Identifying Canadian Regional Business Cycles using the Plucking Model

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It was Friedman (1964, 1993) who noted that the amplitude of a recession is strongly correlated with the following expansion, but the amplitude of an expansion is not correlated with the amplitude of the succeeding contraction. This striking asymmetry is the basic argument supporting the so named “plucking” model of business cycles.¹

Neftci (1984) presented empirical evidence of the kind of asymmetry advanced by Friedman (1964, 1993), when he found that unemployment rates are characterized by sudden jumps and slower declines. Further evidence was found by DeLong and Summers (1986), Falk (1986), and Sichel (1993). As Kim and Nelson (1999b) say, while these kind of asymmetries are consistent with the plucking model, they are also consistent with models where recessions are occasioned by infrequent permanent negative shocks as in the Markov-Switching models of Hamilton (1989) and Lam (1990). According to these authors, what distinguishes the plucking model is the prediction that negative shocks are largely transitory, while positive shocks are largely permanent.² Another important charac-

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² Financial support from the Faculty of Social Sciences is gratefully acknowledged.

1. Keynes (1936) suggested this kind of evidence: “the substitution of a downward for an upward tendency often takes place suddenly and violently”.

2. In this sense, Sichel (1994) also provides support to this fact by showing that post-war real GDP exhibits “peak-reverting behavior”. He also argues the existence of a third, high-growth recovery phase, in addition to the usual recession and expansion phases of the business cycle.

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The fact that recessions can essentially result from occasional transitory shocks may suggest that a recession, once it begins, will dissipate in a fairly predictable period of time. However, the length of an expansion is not helpful in predicting the next recession. This is what in the literature of business cycles is called duration dependence, which was investigated by Diebold and Rudebusch (1990), Diebold, Rudebusch and Sichel (1993), and Durand and McCurdy (1994) in an univariate context; and Kim and Nelson (1998) in a multivariate context. All these references found empirical support for the existence of duration dependence only for recession times.

Recently, Kim and Nelson (1999b) suggested a formal econometric specification of the business cycle. Their specification allows us to decompose measures from economic activity into a trend component and deviations from the trend that show the types of asymmetries implied by the business cycle literature. In this sense, the approach offers more possibilities than standard linear models such as ARIMA models and the unobserved component model of Clark (1987), which cannot account for asymmetries. It may also perform better than other kind of models as the Markov-Switching (Hamilton 1989; Lam, 1990) where the asymmetric behavior is only accounted in the growth rate or stochastic trend component of real output.

Mills and Wang (2002) applied to the output of the G-7 countries the approach of Kim and Nelson (1999b). Gálvao (2002) noted an interesting performance of this approach, where this model is one of the three models capable of reproducing the length of the United States business cycles. In this respect, see the special issue about business cycles published by Empirical Economics in 2002.

In this paper, I follow the same methodology of Kim and Nelson (1999b) applied to the logarithm of the real quarterly GDP of Canadian regions covering the period 1961:1 to 2000:1. For the purpose of comparison, estimations using the real quarterly GDP of Canada as a whole have also been included.

To my knowledge, at least for Canada, regional data has not been used to identify cycles and/or permanent components or business fluctuations in general. Regional data has been used to analyze predominantly the convergence issue; see, among other references, Coulombe (1999, 2000) and the references mentioned therein. One recent exception is Beine and Coulombe (2002) where regional cycles have been calculated with the goal of determining whether Canada can be considered a monetary zone. However, unlike the present paper, it is important to point out that in Beine and Coulombe (2002), the cycles have been calculated using the Hodrick and Prescott (1997) and Baxter and King (1999) filters, which assume symmetry and the absence of a theoretical model supporting the construction of these fluctuations.

As Coulombe (1999) argues, Canada is an interesting case for its density of regional economies, which suggests a different set of economies and possibilities for fluctuations and answers to different shocks. In Beine and Coulombe (2002), for example, one interesting result is the fact that Quebec and Ontario appear to be more linked with the economy of the Great Lakes than with the rest of Canada. In the case of Atlantic Canada, it is relatively poor and dependent on the so-called inter-provincial redistribution. On the other hand, the Prairies region economy (Alberta, Manitoba and Saskatchewan) is based on the extraction of oil and gas with Manitoba appearing relatively more diversified.

