Assessing the impacts that market and policy changes in the forest industry have on communities in rural New Brunswick

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Abstract:

A two-sector computable general equilibrium model is calibrated to the New Brunswick community of Petitcodiac. Simulations are conducted for marginal reductions in both the price of lumber and the timber supply. We observe that both reductions have negative impacts on output and most production factors in the forest sector. Other production sectors tend to expand as production factors flow to where they receive their highest return. Comparing the results of this study with those of an Alberta case study, findings indicate that the New Brunswick community is more significantly impacted from timber supply changes and is less significantly impacted from timber price changes.

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Introduction:

The forest industry plays an important role in the welfare of local communities in the Fundy Model Forest (FMF) region of New Brunswick. In 2000, this industry employed over 4,615 people and produced over $619 million worth of timber.[3] These figures account for an important share of this region's contribution to provincial employment and gross domestic product. With approximately 25 communities in this region designated as moderately or highly forest-dependant (MacGregor 2001), it is clear that changes in the forest industry will have significant impacts on FMF residents.

The fate of the Fundy forest industry has become increasingly uncertain in recent years. This uncertainty, which exists in many Canadian forest regions, stems primarily from two concerns. First, world forest product prices are projected to decrease in the long run.[4] This projection is largely due to the expected increase in global supply of forest products from plantations in Latin America and South East Asia. These southern suppliers are increasingly establishing a comparative advantage over producers in northern regions such as New Brunswick. The comparative advantage is being created from regional differences in timber growth rates, rotation age, labor costs, and environmental regulations (Alavalapati 1999b).

A second concern with regard to the Fundy forest industry's future is the increasing pressure to maintain environmental quality in the forest. This concern has caused government officials and forest managers of both public and private forestland to implement policies directed toward both reducing harvesting scale and augmenting silvicultural practices in the province.[5] One such policy initiative is the recent decision to protect approximately 150,000 hectares of provincial forestland from harvesting operations (NBDNRE 2002).[6] This policy is estimated to have reduced the annual timber supply throughout the province by approximately 160,000 cubic meters (GP 2000). Continued environmental quality concerns may call for enhanced government and forest manager intervention to reduce the timber supply across more areas of New Brunswick. These actions, while creating many socio-economic benefits for the region as a whole, often have significantly negative impacts on forest-dependent communities (Robinson and Freitag 1994).

Given the important role that the forest industry plays in the Fundy Model Forest region and the uncertainties that surround it, an in-depth understanding is needed of the underlying characteristics of this production sector, and its linkages with the rest of the

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[3] The value of timber is computed using MacGregor and MacFarlane's (2000) harvest estimates and applying an average price of $543.75/m^3, as calculated from NSFPMB (2002).

[4] Converting Sohngen et al.'s (1997) world forest product price projections to real values (accounting for inflation) reveals a long-run declining trend for most demand scenarios.

[5] Forest ownership in New Brunswick is divided between crown (50%), industrial freehold (30%), and private woodlots (20%). While public forestland has prescribed annual allowable cut (AAC) limits, private forestland management is increasingly being influenced by market demands (i.e. certification).

[6] There are a total of 10 areas that have been protected across New Brunswick. Three of these areas surround the perimeter of the FMF region.

economy. By understanding the socio-economic impact of market and policy changes in the forest industry, policy makers will be better prepared to help mitigate negative outcomes on the overall economy. In an effort to address the above issues, this paper will investigate the economic impacts of changes in forest product prices and the timber supply on a forest-dependent community in the region.

The case study region investigated in this paper is the community of Petitcodiac, located in the Fundy Model Forest, in southern New Brunswick. This community is chosen because it represents a mid-range level of forest dependence in the region. The village itself covers a total area of about 17 square kilometers. For the purpose of this study, we have expanded the Petitcodiac boundary to include individuals in the surrounding area who would consider themselves Petitcodiac community members. This region is bounded by River Glade in the east, Anagance in the west, Elgin in the south, and New Canaan in the north (Personal Comm. 2002). The community of Petitcodiac is therefore defined as covering a total area of 1,036 square kilometers out of which about 80% is forested. Ownership of the forestland is divided between crown (15%), private woodlot owners (65%), and industrial freehold (20%). The total population in this community is approximately 8,000 (Personal Comm. 2002).

