Investigating Value-Added Production in the Canadian Forest Industry

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Abstract:

Industry analysts have indicated that there is a trend toward more value-added production in the Canadian forest industry. This suggests that the value of output has increased relative to the primary resource costs of production, leaving increased returns available for other production costs. If, however, these other costs out-pace value-added growth, the industry may be in jeopardy as profit levels are diminished. In this paper, I investigate the manner in which economic scale, technological shifts, and price fluctuations affect value-added and variable costs across regions of the Canadian forest industry. By dividing the industry into five producing regions, and assessing the 1965-95 data through regression analysis, I find unique variable relationships. Value-added production tends to exhibit varying degrees scale economies in all forestry sectors and regions. Additionally, significant technological degradation tends to predominate over time. Variable costs tend to be quite sensitive to changes in operational scale and also tend to marginally decline with technological advances. These circumstances, coupled with the variable influences of price changes, may cause variable costs to limit future value-added development in some Canadian regions.

1. Introduction:

The historic downturns that occurred in the Canadian Forest industry between 1980-83 and 1989-91 prompted great interest in strategies that act to insulate domestic forest product producers from such shocks. Today, many groups in Canada, including industry, government, and environmentalists, are emphasizing the potential benefits that value-added production has to offer.[1] Such benefits may include increased profit margins, employment, decreased fiber demand, and diminished environmental degradation (Reed, 1999).

Both the Federal and Provincial governments have been actively promoting value-added production in this industry through various policy approaches. In 1994, for example, the Federal government initiated programs that provide limited financial assistance for modernization and new capacity in value-added wood products manufacturing (ACOA, 1998). Recently, Provincial governments in British Columbia and New Brunswick began providing marketing, technical, and skills training to firms interested in further expanding value-added wood production in their provinces. Additionally, they are providing guaranteed loans not otherwise available to new or expanding value-added wood manufacturing firms (FRBC, 1999, and ACOA, 1998). These multi-level policies promoting value-added production are thought to help foster a sustainable economic environment where there exists continued market growth and a reduced demand on forest resources (Wilson et al., 1999).

In general, value-added production in the forest industry can increase from many sources including (i) increased scale of production (both in terms of individual operations and number of firms), (i) improved technologies, and (iv) beneficial output/input price changes. As indicated above, governments have chosen to focus on encouraging technological improvements and operational scale expansions, particularly in the secondary manufacturing sectors.

Updating the technologies used in the forest industry will be efficient if (i) costs of implementation are outweighed by the benefits of productivity enhancements, and (ii) state of the art technologies are sufficient to offset potentially increasing costs of materials/supplies (which may occur if there is an increasingly limited supply of forest resources, as is predicted in Canada). If technological developments do not keep pace with rising materials/supplies costs, it will reduce potential gains from updating existing production components. These possibilities must be taken into account when assessing the potential for technological improvements to increase value-added production.

The expansion of forest industry output may be profitable if there exists market potential (on the demand side) and/or economies of scale (on the supply side).[2] Otherwise, such expansion may cause firms to lose their competitive edge on the national

[1] Value-added production is defined here as the degree of secondary manufacturing raw materials endure before being sold on the market. A formal definition is provided in Section 2.
[2] The existence of scale economies may indicate potential value-added gains from production expansion by reducing average materials/supplies costs. This is explained in more detail in Section 2.

or international stage. These circumstances must also be accounted-for when assessing the potential for value-added increases in the industry.

Even if value-added production does increase over time, it may be that this growth is outpaced by variable production cost increases. As value-added approaches the variable costs of producing products, industry profits will be reduced and further developments will be impossible without significant re-structuring. As such, a careful examination of both value-added and variable costs is needed in order to determine the potential developments of the industry.

In order to shed light on the above issues, this paper takes a first step toward identifying the underlying factors that affect value-added and variable costs across regions of the Canadian forest industry. Reduced-form equations are specified that independently relate value-added and variable costs to the scale of the industry (including both operational and network scale effects in the logging, wood, and paper&allied sectors, as discussed later), the level of technological progress (the technique effect), and the price of the relevant commodities (the price effect). Regression analysis is conducted over the period from 1965 to 1995 for five regional forest industries including the Atlantic, Quebec, Ontario, Prairie, and British Columbia regions. Point estimates are plotted within the sample and projections are made into the future. Findings indicate that many forest industry regions may experience future profit 'squeezes' as early as 2025.