In summary, the diversity of regional economies in a large country such as Canada seems to be a primary element in supporting the interest in fluctuations in these economies. On the other hand, the presence of negative or positive shocks may have a different effect on the aggregate economy than on the regional ones because of their diversity. Consequently, regions should be able to answer differently in presence of shocks. In other words, it is possible to see the total effect observed at the aggregate level (here, Canada) as simply a “complicated” combination of the different regional fluctuations. The knowledge of particular characteristics of fluctuations can also be important from a regional policy perspective. In this context, some relevant questions to be addressed are the following: are the cycles all alike, are recessions driven by transitory factors or permanent shocks, are these fluctuations coincident with those observed using aggregate data for Canada?

Overall, the empirical results support the theoretical predictions made by the plucking specification. In fact, the coefficient associated with the discrete shock in the transitory component is negative and significant in all of the economies analyzed. This means that negative transitory shocks hit the regional economies putting down the real output. After that, the regional economies enter in a recovery phase and after this they operate again near the trend ceiling level. The chronology of the regional business cycles shows that there are some particular episodes corresponding to the regional dynamics, which are not present at the aggregate level. There are also recession dates at the aggregate level, which are also present at the regional level.

The rest of the paper is organized in the following manner. Section 2 presents the econometric specification of the plucking model. Section 3 deals with the empirical results. Section 4 presents a chronology of the regional business cycles and the filtered probabilities. Section 5 concludes.

**Econometric Specification of the Plucking Model**

Let \( y_t \) denotes the logarithm of the real output for a specification province or region in period \( t \). Following the literature of unobserved components (see Watson 1986), it is possible to decompose \( y_t \) into a trend component and a transitory component, which are denoted as \( \tau_t \) and \( c_t \), respectively. That is,

\[
y_t = \tau_t + c_t.
\]  

(1)

Adopting a similar notation as in Kim and Nelson (1999b), I assume that shocks to the transitory component are a mixture of two different types of shocks, which
will be denoted \( \pi \), and \( \mu \), respectively. This allows us to account for regime shifts or asymmetric deviations of \( y \) from its trend component. In formal terms, the transitory component and the shocks affecting their behavior are specified as follow:

\[
\begin{align*}
\xi_t &= \Phi_1 \xi_{t-1} + \Phi_2 \xi_{t-2} + \mu_t \\
\mu_t &= \pi \xi_t + \mu_t \\
\pi \xi_t &= \pi \xi_t \\
\mu_t &= N(0, \sigma^2_{\mu_t}) \\
\sigma^2_{\mu_t} &= \sigma^2_{\mu_t} (1-S_t) = \sigma^2_{\mu_t} S_t, \\
S_t &= 0.1
\end{align*}
\]

where \( \pi \neq 0 \). In the above specification, the term \( \mu_t \) is the usual symmetric shock. The term \( \pi \xi_t \) is an asymmetric and discrete shock, which is dependent upon an unobserved variable denoted by \( S_t \), which is an indicator variable that determines the nature of the shocks to the economy. When the economy is near the potential or trend output, it could be qualified as normal times. In this case, \( S_t = 0 \), which implies that \( \pi \xi_t = 0 \). In the opposite situation, which could be qualified as a period of recession, the economy is hit by a transitory shock potentially with a negative expected value, that is, \( \pi \xi_t = \pi < 0 \). In this case, aggregate or other disturbances are plucking the output down.

Note that equations (5) and (6) allow for the possibility that the variance of the symmetric shock \( \mu_t \), be different during normal and recession times. In order to account for a persistence of normal periods or periods of recession, it is assumed that \( S_t \) evolves according to a first-order Markov-switching process as in Hamilton (1989). It means that

\[
\begin{align*}
\Pr[s_t = 1 | s_{t-1} = 1] &= q \\
\Pr[s_t = 0 | s_{t-1} = 0] &= p
\end{align*}
\]

where, according to (10) and (11), the permanent component \( \tau \), is subject to shocks to the level and shocks to the growth rate. These shocks are given by \( v_t \) and \( w_t \), respectively. Note that it is allowed for the possibility that the variance of the shock to the level may be different during normal and recession times. However, variance of the shock to the growth rate is not likely to be systematically different during the normal and the recession times.