According to Statistics Canada, the labour force participation rate in Petitcodiac is 53.1% of the total population (Stats. Can. 2002). The service sector is the principal employer (at 73%) followed by manufacturing (at 14%) and resource-based industries (at 13%). There are a total of 515 businesses out of which 35 are directly forest-related (10 logging and 25 lumber/wood/pulp companies). Furthermore, according to village council members and key informants from the community, the forest industry contributes approximately $150 million to the region's $500 million GDP total, and employs approximately 600 of the 4,770 full time equivalent workers (Personal Comm. 2002). The lumber sector produces the lion's share of the forest industry's GDP, and employs about 80% of this industry's labour force. Additional information reveals that the 2002 average annual wage/salary for forest-related employees in the region is $23,000. This is approximately $3,000 above the aggregate industrial average in the region.

In order to investigate market and policy changes in the case study region, a two-sector (forest and composite), five-input (capital, labour, energy, land, timber) computable general equilibrium (CGE) model is specified. Although CGE models have been used in the past to study such changes, ours is uniquely specified and calibrated to the case-study region. Simulation results can be compared to other studies in order to provide some insight to the variation in regional impacts. Additionally, we estimate market and policy impacts under both flexible and fixed wage scenarios. This provides some sense for how responsive the results are to a change in wage flexibility assumptions.

In calibrating the CGE model to the case study region, we rely on previous research for a number of industry-level elasticity measures. These measures are used, together with other data gathered from statistical agencies and village council/business members in our case-study region, to calibrate the CGE model and run the market and policy simulations.

The organization of this paper is as follows. In the next section, a review of the CGE forestry literature is conducted. The following section explains the methodology and data sources of the study. A fifth section presents the results of the analysis. Then, a sixth section concludes the study.

Methodology

The CGE model specified in this study is similar to that of Alavalapati et al. (1999b), Daniels et al. (1991), and Calves and Jones (1985). In these models, a two output (forest and composite) and four production factor (labour, capital, land, timber) economy is assumed. The economic region is assumed to exhibit small open economies with constant returns to scale production technologies, perfect competition, and fixed commodity prices.[7] Additionally, wages may be fixed or flexible, depending on the timing of economic shocks.[8] Alavalapati et al. (1999b) make further assumptions that: (i) land and timber are in fixed supply; (ii) capital is the only mobile factor between sectors; and (iii) household income originates from wage income alone. The model developed in the current study, and described in more detail in Appendix 1, differs from these earlier models in its treatment of a number of important factors. Specifically, based on an interview with village council and business members of the Petitcodiac community, we assume that: (i) there are five factors of production (labour, capital, energy, land, timber); (ii) labour, capital, land, and timber supplies are responsive to their respective input price;[9] (iii) labour, capital, and energy inputs are mobile between sectors and in/out of the region;[10] and (iv) households receive income from wage, capital/land rent, and stumpage revenues (Personal Comm. 2002). Consequently, divergent simulation results are expected for the current New Brunswick study and those of Alavalapati et al.'s (1999b) Alberta study.

There are two major categories of data required for our CGE model analysis. The first category includes data on the production structure of the sectors analyzed. Specifically, we require estimates for price and factor substitution elasticities in the forest and composite sectors. In the case of the forest sector elasticities, we rely on the national estimates produced in Singh and Nautiyal (1986). Data for estimating the composite sector production structure, on the other hand, is not as readily available. As such, we compile the required elasticity estimates from those produced in the United States by Thompson (1997), Klein (1974), Paraskevopoulos (1979) and Fishelson (1979).[11]

[7] Fixed commodity prices result from the assumption that the agents in the economy are price takers (Alavalapati et al. 1999b).
[8] Wages may be rigid in the short-run since some forestry and composite sector workers are unionized, and thus have fixed salaries.
[9] Land and timber supplies are expected to be responsive to input prices in regions where there is excess land capacity and a significant amount of forestland privately owned, respectively. Both of these circumstances exist in the case-study region. We also assume that land and forestland released from composite and forestry production is not available for use in other sector (Alavalapati et al. 1999b; Alavalapati et al. 1997).
[10] These assumptions result from community members' indications that these inputs do indeed move freely between sectors in the region (even in the immediate short run).
[11] All input price and substitution elasticity estimates used in this study are available from the authors upon request.