This paper is organized as follows. In Section 2, value-added production and variable costs are defined and historic trends are revealed. Then, in Section 3, the scale, technique, and price effects are theoretically revealed. The methodology of the study is defined and data sources are discussed in Section 4. Section 5 reveals the results of the regression analysis and investigates future development trajectories in each forest industry region. The last section concludes the study.

2. Value-added Production and Variable Cost Trends:

Value-added is defined by Statistics Canada as the difference between the shipment value of a good sold in the market and the costs of primary resource inputs (Statistics Canada, Canadian Forestry Statistics, cat 25-202). As such, it provides a measure for the amount of processing that primary resources endure before being shipped and sold. Value-added (VA) production can be expressed as follows:[3]

$$VA = \begin{bmatrix} Value \;\; of \\ Production \;\; Output \end{bmatrix} - \begin{bmatrix} Costs \;\; of \\ Materials \;\; \& \;\; Supplies \end{bmatrix} \qquad (1)$$

All sectors of the forest industry exhibit some degree of value-added. However, value-added production varies significantly from one sector to the next. Such primary

[3] Statistics Canada's definition includes energy costs as an additional cost to materials/supplies. Energy costs have been excluded in equation (1) in order to concentrate on resource conversion efficiency.

product-producing sectors as logging and sawmills tend to have relatively little value-added production whereas such final goods-producing sectors as paper and allied products and some wood industries have substantial value-added components.[4]

By summing the value-added production in each forest product sector of the Atlantic, Quebec, Ontario, Prairie, and British Columbia regions, aggregate measures for regional industrial value-added production are determined. Figure 1 plots the time trends of real value-added in each of the above regions (values are deflated by the Industrial Products Price Index). This figure reveals that each region exhibits increased value-added production trends over the years 1965 to 1995. There have, however, been periods of short-run downturns in most regions. The Atlantic and British Columbia regions seem to have experienced the largest of these over the early 1980's and then again in the early 1990's.

It is interesting to note in Figure 1 that while regions such as Quebec and British Columbia have experienced very similar value-added trends over time (in terms of levels and trends), the magnitude of short-run fluctuations tend to differ significantly. Additionally, some regions seem to exhibit diminishing trends (such as British Columbia) while others seem to exhibit exponential trends (such as the Prairie region). If the current trends continue, it would seem that regions such as Quebec and the Prairies have the most favourable outlook. However, these trends require a more scientific investigation before such assessments can be made. Additionally, we must account for variable costs of production.

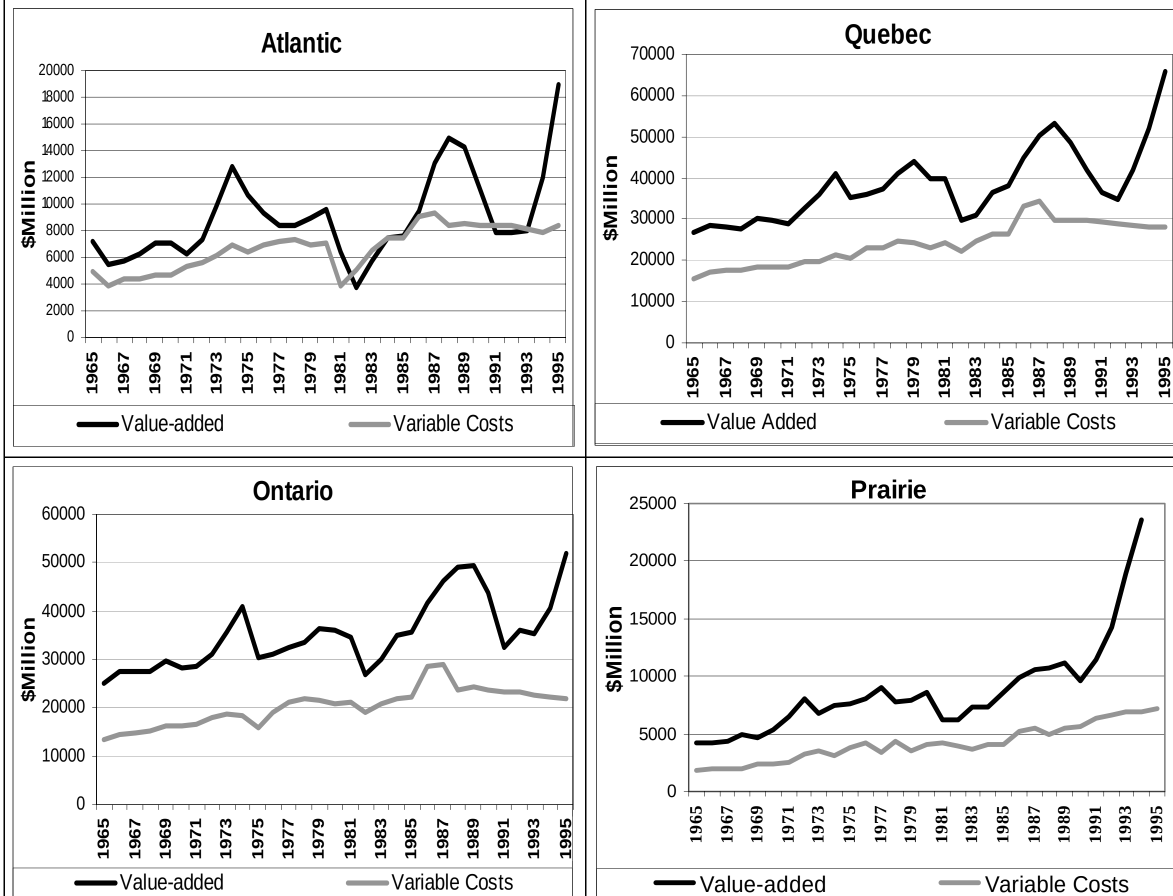
Variable costs (VC) in the Canadian forest product industry can be defined as the expenditures on labour and energy as inputs in the production process. This can be expressed formally as follows[5]:

