value, normal growth is captured by a positive intercept value that is smaller than rapid growth episodes. The transition probability matrix reveals that the regimes are persistent when a 1/2 rule is chosen as a benchmark and that there is an equal probability (16%) of moving from a period of recession to periods of normal and high growth. However, the converse is not true, the probability of going from normal growth to recession (12.23%) is three times higher than that of going from high growth to recession (4.04%). The duration of the regimes confirms that recessions are briefer than expansions in North America. Generally, recessions last less than a year, normal growth about 2 years and rapid growth a little more than a year.

The contemporaneous correlation matrix of growth shocks shows that periods of recessions in United States are highly (above 50%) positively correlated with those in Canada. By contrast, a weak negative correlation characterizes U.S.-Mexico (−4.86%) and Canada-Mexico (−11.52%). The degree of association of Regime 2 across the three
countries displays a quasi-similar picture except that the link between Canada and the U.S. is now weaker (25%). In terms of regime 3, the only thing that changes is that correlation between the United States and Mexico is positive. The volatility of the North American business cycle is mostly due to Mexico’s contribution as evidenced by the standard errors, the highest of all. Overall, the results being interpreted so far show that the North American Business cycle uncovered in the multivariate framework is not too different than the combined results obtained from isolated univariate cases, which unequivocally suggests a closer link between U.S. and Canada than between Canada-Mexico and Mexico-United States. The next step is to determine whether the dates inferred by the smoothed probability of recession of the system are close to the official dates of recession dictated by the NBER and ECRI for each country.

Table 1: Multivariate MS-VAR model estimation

<table>
<thead>
<tr>
<th>Regime dependent</th>
<th>Canada</th>
<th>United States</th>
<th>Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recession</td>
<td>-0.972</td>
<td>-0.952</td>
<td>-0.957</td>
</tr>
<tr>
<td>Normal Growth</td>
<td>0.552</td>
<td>0.635</td>
<td>1.558</td>
</tr>
<tr>
<td>High Growth</td>
<td>1.221</td>
<td>1.302</td>
<td>1.715</td>
</tr>
<tr>
<td>Parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ycan_1</td>
<td>0.198</td>
<td>0.076</td>
<td>-0.002</td>
</tr>
<tr>
<td>Yus_1</td>
<td>0.110</td>
<td>0.275</td>
<td>-0.191</td>
</tr>
<tr>
<td>Ymex_1</td>
<td>0.0515</td>
<td>-0.006</td>
<td>0.068</td>
</tr>
<tr>
<td>Dummy</td>
<td>0.820</td>
<td>0.511</td>
<td>1.426</td>
</tr>
<tr>
<td>Standard errors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recession</td>
<td>1.401</td>
<td>1.664</td>
<td>2.275</td>
</tr>
<tr>
<td>Normal Growth</td>
<td>0.969</td>
<td>0.589</td>
<td>1.921</td>
</tr>
<tr>
<td>High Growth</td>
<td>2.134</td>
<td>1.307</td>
<td>1.964</td>
</tr>
<tr>
<td>Duration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recession</td>
<td>3.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Growth</td>
<td>8.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Growth</td>
<td>5.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transition Probability Matrix</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recession</td>
<td>Normal Growth</td>
<td>High Growth</td>
<td></td>
</tr>
<tr>
<td>Recession</td>
<td>68.63</td>
<td>15.70</td>
<td>15.68</td>
</tr>
<tr>
<td>Normal Growth</td>
<td>12.23</td>
<td>87.60</td>
<td>0.17</td>
</tr>
<tr>
<td>High Growth</td>
<td>4.04</td>
<td>13.58</td>
<td>82.38</td>
</tr>
</tbody>
</table>

All variables are significant at the 5 percent level.

The trough dates extracted from the common cycle are fairly close to the dates reported by the NBER for the U.S. and by the ECRI for the three countries. The complete regime probabilities (filtered, predicted, and smoothed) of being in any given state are presented in Figure 2. Interesting enough, the recession periods that the Markov-switching vector autoregression model is able to capture coincides with the recession episodes extracted from the univariate models, as shown in Figure 3 in the Annex. In short, the multivariate model coincides with the univariate model implying that there exist a common component to all the three cycles. As stated earlier, it is the unobserved
component (non-Gaussian component of the series) that makes all three cycles behave in the same way, suggesting the existence of a North American Cycle. This in turn raises a number of interesting questions: (1) Is the common cycle symmetric? And (2) How do we relate the contribution of the North American business cycle to each country’s specific cycle, growth rate of output, and uncover how each country responds to the common unobserved components?

Figure 2. The North American Business Cycle

The common component of the North American business cycle extracted shows that the troughs in the mean growth rates coincide with the materialization of major exogenous shocks in North America. We could argue that the North American cycle is driven by common exogenous shocks, be they oil crisis, debt crisis, global uncertainty, political unrests, wars, or high tech burst. Further evidence as to how the North American cycle contributes to the process of economic growth of each individual country is shown in Figure 4. It shows that Canada and the U.S. are affected in a similar fashion by the North American business cycle over the full sample period. However, the full process of synchronization of the three countries in the way they are influenced by the common cycle seems to have intensified after the debt crisis in 1982. The 1990s even display a stronger convergence.