The model can be written in state-space form. The observation equation is

\[
y_t = [1 \ 1 \ 0 \ 0] \begin{bmatrix} \tau_t \\ \xi_t \\ \varepsilon_{t-1} \\ \mu_t \end{bmatrix}
\]

while the state equation is

\[
\begin{align*}
\xi_t &= \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \tau_{t-1} \\ \varepsilon_{t-1} \\ \mu_{t-1} \\ \mu_t \end{bmatrix} + \begin{bmatrix} v_t \\ w_t \end{bmatrix} \\
\end{align*}
\]

where \( E'(V_t V_t') = Q_S \), and

\[
Q_S = \begin{bmatrix} \sigma_{x_t}^2 & 0 & 0 & 1 \\ 0 & \sigma_{x_t}^2 & 0 & 0 \\ 0 & 0 & \sigma_{x_t}^2 & 0 \\ 0 & 0 & 0 & \sigma_{x_t}^2 \end{bmatrix}
\]

Notice that the model expressed by (13) and (14) nests the model suggested by Clark (1987). As it is well known, the model of Clark (1987) does not account for asymmetries, which in the context of the specification (13) and (14) implies that \( p = q = 0 \). On the other hand, in the model of Clark (1987) \( \sigma_{x_t} = \sigma_{x_t} = \sigma \), and \( \sigma_{x_t} \)
= \sigma_{ul} = \sigma_u$. In the empirical section, the plucking model is tested against the symmetric model proposed by Clark (1987). Therefore, a rejection of the null hypothesis indicates the presence of asymmetries in the regions analyzed.

**Empirical Results**

The model presented in the last section is estimated using the logarithm of the quarterly GDP of the Canadian regions covering the period 1961:1 to 2000:1, using the first 21 observations as starting values. The regions analyzed are British Columbia, Atlantic, Ontario, Prairies and Quebec. The Atlantic region includes the provinces of New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland. On the other hand, the region noted as the Prairies is formed by Alberta, Manitoba and Saskatchewan. As it is apparent, this region covers very different provincial economies. In my opinion, Alberta has different dynamics than the other two provinces and consequently, I am considering another region, denoted as the Prairies-ex, which is formed only by Manitoba and Saskatchewan. Hence, Alberta is also considered separately in the subsequent analysis. Finally, for purpose of comparison, I also include estimations using the logarithm of the quarterly GDP of Canada as a whole.

Table 1 presents the LR statistics (and its p-values) of testing the unrestricted plucking model against the symmetric model suggested by Clark (1987). The p-values are obtained using a \(\chi^2\) distribution, where \(v\) denotes the number of restrictions, which in this case are \(\sigma_{ul} = \sigma_u = 0\), \(\pi = 0\) and \(p = q = 0\). The results indicate a strong rejection of the null hypothesis except for the Atlantic region and the Prairies with p-values of 0.314 and 0.338, respectively. Therefore, the LR statistic supports the hypothesis of the existence of asymmetries in most of the Canadian regions. Even when the null hypothesis has not been rejected for the Atlantic region and the Prairies, I continue to use these regions in the following steps because it is possible that a more reduced model than the unrestricted plucking model, but larger than the model of Clark (1987), is adequate for both regions.

The third column of the Table 1 shows the results of testing for the restriction that \(\sigma_{ul} = 0\), which is equivalent to arguing that the trend growth component has been constant, or in other words, that the output has not undergone a productivity slowdown. The results support rejection of the null hypothesis for all regions except for Ontario and Prairies-ex. The last column of the Table 1 tests for the restriction that \(\sigma_{ul} = \sigma_u = 0\), which is equivalent to arguing that the asymmetries in the transitory component are not derived from the term \(u_t\), and therefore, they account exclusively for the asymmetric discrete shock \(\pi_{st}\). The results support rejection of the null hypothesis only for Canada as a whole.

In summary, all hypotheses have been rejected when only using the aggregate of Canada, suggesting that traditional asymmetric shocks to the transitory component, the discrete asymmetric shock \(\pi_{st}\) and shock to the permanent components are relevant. In this sense, an unrestricted plucking model is selected for Canada as a whole.

On another hand, the regions of British Columbia, Quebec, and the province of Alberta rejected the null hypothesis implied by the model of Clark (1987), and also the null hypothesis that the trend growth component has been constant. However, the hypothesis that \(\sigma_{ul} = \sigma_u = 0\) was not rejected. Therefore, a restricted plucking model with \(\sigma_{ul} = \sigma_u = 0\) is selected for these economies.