The second category of data required for CGE analysis is community-specific. Most of the data for the community of Petitcodiac has been collected from a group interview with village council/business members from the community. Such information as: (i) the value of total output from the forest and the composite sectors; (ii) the total/share of employment for the sectors in the community; (iii) the average annual wage in each sector and the value of total timber used as input in the forest sector; (iv) the total capital in each sector; (v) the amount of energy consumed in the two sectors; and (vi) the price per KWH of energy has been estimated by the informants.[12]

Results

The CGE simulation results for marginal reductions in the lumber price and the timber supply are presented in Tables 1 and 2, respectively. When the price of lumber decreases by 1% in the flexible wage scenario (Column 3 in Table 1), forest sector output decreases by 0.530%. This causes the producer’s demand for labour, capital, energy, and timber to decrease by 0.340%, 0.300%, 1.061%, and 0.655%, respectively. These changes cause input suppliers to accept a 0.679% lower wage, a 0.007% (numeraire) lower rental rate of capital, and a 1.309% lower stumpage price.

The drop in the wage rate and the rental rate of capital in the lumber price simulation causes labour and capital to flow out of the forest sector and into other sectors of the economy where they receive higher returns. As a result, the composite sector experiences an increase in output of 0.013%, in labour of 0.001%, in capital of 0.022%, and in land of 0.013%. Energy demand in this sector decreases by 0.901% as producers make cost-efficient input substitutions. These changes cause wages to increase by 0.003%, the rental rate of land to increase by 0.026%, and household income to decrease by 0.407%. Overall, the Petitcodiac community experiences a significant reduction in total output, labour, and capital in the region.

Under the fixed-wage scenario, the marginal lumber price reduction generally causes a similar impact on most model variables relative to the flexible wage scenario (revealed in column 4 of Table 1). More specifically, the 1% reduction in the lumber price causes: (i) a relatively larger decrease in forest sector output, labour, timber, and stumpage rate; (ii) a relatively smaller decrease in forest sector capital and energy; (iii) a relatively smaller increase in composite sector output, capital, land, wage, rental rate of capital, and land. The only variable that reacts in a different manner is energy. In the case of fixed wages, energy in the composite sector is increased by 0.002% (leading to a smaller overall decline in total energy in the economy). This reduction results from the combined effects of: (i) the complementary relationship that energy has with labour (embodied in the elasticity estimates employed); and (ii) the relatively large reduction in labour that results from the fixed wage assumption.

[12] The questionnaire given to the participants is available from the authors upon request.

Table 1: Economic impacts of a 1% decrease in the price of lumber for the Petitcodiac community

Variables	Base value (2001)	Price impact (in % change)	
		Flexible wage scenario	Fixed wage scenario
Output in forest sector (X_F)	$150.0 million	-0.530	-0.668
Output in composite sector (X_C)	$350.0 million	0.013	0.002
Labour in forest sector (L_F)	600	-0.340	-0.909
Labour in comp. sector (L_C)	4,170	0.001	0.001
Total labour in economy (L)	4,770	-0.068	-0.186
Capital in forest sector (K_F)	$15.0 million	-0.300	-0.048
Capital in comp. sector (K_C)	$175.0 million	0.022	0.004
Total capital in economy (K)	$190.0 million	-0.003	-0.001
Energy in forest sector (E_F)	$7.5 million	-1.061	-0.648
Energy in comp. sector (E_C)	$35.0 million	-0.901	0.002
Total energy in economy (E)	$42.5 million	-0.929	-0.113
Timber in forest sector (M)	9.063 mill. m^3	-0.655	-0.746
Land in comp. sector (D)	15,540 ha	0.013	0.002
Wage in forest sector (W_F)	$27.0 million	-0.679	0.000
Wage in comp. sector (W_C)	$105.0 million	0.003	0.001
Rental rate of capital (R)	Numeraire	-0.007	-0.001
Stumpage rate of timber/m^3 (S)	$40	-1.309	-1.492
Rental rate of land/ha (V)	$1,297	0.026	0.004
Income of household (Y)	$142.4 million	-0.407	-0.407

[a] National input substitution elasticity estimates are from Singh and Nautiyal (1986).