Country specific shocks dominate during the oil crisis of early 1970s, the debt crisis of early 1980s, the recession of early 1990s (except Mexico), and the early 2000s for all three countries. However, there are few cases where the common component is stronger. The implication of these findings from a policy standpoint is that a common policy might be used to smooth out the common component whereas country-specific policies might be used to address country specific component of the business cycle fluctuation. This
distinction in terms of the types of policy to use is most important for Mexico. Canada appears to have its common and specific components more in line than any other country. To determine how a North American shock affects each country when they are in a certain state, we analyze the impulse responses of each country to a North American recession, normal growth, and high growth. Regardless of the measure of output considered, the message is that all the three countries display similar dynamic patterns (see Figure 5 in the Annex). We discover that when a North American recession hits while countries are in a normal growth mode, industrial production in each country falls and all the countries reach a trough simultaneously in the fifth quarter. However, Canada and the United States show signs of recovery faster than Mexico, and have almost identical patterns of recession. When the economies are initially in normal growth, a positive North American shock has quite a strong impact on Canada and the United States than on Mexico. These confirm that there is a closer bond between Canada and the United States and they are affected by and respond in a similar fashion to shocks.

Overall, the key finding of this paper is that Canada and United States are mostly similar. However, if one has to take into account the synchronization of the business cycle that has been intensifying since the 1990s, there is no doubt that ups and downs in the level of economic activity in one country are closely associated with those of the other two countries. These findings based on industrial production indexes are no different from those resulting from the use of real GDP. It is worth noting that quarterly data on real GDP for Mexico is only available through IFS CD-ROM online starting 1980. We address this issue by cutting the sample on industrial production index accordingly and present two sets of results for the period 1980Q1 - 2004:3 showing the North American cycle dating, the contribution of the common component to individual countries, and the impulse responses of individual countries to North American shocks. The results convey the message that there are no real issues in capturing business cycle dynamics through either measures of output. The only peculiarity is that the Real GDP growth fails to capture the recession of early 2000s. The results for the real GDP analysis can be furnished upon request. The increase in the degree of industrialization of Mexico after joining NAFTA, as shown in Guisan, Exposito and Malacon (2003), together with other factors that affect positively the evolution of Mexico, will increase the degree of integration with the other countries of this trade agreement and will contribute to a higher degree of synchronization of business cycles.

6. Conclusion

This paper has investigated the cyclical compatibility of higher level of economic integration between Canada, United States, and Mexico. The paper first estimates the original Hamilton model in order to extract and date the business cycle of each country. The regime probabilities of being in recession are then used in a cross correlation and contingency analysis in order to detect any commonality among the three countries. These exercises reveal that the three countries follow the same business cycle patterns but the speed at which Canada and the U.S. reach the turning points is different from that at which Mexico reaches the same. There is a higher degree of concordance between U.S. and Canada than between U.S.-Mexico or Canada-Mexico.

The paper models the three countries jointly in a vector autoregression with switching intercept and covariance matrix, in order to determine whether there is a common North
American cycle. The MSVAR model extracts and dates the North American business cycle, and test for asymmetry. The unobserved component driving the common cycle obtained is used to shed light on how each country is affected in terms of impulse responses and in relation to their own specific shocks. Tests of co-movement of economic variables suggest that Canada and Mexico each share a common cycle with United States but not with each other. When taken as a block, Canada and the United States do not share a common cycle with Mexico.

Further research in this area is needed to determine whether consumption and investment across the three countries follow a similar pattern, most importantly, after the signing of NAFTA.

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On line Annex at the journal web site

Journal published by the EAAEDS: http://www.usc.es/economet/eaa.htm

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Appendix

In its broadest form, a Markov switching mean vector autoregression of order \( p \) with \( M \) regimes [MSM(M − VAR(p))] is given by:

\[
y_t - \mu(s_t) = A_1(s_t)(y_{t-1} - \mu(s_{t-1})) + ... + A_p(s_t)(y_{t-p} - \mu(s_{t-p})) + u_t
\]

where \( u_t \sim NID(0, \Sigma(s_t)) \) and \( \mu(s_t) \) is \( K \times 1 \) dimensional mean of the \( k \)-th dimensional time series vector \( y_t \), \( A_1(s_t), ..., A_p(s_t) \) are slope coefficients, \( u_t \) is a disturbance term whose covariance matrix \( \Sigma(s_t) \) along with all parameters of the model is dependent on the unobservable regime, \( s_t \). For example, in a three-regime set up:

\[
\begin{align*}
\mu(s_t) &= \mu_1 < 0, \text{ if } s_t = 1 \text{ (‘recession’)} \text{ with } \sigma_2(s_t) = \sigma_{21} \\
\mu(s_t) &= \mu_2 > 0, \text{ if } s_t = 2 \text{ (‘normal growth’)} \text{ with } \sigma_2(s_t) = \sigma_{22} \\
\mu(s_t) &= \mu_3 > 0, \text{ if } s_t = 3 \text{ (‘rapid growth’)} \text{ with } \sigma_2(s_t) = \sigma_{23}
\end{align*}
\]