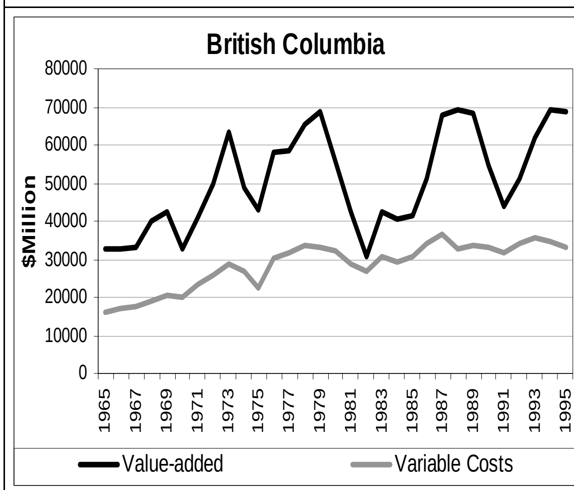
$$VC = \begin{bmatrix} Costs \quad of \\ Labour \end{bmatrix} + \begin{bmatrix} Costs \quad of \\ Purchased \quad Energy \end{bmatrix} \qquad (2)$$

By summing the variable costs of energy and labour used in each regional forest product industry, an aggregate measure of total variable costs results. The real variable cost time trends are plotted in Figure 1 for each forest product region (values are again deflated by the Industrial Products Price Index).

[4] Wilson et al. (1999) suggest that too often, value-added production is equated with secondary or final goods production. He emphasizes the need to include all sectors when considering value-added production.
[5] Capital expenditures are assumed here as sunk costs, and are treated as a fixed factor of production. This assumption has been supported in the literature (Meil, 1990), however, measures of capital opportunity costs have been explored. This may be an area for further investigation.

Figure 1.
Regional Value-Added[a] and Variable Cost[b] Trends in the Canadian Forest Industry





[a] Value-added production is calculated as the sum of shipment values less the costs of materials/supplies in each regional forestry sector (Statistics Canada, 1965-95).

[a] Variable costs are calculated as the sum of labour and energy expenditures in each regional forestry sector (Statistics Canada, 1965-95).

It is evident, from Figure 1, that variable costs in all regional forest industries have followed an increasing trend over time. However, most recently, many regions have experienced relatively flat variable cost trends. This may be a result, among other possibilities, of declining energy prices or increased automation in the production of forest products in these regions.[6]

If variable costs surpass value-added production, there will be negative (variable) profits in the industry. While it may be feasible for a firm to endure short-run losses, there must be foreseeable profits in the future; otherwise many firms will be forced out of business.[7] It is evident from Figure 1 that all regions experienced a 'profits squeeze' in the early 1980's. This is especially true in the British Columbia and Atlantic regions where zero to negative profits were realized for a short while. It may not be a coincidence that governments in these regions have been the leaders of supporting value-added production. This move may have been out of necessity. It would seem as though British Columbia has become much more effective at improving value-added production, as they did not experience as much of a squeeze during the early 1990's (as did the Atlantic region). As such it appears as if British Columbia has better insulated their industry against market downturns. These claims are further investigated below.