When the timber supply is reduced by 1% in the flexible wage scenario (Column 3 in Table 2), forest sector output, labour, capital, and energy decrease by 8.871%, 0.386%, 1.311%, and 1.497%, respectively. These reductions cause downward pressure on forest sector wages by 0.773% and rental rates on capital by 0.030%. Stumpage rates, on the other hand, increase by 0.212% as producers bid up the price of the declining input.

The wage rate and rental rate of capital reduction in the timber supply simulation again cause labour and capital to flow out of the forest sector and into other sectors of the economy. In this case, the composite sector experiences an increase in output, labour, capital, and land of 0.056%, 0.006%, 0.096%, and 0.057%, respectively. Energy demand decreases by 0.980% as firms make cost-efficient factor substitutions. These changes cause the wage rate to increase by 0.012%, the rental rate of land to increase by 0.113%, and household income to decrease by 0.339%. Overall, the Petitcodiac community again experiences a significant reduction in total output, labour, and capital in the region.

Table 2: Economic impact analysis of a 1% decrease in the timber supply for the Petitcodiac community

Variables	Base value (2001)	Timber supply impact (in % change)	
		Flexible wage scenario	Fixed wage scenario
Output in forest sector (X_F)	$150.0 million	-0.871	-0.931
Output in composite sector (X_C)	$350.0 million	0.056	0.039
Labour in forest sector (L_F)	600	-0.386	-0.936
Labour in comp. sector (L_C)	4,170	0.006	0.004
Total labour in economy (L)	4,770	-0.074	-0.188
Capital in forest sector (K_F)	$15.0 million	-1.311	-0.928
Capital in comp. sector (K_C)	$175.0 million	0.096	0.068
Total capital in economy (K)	$190.0 million	-0.015	-0.011
Energy in forest sector (E_F)	$7.5 million	-1.497	-0.931
Energy in comp. sector (E_C)	$35.0 million	-0.980	0.044
Total energy in economy (E)	$42.5 million	-1.071	-0.128
Timber in forest sector (M)	9.063 mill. m^3	-1.00	-1.00
Land in comp. sector (D)	15,540 ha	0.057	0.040
Wage in forest sector (W_F)	$27.0 million	-0.773	0.000
Wage in comp. sector (W_C)	$105.0 million	0.012	0.008
Rental rate of capital (R)	Numeraire	-0.030	-0.021
Stumpage rate of timber/m^3 (S)	$40	0.212	0.003
Rental rate of land/ha (V)	$1,297	0.113	0.080
Income of household (Y)	$142.4 million	-0.339	-0.307

The marginal timber supply reduction in the fixed-wage scenario (column 4 in Table 2), once again causes similar impacts on most model variables relative to the flexible wage scenario. The exceptions in this case include energy for reasons discussed in the price shock scenario.

The simulation results presented in Tables 1 and 2 tend to generally show the same sign directions as found in Alavalapati et al.'s (1999b) Alberta study. When comparing a 1% reduction in the timber supply (or in their case AAC) simulations, however, the Alberta study produces much smaller percentage impacts than those in our New Brunswick study.[13] This result emerges from regional variation in production structure.

The 1% reduction in forest product prices, on the other hand, tend to be much greater in Alavalapati et al.'s (1999b) Alberta study. This difference may be created, again, by the different production structures in each region. This factor is emphasized by the fact that different forest product prices were considered in each study (based on the most predominant forest sector in each region).

[13] The Alberta study simulation results are converted to 1% reductions by assuming constant proportional changes as percentages are reduced (from 6% in the case of the AAC and 10% in the case of pulp prices) to 1%.