In the case of the region of Prairies-ex, a restricted plucking model with \(\sigma_{ul} = \sigma_u = 0\) is selected. The same model appears to be also justifiable for the region of Ontario. However, estimates from the unrestricted plucking model or the model implied by the third column of the Table 1, suggest that \(\sigma_u = 0\) is statistically different from zero. Therefore, before selecting the final model, I estimate two alternative models. They impose the restrictions \(\sigma_{ul} = 0\), and \(\sigma_u = 0\), respectively. A p-value of 0.06 supports a rejection of the second model. Conse-

---

Table 1 LR Statistics

<table>
<thead>
<tr>
<th>Region</th>
<th>LR Statistic</th>
<th>p-Value</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Columbia</td>
<td>49.96</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Atlantic</td>
<td>5.92</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Ontario</td>
<td>11.35</td>
<td>0.34</td>
<td>0.00</td>
</tr>
<tr>
<td>Prairies</td>
<td>5.68</td>
<td>0.338</td>
<td>0.00</td>
</tr>
<tr>
<td>Quebec</td>
<td>16.55</td>
<td>0.00</td>
<td>0.26</td>
</tr>
<tr>
<td>Alberta</td>
<td>12.87</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Prairies-ex</td>
<td>34.19</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Canada</td>
<td>270.73</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Note: *p-values in parenthesis.

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4. Of course, other opinions may suggest that Saskatchewan also constitutes a very different economic structure and it should be analyzed separately. While I accept some degree of arbitrariness in the decision to analyze separately the province of Alberta, my support is the fact that this province is essentially dedicated to the extraction of oil and gas, while Saskatchewan is principally a region based on agriculture like Manitoba, even when this last province presents some greater degree of diversification.
TABLE 2 Estimates from the Selected Models

<table>
<thead>
<tr>
<th></th>
<th>BC</th>
<th>Atlantic</th>
<th>Ontario</th>
<th>Prairies</th>
<th>Quebec</th>
<th>Alberta</th>
<th>Prairies-ex</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>(q)</td>
<td>0.9100</td>
<td>0.2334</td>
<td>0.9519</td>
<td>0.7678</td>
<td>0.5083</td>
<td>0.6949</td>
<td>0.5492</td>
<td>0.9452</td>
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<tr>
<td></td>
<td>(0.0827)</td>
<td>(0.2667)</td>
<td>(0.0348)</td>
<td>(0.1240)</td>
<td>(0.0181)</td>
<td>(0.1836)</td>
<td>(0.1549)</td>
<td>(0.0416)</td>
</tr>
<tr>
<td>(p)</td>
<td>0.9591</td>
<td>0.8731</td>
<td>0.9620</td>
<td>0.9130</td>
<td>0.9852</td>
<td>0.9844</td>
<td>0.9672</td>
<td>0.9644</td>
</tr>
<tr>
<td></td>
<td>(0.0233)</td>
<td>(0.1138)</td>
<td>(0.0231)</td>
<td>(0.0561)</td>
<td>(0.0121)</td>
<td>(0.0111)</td>
<td>(0.0169)</td>
<td>(0.0226)</td>
</tr>
<tr>
<td>(\phi_1)</td>
<td>-0.0043</td>
<td>0.3818</td>
<td>0.9315</td>
<td>0.3916</td>
<td>1.4977</td>
<td>0.1923</td>
<td>0.4985</td>
<td>1.4683</td>
</tr>
<tr>
<td></td>
<td>(0.0278)</td>
<td>(0.1766)</td>
<td>(0.0816)</td>
<td>(0.1979)</td>
<td>(0.1202)</td>
<td>(0.1138)</td>
<td>(0.1178)</td>
<td>(0.1125)</td>
</tr>
<tr>
<td>(\phi_2)</td>
<td>0.0018</td>
<td>-0.5207</td>
<td>-0.0434</td>
<td>0.2380</td>
<td>-0.5429</td>
<td>0.5542</td>
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<td>-0.6173</td>
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<tr>
<td></td>
<td>(0.0094)</td>
<td>(0.1786)</td>
<td>(0.0763)</td>
<td>(0.2023)</td>
<td>(0.1166)</td>
<td>(0.1310)</td>
<td>(0.1203)</td>
<td>(0.1149)</td>
</tr>
<tr>
<td>(\sigma_{1, w})</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.0043</td>
<td>--</td>
</tr>
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<td></td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>(0.0015)</td>
<td>--</td>
</tr>
<tr>
<td>(\sigma_{2, w})</td>
<td>--</td>
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<td>--</td>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>(0.0007)</td>
<td>--</td>
</tr>
<tr>
<td>(\sigma_{1, u})</td>
<td>0.0087</td>
<td>0.0099</td>
<td>0.0083</td>
<td>0.0082</td>
<td>0.0074</td>
<td>0.0119</td>
<td>0.0095</td>
<td>0.0048</td>
</tr>
<tr>
<td></td>
<td>(0.0009)</td>
<td>(0.0009)</td>
<td>(0.0008)</td>
<td>(0.0011)</td>
<td>(0.0005)</td>
<td>(0.0008)</td>
<td>(0.0006)</td>
<td>(0.0013)</td>
</tr>
<tr>
<td>(\sigma_{2, u})</td>
<td>0.0196</td>
<td>0.0111</td>
<td>0.0086</td>
<td>0.0103</td>
<td>0.0021</td>
<td>0.0090</td>
<td>0.0228</td>
<td>0.0040</td>
</tr>
<tr>
<td></td>
<td>(0.0029)</td>
<td>(0.0032)</td>
<td>(0.0009)</td>
<td>(0.0027)</td>
<td>(0.0013)</td>
<td>(0.0029)</td>
<td>(0.0056)</td>
<td>(0.0026)</td>
</tr>
<tr>
<td>(\sigma_{w})</td>
<td>0.0005</td>
<td>0.0005</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.0004</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td>(0.0003)</td>
<td>(0.0003)</td>
<td>(0.0004)</td>
<td>(0.0005)</td>
<td>(0.0004)</td>
<td>(0.0005)</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>(\pi)</td>
<td>-0.0377</td>
<td>-0.0116</td>
<td>-0.0217</td>
<td>-0.0193</td>
<td>-0.0180</td>
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<td>-0.0367</td>
<td>-0.0118</td>
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<tr>
<td></td>
<td>(0.0062)</td>
<td>(0.0046)</td>
<td>(0.0035)</td>
<td>(0.0049)</td>
<td>(0.0028)</td>
<td>(0.0035)</td>
<td>(0.0055)</td>
<td>(0.0024)</td>
</tr>
</tbody>
</table>