3. Influencing Factors:

There are many factors that have contributed to the trends observed in Figure 1. These may include the scale of industry, the techniques used in production, and the price of the relevant commodities. In order to detail the impact that each of these factors may have on value-added production and variable costs in the forest industry, equations (1) and (2) are more explicitly modeled as follows:

$$VA = P^y Y - P^m M \tag{3}$$

$$VC = P^e E + P^l L \tag{4}$$

$$Y = f(L, \bar{K}, E, M) \tag{5}$$

where, in equation (3), P^y and P^m are the prices of output and materials/supplies, respectively, Y and M denote the amount of output and materials/supplies used; in equation (4), P^e and P^l are the prices of energy and labour, respectively, and L and E denote the total use of energy and labour respectively; and equation (5) represents a standard production function, assuming capital is a sunk cost of production, as denoted by $\bar{K}$.

[6] This is an area for further investigation.

[7] Total profit (encompassing both variable and fixed costs) will become negative prior to variable profit as defined above. As such, a negative value for the latter measure of profit indicates a serious need for industrial re-structuring.

3.1 Scale Effect:

Output scale, at the aggregate level (*Y*), is composed of firm-level output (defined here as 'operation' scale) multiplied by the number of firms in the industry (defined here as 'network' scale). Value-added and variable cost trends may be affected by changes in both of these scale components. For example, value-added production increases may be the result of materials/supplies cost savings that occur from increased operational scale.[8] This possibility can be further explored through the analysis of equations (3) and (5) above. It is evident that an increase in output for a firm, assuming all else equal, will increase aggregate output, *Y*. This will affect both the value of shipments, P^yY, and the use of materials/supplies, which can be represented as $M = f(L, \overline{K}, E, Y)$ by simply re-arranging equation (5). As the scale of operations increase for a firm, the cost of materials/supplies may increase less proportionately, thereby increasing the difference between the market value of the good and the resource costs of production.[9] Thus, the increasing returns to operation scale that may exist for value-added production implies that output would be elastic with respect to this input. Similar analysis can be conducted in the case of decreasing returns.

An increase in operation scale may also cause a less/more than proportional increase in variable costs. From equations (4) and (5), it is evident that an increase in *Y* will affect the use of energy and labour, which can be represented by $E=f(L, \overline{K}, M, Y)$ and $L=f(\overline{K}, E, M, Y)$, respectively, by again re-arranging equation (5). A less/more than proportional increase in variable costs would imply increasing/decreasing returns to operational scale in labour and/or energy costs (or that output is elastic/inelastic with respect to the aggregate effect of changes in these inputs).

Changes in the other scale factor, namely the number of firms, will also affect value-added and variable costs. As the number of firms increase in a region, value-added production may increase, and variable costs may increase in less proportion, if 'network' economies of scale exist. This economies of scale effect refers to the possibility that more infrastructure (roads, communications, etc.) will be created for/by a larger group of firms in a region; leading to a reduction in per unit costs of production. The mechanisms by which the 'network' scale factor affects value-added and variable costs are similar to those described at the firm (or operational) level above.

There is a substantial amount of literature that investigates the returns to scale (and output elasticities of factor inputs) in the Canadian forest industry. In general, findings indicate that increasing returns to scale do exist.[10] Quite often, the literature indicates that most of the cost savings is in terms of labour. For example, Martinello

[8] This result is closely related to the concept of scale economies, however, a difference exists because I am not referring here to the proportional change in all production costs that result from a percentage change in a firm's output.

[9] This result would emerge if the cost savings are not passed on in lower output prices, as might result from competition in the long run. Additionally, firms may adjust labour and capital use as a result of such scale changes, which may further affect value-added production.

[10] It is often not clear in these studies whether increasing returns to scale exist at the operational level or the network level.