Conclusions

The forest sector is a significant contributor to the economic well being of the Petitcodiac community in New Brunswick. Any changes that affect the forest sector are likely to have substantial effects on the stability of the community. In an effort to examine potential future economic impacts of market and policy changes in the forest sector on the community of Petitcodiac, this paper has developed, calibrated, and run simulations on a CGE model for the region. Simulations have been conducted for a 1% reduction in the price of lumber and the timber supply. In general, we observe that both of these changes will have negative impacts (at least in the short run) on the economy and most factors of production. As production factors are released from this industry, they flow to other sectors, causing an increase in composite sector output. This expansion, however, is not large enough to offset the decline in the forest sector and therefore, aggregate output, labour, and capital is reduced in the region.

Although not modeled here, the above reductions in forest sector output may tend to increase passive-use values of the forest. This may induce the expansion of such sectors as eco-tourism, and wildlife hunting; ultimately resulting in a stimulation of the local economy. Investigating such opportunities and building them into the analysis is the intention of the authors in a future study. Additionally, a full benefit-cost framework that incorporates the full range of socio-economic impacts is needed. Such a framework is essential in aiding decision-makers in their efforts to accommodate the increasing public demand for non-timber values (van Kooten 1993; Binkley et al. 1994).

Appendix 1: The CGE model structure

A. Commodity Supply

Assuming a competitive economy with constant returns to scale technologies, we can derive identities that describe the relationship between the total supply of a commodity and its factor shares. Taking the changes in these relationships results in the following commodity supply equations:[14]

$$(1)\qquad X_F' = \theta_{LF} L'_F + \theta_{KF} K'_F + \theta_{EF} E'_F + \theta_{MF} M'_F$$
$$(2)\qquad X_C' = \theta_{LC} L'_C + \theta_{KC} K'_C + \theta_{EC} E'_C + \theta_{DC} D'_C$$

where for i = [forest (F), composite(C)] and k = [labour(L), capital(K), energy(E), timber(M), land(D)], X_i is the quantity of domestic product supplied by the i^{th} sector, and θ_{ki} is the share of input k in the cost of producing output i.

B. Factor Demand

The competitive market and constant returns to scale assumptions allow us to derive identities that relate factor input demands to factor prices and output. Taking the changes in these relationships results in the following set of factor demand equations:

$$(3)\qquad L'_F = \theta_{LF}\, \sigma^F_{LL}\, W'_F + \theta_{KF}\, \sigma^F_{LK}\, R' + \theta_{MF}\, \sigma^F_{LM}\, S' + \theta_{EF}\, \sigma^F_{LE}\, G' + X_F'$$
$$(4)\qquad K'_F = \theta_{LF}\, \sigma^F_{KL}\, W'_F + \theta_{KF}\, \sigma^F_{KK}\, R' + \theta_{MF}\, \sigma^F_{KM}\, S' + \theta_{EF}\, \sigma^F_{KE}\, G' + X_F'$$
$$(5)\qquad M'_F = \theta_{LF}\, \sigma^F_{ML}\, W'_F + \theta_{KF}\, \sigma^F_{MK}\, R' + \theta_{MF}\, \sigma^F_{MM}\, S' + \theta_{EF}\, \sigma^F_{ME}\, G' + X_F'$$
$$(6)\qquad E'_F = \theta_{LF}\, \sigma^F_{EL}\, W'_F + \theta_{KF}\, \sigma^F_{EK}\, R' + \theta_{MF}\, \sigma^F_{EM}\, S' + \theta_{EF}\, \sigma^F_{EE}\, G' + X_F'$$
$$(7)\qquad L'_C = \theta_{LC}\, \sigma^C_{LL}\, W'_C + \theta_{KC}\, \sigma^C_{LK}\, R' + \theta_{DC}\, \sigma^C_{LD}\, V' + \theta_{EC}\, \sigma^C_{LE}\, G' + X_C'$$
$$(8)\qquad K'_C = \theta_{LC}\, \sigma^C_{KL}\, W'_C + \theta_{KC}\, \sigma^C_{KK}\, R' + \theta_{DC}\, \sigma^C_{KD}\, V' + \theta_{EC}\, \sigma^C_{KE}\, G' + X_C'$$
$$(9)\qquad D'_C = \theta_{LC}\, \sigma^C_{DL}\, W'_C + \theta_{KC}\, \sigma^C_{DK}\, R' + \theta_{DC}\, \sigma^C_{DD}\, V' + \theta_{EC}\, \sigma^C_{DE}\, G' + X_C'$$
$$(10)\qquad E'_C = \theta_{LC}\, \sigma^C_{EL}\, W'_C + \theta_{KC}\, \sigma^C_{EK}\, R' + \theta_{DC}\, \sigma^C_{ED}\, V' + \theta_{EC}\, \sigma^C_{EE}\, G' + X_C'$$