LogLdf: 392.7437 419.7821 438.6214 421.6318 461.8499 393.8828 412.7678 500.5384

Note: * Standard errors in parenthesis.

The results of the estimations are presented in Table 2, where values in parenthesis indicate the standard errors. There are some observations to point out. One important issue is concerned with the value of the sum of the autoregressive coefficients of the transitory component (\(\phi_1\) and \(\phi_2\)). The highest values correspond to the regions of Quebec, Ontario and the aggregate of Canada with 0.954, 0.931, and 0.851, respectively. While Alberta presents a value of 0.746, the rest of regions show lower levels of persistence with the regions of British Columbia and Atlantic showing the smallest levels of persistence. In these cases, the results suggest that there are no subsequent effects on the series originated by the transitory shock. Observing the roots associated with the AR(2) polynomial of the transitory component, only the Atlantic region and Canada as a whole present pseudo-cyclical behaviour with periods of 4.82 and 17.25 quarters, respectively.

Another important issue is related to the estimates of \(\pi\), the coefficient associated with the discrete shock of the transitory component. According to the results, this coefficient is always statistically significant and negative suggesting strong support for the plucking model.

From the specification of the plucking model, we know that the transitory component is also subject to a symmetric continuous shock, denoted by \(u_a\). As it was shown from the results of Table 1, the null hypothesis \(\sigma_{1, w} = \sigma_{1, u} = 0\) was not rejected for most of the regions, indicating that the volatility of the transitory shocks in recession and normal times appears to be insignificant. All this suggests that the discrete shock \(\sigma_{w}\) explains most of the dynamics in the transitory component of most of the economies analyzed.

On another hand, the estimates of the variances associated with the level of the permanent component \((\sigma_{1, w}^2\) and \(\sigma_{1, u}^2\)), are significant in almost all regions. The exception is Canada as a whole where the estimate of \(\sigma_{w}^2\) is not statistically different from zero. The variance of the growth rate of the permanent component \((\sigma_{\sigma}^2\)) is not significant for the regions of Ontario and the Prairies-ex. Therefore, it is concluded that the trend growth has been constant in these territories.