(1985) estimates that the pulp & paper, sawmills & shingle mills, and logging sectors of the Canadian forest industry exhibit increasing returns to scale (at 2.054, 1.114, and 1.463).[11] While there exists significant cost savings in labour and capital expenditures for each sector (at 0.544, 0.715, 0.847), energy and material costs (i) increase more than proportionately for the sawmill & shingle mill sector (at 1.218 and 1.064), (ii) increase less than proportionately for the pulp & paper mill sector (at 0.868 and 0.850), and (iii) increase more than and less than proportionately, respectively, for the logging sector (at 1.083 and 0.428).[12] In general, the findings of Martinello's study imply that, all else equal, value-added production in sectors such as pulp & paper and logging will increase with output scale, while the opposite will occur in sectors such as the sawmill & shingle mill sectors. Additionally, while variable costs (as defined in equation (2)) in sectors such as pulp & paper will increase at declining rates, they may increase at decreasing or increasing rates in other sectors, depending on the proportion of labour-to-energy use. These findings are generally supported by Kant and Nautiyal (1997) and Meil and Nautiyal (1988) in their studies of the Canadian logging industry, and various softwood lumber producing regions of Canada, respectively.[13]

In general, the overall effect of scale on value-added and variable costs in a region's forest industry will depend on (i) the relative proportions of input factors used in each sector, (ii) the relative proportions of sectoral representation in aggregate industry output, and (ii) the degree to which a particular forest industry region has exhausted their potential returns to scale.

3.2 Technique Effect:

As new technologies are developed in the forest industry over time, the same level of output may be sustained at declining average costs of production. This would indicate that, all else equal, value-added production may increase, and variable costs may decrease with technological change.[14] More specifically, if technological change leads to more efficient production techniques, the costs of producing a unit of output will decrease. As such, variable costs may decrease if there are cost savings in labour and energy. Value-added, on the other hand, may increase if cost savings occur in materials/supplies. Using equations (3) – (5), it is evident that if technological innovations allowed *L*, *K*, *E*, and *M* to decreased while *Y* was maintained at a given level, value-added and variable costs would increase and decrease, respectively, in value.

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[11] Elasticity of scale is defined as $\left(\dfrac{\partial \ln C}{\partial \ln Q}\right)^{-1}$, where *C* = costs and *Q* = output.

[12] Output elasticities of factor inputs are defined as $\left(\dfrac{\partial \ln I_i}{\partial \ln Q}\right)$, where *I* = (Labour, Capital, Energy, Materials/Supplies).

[13] Other studies investigating scale effects include Singh and Nautiyal (1985), De Borger and Buongiorno (1985), and Banskota et al. (1985).

[14] The value-added result again depends on the assumption that the cost savings are not passed on in lower output prices, and that changes in the use of production inputs by firms do not significantly counter the direct effects.

However, it has been argued in the literature that for some sectors of the industry, the productivity of operations decline over time, indicating that technologies have deteriorated. This may be especially true for primary forest product producers who face increasingly difficult terrain conditions (Kant and Nautiyal, 1997) and declining product quality (Barbour and Kellogg, 1990). This latter case implies that value-added production may tend to decrease over time as technologies (or wood supplies) deteriorate.

In the study conducted by Martinello (1985), findings support the notion that technological change increases costs in the pulp & paper, sawmill & shingle mill, and logging sectors of the Canadian forest industry (at -0.095, -0.043, and –0.004).[15] Additionally, technological change is heavily capital using and slightly labour, energy, and materials/supplies saving in the pulp & paper sector (at 0.215, -0.147, -0.054, and -0.084). The sawmill & shingle mill and logging sectors exhibit capital and energy using technological change (at 0.218 and 0.017 for sawmill & shingle mills, and 0.148 and 0.012 for logging). Technological change is also materials/supplies saving in sawmills & shingle mills (at –0.031), while materials/supplies using in the logging sector (at 0.080).[16] Kant and Nautiyal (1997) and Meil and Nautiyal (1988) generally support these findings. However, the latter study reveals that many regional sawmills are characterized by materials/supplies-using technological change.

Overall, the above studies suggest that the forest product sectors characterized by relatively low levels of secondary manufacturing tend to exhibit operational productivity losses over time. This indicates that variable costs will increase and value-added production will decline in these forest sectors over time. On the other hand, forest product sectors that are characterized by relatively high levels of secondary manufacturing tend to exhibit operational productivity gains, causing variable costs to decline and value-added production to increase over time. As such, the impact of technology on any region's forest industry will depend on their relative proportion of secondary manufacturing produced out of total output.