where W_i is the wage rate in the i^{th} sector, R is the rental price of capital, S is the stumpage price, G is the price of electricity, V is the rental price of land, σ's are the partial elasticities of substitution between factor inputs.

Restrictions on the cost share weighted elasticities of substitution permit one of the demand equations from each sector to be dropped and determined residually (Hertel 1988). Accordingly, the shaded equations (i.e., the energy demand equation from the forest sector and the land demand equation from the composite sector) have been dropped from the system.

[14] Apostrophes on variables indicate proportional changes (i.e. F' = dX/X). This proportional change technique is refered to as the Johanson (1960) approach, and is employed by most of the CGE references cited throughout this study.

C. Factor Supply

The households' and producers' respective utility and profit maximizing conditions allow us to derive the factor supply functions. Additionally, we can specify equations that allow for the free mobility of inputs across production sectors. Based on our interview with community members in the case study region, we assume that: (i) labour, capital, timber, and land supplies are responsive to changes in their prices; (ii) energy is supplied in unlimited quantity; and (iii) labour, capital, and energy are freely mobile across production sectors and into/out of the region. Taking the changes in these relationships results in the following set of factor supply equations:

$$(11) \quad L'_F = \eta_F W'_F$$
$$(12) \quad L'_C = \eta_C W'_C$$
$$(13) \quad K' = \kappa_R R'$$
$$(14) \quad M'_F = \lambda_S S'$$
$$(15) \quad D'_C = \mu_V V'$$
$$(16) \quad L' = \nu_{LF} L'_F + \nu_{LC} L'_C$$
$$(17) \quad K' = \xi_{KF} K'_F + \xi_{KC} K'_C$$
$$(18) \quad E' = \pi_{EF} E'_F + \pi_{EC} E'_C$$

where η_i, κ_R, λ_S, and μ_V are the supply elasticities of labour, capital, timber, and land in sector i, respectively, and ν_{Li}, ξ_{Ki}, π_{Ei} are the shares of sector i in total labour, capital, and energy, respectively.

D. Profits

The competitive market and constant returns to scale assumptions imply zero producer profits. This results because input factors are paid their opportunity costs and, as shown above, factor payments exhaust the total revenue in each industry (Euler's theorem). Taking the changes in these relationships results in the following zero profit conditions**:**

$$(19) \quad P'_F = \theta_{LF} W'_F + \theta_{KF} R' + \theta_{MF} S' + \theta_{EF} E'$$
$$(20) \quad P'_C = \theta_{LC} W'_C + \theta_{KC} R' + \theta_{DC} V' + \theta_{EC} E'$$

where P_i is the market price of the i^{th} sector product.

E. Household Income

According to a households' utility maximization problem, we can derive an identity that relates total household income to the shares of income sources. Based on our interview with community members in the case study region, we assume that income is generated from labour, capital, timber, and land supply by households. Taking the change in the household income relationship results in the following equation:

$$(21) \quad Y' = \varsigma_{LFWF} (L'_F + W'_F) + \varsigma_{LCWC} (L'_C + W'_C) + \varsigma_{KR} (K' + R') + \varsigma_{MS} (M' + S') + \varsigma_{DV} (D' + V')$$

where Y' represents household income, and ς's are the shares of income sources.

The above system encompasses 22 unknown variables in 19 equations. The aforementioned assumption of constant commodity prices reduces the unknown variables to 20. This system can be solved by exogenously setting the policy variable(s) of interest.[15] The GAMS 20.5 (2001) software package is used to perform the simulations.

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[15] When considering the fixed-wage scenario, we replace equation (11) with the restriction $W'_F = 0$.

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