In summary, the estimates suggest that during normal times \((\delta = 0)\), most of the regional economies analyzed are subject principally to permanent disturbances and they operate near the trend ceiling. In the other case, during recessions and the recovery periods that follow, the transitory component plays a principal role in regional output fluctuations. At the same time, given the magnitude of the sum of the autoregressive coefficients, when regional economies are near the end of a period of recession, and there are no other negative shocks, the fast-decaying negative impact of the discrete shock \(\sigma_{w}\) is significant in almost all regions.
-tive shocks give origin to a third phase, which Sichel (1994) named high-recovery phase. This is also supported for the case of Alberta and Canada as a whole but not in the rest of regions.

On the other hand, unlike the behavior of the Prairies-ex, Alberta presents a statistically significant estimate of \( \alpha_w \) meaning that the trend growth has not been constant in this province. It supports the argument that its dynamics is different from the other two provinces forming the Prairies-ex.

Figures 1 and 2 visually summarize the preceding discussions. Notice that all estimates presented in the graphs represent filtered estimates, that is, they are estimates based on information until time \( t \). Figure 1 shows the evolution of the logarithm of the real output and its trend component for each region \( (t_{1:t}) \) while Figure 2 shows the estimates of the transitory components for each region \( (c_{1:t}) \).

Essentially, Figure 1 indicates that most of the time the regional economies are operating on or near the trend ceiling component. In periods of recession, the economy is operating below the trend-ceiling component. Notice that there are some cases where the economy is notably below the ceiling component. All these issues can be appreciated more clearly in Figure 2. It is possible to observe that after a trough, the negative transitory shocks are deteriorating, restoring the economy back to the trend ceiling, or the normal level.

In conclusion, once a series of negative transitory shocks hit regional economies, it plucks output down, their effects decay relatively fast as implied by \( \Phi_1 + \Phi_3 \), especially in the cases of the Atlantic region and British Columbia. In other words, the negative shocks are relatively short-lived. Near the end of the recession, with no further new negative shocks, the fast decaying negative shocks give rise to a third, high recovery phase. Then by the time the effects of these negative shocks are all gone, the economies are again operating near the trend ceiling component. We have, in consequence, three distinctive phases of the business cycle fluctuations, as suggested by Sichel (1994).

A Chronology of the Regional Business Cycles

Using the estimates of probabilities \( (p \) and \( q) \), it is possible to calculate the expected durations of a recession and of normal times defined by \( 1/(1-q) \) and \( 1/(1-p) \), respectively. The estimates suggest that the region presenting higher expected durations of normal times is Quebec and also the province of Alberta with around 64 quarters. The regions of Ontario, British Columbia and Prairies-ex show dura-
tions of around 24 to 30 quarters. In the case of Canada as a whole, it presents duration of around 28 quarters. In the cases of the Atlantic region and the Prairies, shorter durations are observed (around 8 to 12 quarters).

Concerning the expected duration of recession times, the region of Ontario and the aggregate of Canada show a duration of around 20 quarters. The region of British Columbia presents a duration of 17 quarters and the rest of the regions present shorter durations (between 1.3 and 4.3 quarters).

Figure 3 represents the probabilities of negative shocks to the transitory component \( P(S_t = 1) \). Using these probabilities, Table 3 presents a chronology of the Canadian regional business fluctuations. I consider the last quarter before a recession as a peak and the last quarter of a recession as a trough where a recession should last at least for two quarters. I use the practical rule proposed by Hamilton (1989), where a probability larger than 0.5 indicates (in this case) that there is a recession.

For Canada the recession times identified by the model are the periods 1975:1-1975:3, 1982:1-1983:4, and 1991:1-1991:3. Interestingly enough, recessions in Canada are not exactly coincident with those experienced by in the US but rather they always occur after a recession in the US. In fact, for example, the oil crisis appears to have affected the US economy immediately but Canada is not affected until some quarters after. However, note that the oil crisis is not detected in the province of Alberta. The last two recession periods identified for Canada are normally found in other studies; see Goodwin (1993), Bodman and Crosry (2000), Cross (2001), and Mills and Wang (2002). As it is well known, in the 1980s Canada was affected by two shocks. The first shock was a shift in the international patterns; while the second shock was associated with the presence of labor rigidities coming from structural differences among the ten provinces.