It is also expected that \( \sigma_{22} < \sigma_{21} < \sigma_{23} \) because episodes of rapid growth are normally more volatile than periods of recession, which in turn are more volatile than period of slow growth (in the vicinity of the steady state). One characteristic of this modeling device, however, is that it allows for an immediate one-time jump in the mean following a shift in regime, which, according to Krolzig, does not account for the possibility that the mean may smoothly approach a new level after the transition from one state to another. In order to factor in this feature, Krolzig therefore suggests a regime-dependent intercept \( \nu(s_t) \) that can take into account the smooth transition of the mean:

\[
y_t = \nu(s_t) + A_1(s_t)y_{t-1} + ... + A_p(s_t)y_{t-p} + u_t
\]

where \( \nu(s_t) = \mu(s_t)(I - \sum_{j=1}^{p} A_j(s_t)) \)

As Krolzig (1997a, Ch.3; 1998) has demonstrated, the [MSM(M − VAR(p))] and the Markov switching intercept vector autoregression of order \( p \) with \( M \) states [MSI(M − VAR(p))] are two different models that imply two different dynamic adjustments of the observed variables in response to a change in regime. The former implies that a permanent regime shift leads to an immediate jump in the mean growth rate of the process to its new level. For the latter, a once-and-for-all regime shift in the intercept gives rise to a dynamic response of the growth rate of the observed variable that is identical to an equivalent shock in the white noise series \( u_t \).

The unobservable regime, \( s_t \), is generated by a first-order Markov chain defined by transition probabilities:

\[
p_{ij} = Pr(s_{t+1} = j|s_t = i) \quad \sum_{j=1}^{M} p_{ij} = 1 \quad i,j = 1...M
\]
By using the MSVAR process, we are able to determine whether there is an underlying common unobserved component that governs the dynamics of the mean growth rates of output within and across the group of countries. But our focal point is on the impulse response functions for non-linear models introduced by Krolzig and Toro (1998) and employed by Artis et al. (2003). In their view: “if the unobservable variable is to be interpreted as the state of the business cycle, an alternative procedure is to look at cyclical fluctuations in terms of the response of the variables to changes in the regime of the state variable.” Following these authors footsteps, our paper will concentrate on the path followed by each country’s or the group of countries’ output growth in response to changes in regime of the state variable in order to establish whether there is a link between business cycles and degree of economic development.

In few words, we decompose the vector of growth rate of output per capita for the countries in each group and across groups as the sum of two terms: a non-Gaussian component and a Gaussian component. The former would capture the contribution of a specific group’s cycle to individual countries while the latter would reflect each country’s specific shocks. Rewriting Equation 2:

$$\Delta y_t = A(L)^{-1}v(s_t) + A(L)^{-1} \sum^{1/2}(s_t)u_t$$

The contribution of country specific shocks to the growth rate of output is given by:

$$\lim_{j \to \infty} \frac{\partial E_t(\Delta y_{t+j})}{\partial u_t}$$

Where $E_t(\Delta y_{t+j})$ is the output forecasted at time $t$ for $j$ periods ahead. However, when there is a switch in regime from recession ($s_t = 1$) to expansion ($s_t = 2$) or vice versa, the impact in the long-run future level of output is given by:

$$\lim_{j \to \infty} \{E_t(\Delta y_{t+j} | s_t = 2) - E_t(\Delta y_{t+j} | s_t = 1)\}$$

Where $E_t(\Delta y_{t+j} | s_t = i)$ is the output forecasted in time $t$ for $j$ periods ahead when the economy is in state $i$. So the difference between the two terms reflect the impact on the growth rate of output when there is a change in regimes, which can be interpreted as the response of each country to the “group’s” recession or expansion.

The investigation of a common cycle between Canada, Mexico, and the United States is carried out in a two-step procedure. The first step is the Johansen maximum likelihood procedure for testing for cointegration (long run relationship) between the observables, in order to obtain the cointegrated matrix. If a long-run relationship is confirmed, the second
step boils down to estimating an MS-VECM [i.e. an MS-VAR with the cointegrating vector incorporated], using the expectation maximization (EM) algorithm in order to capture short-run dynamics. Otherwise, a pure MS-VAR is estimated via the same technique. The test used to uncover whether the three countries share a common cycle follows Hamilton and Perez-Quiros’s (1996) original contribution.

Figure 3. Probabilities of a Recession. (North American Recession vs. Country-specific Recession)
Figure 4. Contribution of the North-American Cycle to Individual Countries

Figure 5. Impulse Responses to North American Shocks Based on Full Sample