The model selected for British Columbia detects a long period of recession between 1970:2 and 1976:2. The short period of 1970:1-1970:4 appears as a recession time for Manitoba and Saskatchewan (the Prairies-ex). The recession time of 1982-1983 appears as a common period for the regions of Quebec, British Columbia, and the province of Alberta although in British Columbia the recession appears longer. The provinces of Manitoba and Saskatchewan (Prairies-ex) present a recession time previous to the period identified for other regions or for Canada as a whole. The period 1986:2-1987:3 appear to be common to the regions of British Columbia, and the Prairies. Observing the Prairies and the province of Alberta, it is clear that the province of Alberta is responsible for this recession time. Note that this recession time is not observed at the aggregate level. The last recession time observed for Canada as a whole is only observed in the region of Ontario.

It is worth to note that the Table 3 presents different recession times for the regions of Ontario and Quebec, although both periods are detected at the aggregate level. Observing the Figure 2 or 3, the pattern followed by the regions of Ontario and Quebec appears to be very similar and therefore, it could be expected finding similar periods of recession times. Because we are using the standard rule that a recession should last at least for two consecutive quarters, some quarters are not detected in both regions. For example, for the region of Quebec, 1991:1 presents a probability of 0.49, which indicates that the recession time detected in the region of Ontario or at the aggregate level appear also in Quebec but very transitorily. In the case of the region of Ontario, the quarters 1982:4-1983:1 appear with probabilities of 0.45 and 0.62, respectively indicating that this period was a transitory slow-
down in the Ontarian economy.

In the case of the Atlantic region, the previous results indicate that a linear symmetric model cannot be rejected in favor of the plucking model. Even then, Table 2 shows estimates obtained from a restricted plucking model. Notice that the coefficient \( q \) is not statistically significant but the opposite situation is observed for other parameters including the asymmetric discrete coefficient. In spite of that, the cycles detected for this region (see Figure 2) show high volatility and it is very clear, that unlike the other economies analyzed, the pattern implied by the plucking model is not present. Figure 3 verifies this issue in the sense that no periods of recession or normal times are possible to be identified. The results are consistent with the initial evidence in favor of the linear symmetric model.

A further issue that is worth to be discussed is related to the correlations between the different regional cycles. The cycles of the regions of Quebec, Ontario, British Columbia and the Prairies are correlated with Canada as a whole with coefficients of correlation of 0.789, 0.671, 0.467, and 0.422, respectively. It is interesting to note that the province of Alberta shows a coefficient of correlation of 0.289 while the Prairies-ex (Manitoba and Saskatchewan) present a small but negative coefficient of correlation (-0.114). In the case of the Atlantic region, the cycle obtained using the restricted plucking model allows us to obtain a coefficient of correlation of 0.131. A higher value (0.392) is obtained when the linear symmetric model of Clark (1987) is used.

Observing the correlation between regions, the following issues are of note. The region of British Columbia appears more correlated with the Prairies (0.605), Quebec (0.370), Prairies-ex (0.324), Alberta (0.257) and Ontario (0.222). In the case of the region of Ontario, it is higher correlated with Quebec (0.824), and the Prairies (0.522). The region of Quebec, further to Ontario, appears higher correlated with the Prairies (0.638). The region of the Prairies-ex presents small but negative coefficients of correlation with the regions of Quebec and Ontario. In the case of the Atlantic region, it presents the smallest coefficients of correlation with the rest of regions or with Canada as a whole.

Conclusions

While most of the business cycles research has been focused on the use of aggregate data at the international level, no study has been dedicated to regional data. Given that Canada represents an interesting example of the density of regional economies, this paper represents a first attempt at identifying recessions at this level. Among the many reasons justifying the interest in regional business fluctuations, the variety and the different dynamics and possible answers to the presence of a shock are of most importance.

The principal goal of this paper is to provide empirical evidence on regional business fluctuations using Canadian regional data. To do this, I used the econometric specification of the plucking model of Friedman (1964, 1993) proposed by Kim and Nelson (1999b). This model, after imposing an asymmetric discrete shock in the transitory component of the series, allows for estimation of the permanent and the transitory components of the series.

The results confirm the relevance of the plucking model using Canadian regional data. The estimates indicate the importance of the asymmetric discrete coefficient in almost all regional economies. Permanent and transitory components are identified and the evidence suggests that regional economies are working near the ceiling level until a shock strikes the economy and this lowers the output. After that, recovery starts again until another shock appears. Different answers can be inferred when the probabilities of being in a recession have been calculated. There are some "common" periods of recession in the sense that they are observed at the aggregate level and also at the regional level. But there also exist "regional" recessions which are observed only at the regional level.

References