Meil (1990) investigates the impact that technological change has on value-added production and variable costs in the Canadian softwood lumber producing regions of British Columbia, Ontario and Quebec. He finds that, in the period from 1970 to 1984, value-added production and variable costs followed a declining trend. This, he contends, implies that the return to fiber was decreasing in all regions of the Canadian softwood lumber industry during this period. Thus, product yield did not keep pace with the increasing cost of fiber, or slowly declining variable costs. This analysis provides support for the studies mentioned above, however, it may attribute too much of the value-added

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[15] The impact of technological change on total costs is defined as $\left(-\dfrac{\partial \ln C}{\partial \ln Z}\right)$, where C = costs and Z = technological change (measured as a time trend).

[16] The impact of technological change on individual input costs is defined as $\left(-\dfrac{\partial \ln I}{\partial \ln Z}\right)$, where I = (Labour, Capital, Energy, Materials/Supplies).

and variable cost trends to technological change (since there are many other factors that affect value-added production).

3.3 Price Effect:

Basic economic theory indicates that as the demand for a market good increases, all else equal, the price of the product will increase as well. From equation (3), this implies that value-added will increase (and vice versa for decreases in demand).[17] Historically, due to increasing demands, wood product prices have generally outpaced inflation, indicating that the price effect may be one of the causes for the increasing value-added trends observed in Figure 1.[18] However, Schuler and Meil (1990) indicate that many of the socio-economic changes occurring in Canada today may have significantly negative impacts on future wood product demand (and therefore prices). For example, they suggest that there is a trend away from traditional wood products (such as lumber for housing) and toward composite products including wood and non-wood combinations. This implies that demand for traditional wood products is expected to decline and may lead to diminished value-added production. Thus, such historic and future price trends must be taken into account when assessing value-added trends in any particular region.[19]

Variable costs in the regional forest industries are directly impacted by the prices of energy and labour, P^e and P^l, respectively. As forest sectors are unionized, and energy supplies are reduced on the market, variable costs will increase. Such historic events may have played important roles in causing variable costs to remain close to value-added production, and thus, limiting profits in the forest industry.

4. Methodology and Data:

In order to investigate the role that output scale (*S*), technique (*T*), and price (*P*) effects have on value-added production and variable costs, a generalized reduced-form equation is specified as follows:

$$V_{ijt} = \alpha_{ij} + \sum_{k=1}^{K} \gamma_{ijk} S_{ikt} + \Phi_{ij} T + \sum_{m=1}^{M} \beta_{ijm} P_{ijmt} + \varepsilon_{ijt} \qquad (6)$$

where V_{ijt} represents the i^{th} value (*i* = value-added (VA), variable cost (VC)) in region *j* (*j* = Atlantic, Quebec, Ontario, Prairies, British Columbia) at time *t*, α_{ij} is

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[17] Output prices may also be affected by changes in input prices. If, for example, materials prices were to increase from resource scarcity, firms will charge higher output prices to cover increased costs of production. In this case, value-added will depend on the relative changes in prices, inputs used, and output produced.

[18] There have been periods, however, when particular forest product prices have drastically declined. For example, between the 1960's to the 90's, real aggregate softwood lumber prices trended downward (Booth, 1989).

[19] Fluctuating stumpage fees will affect materials costs. However, this data could not be found. As such, this is left for future investigation.

the intercept term, γ_{ijk} is the unknown vector of slope coefficients for the scale effect vector S_{ikt}, where K = 6 when three operational scale effects (scale of operations in the logging, *SOL*, the wood, *SOW*, and the paper & allied, *SOP*, sectors) are measured by average firm sizes and three network scale effects (scale of networks in the logging, *SNL*, the wood, *SNW*, and the paper & allied, *SNP*, sectors) are measured by the number of firms in the sector ($S_{ikt} = SOL_{it}, SOW_{it}, SOP_{it}, SNL_{it}, SNW_{it}, SNP_{it}$), Φ_{ij} is the vector of coefficient estimates on the technology variable *T*, where *T* is a time index (in this study, *T* = 1965, 1966, … 1995), β_{ijk} is the unknown vector of slope coefficients for the price effect vector P_{ijmt}, where *M* = 1 in the value-added equation, reflecting the price of output, *PO*, ($P_{i,VA,m,t} = PO_{i,VA,t}$), and *M* = 2 in the variable cost equation, reflecting the prices of labour, *PLA*, and energy, *PE* ($P_{i,VC,m,t} = PLA_{i,VC,t}, PE_{i,VC,t}$), and ε_{ijt} is the contemporaneous error term.

As indicated above, the Canadian forest industry is divided into five regions including the Atlantic Provinces, Quebec, Ontario, the Prairie Provinces, and British Columbia. Three forest industry sectors are defined in each region, namely the logging, wood and paper&allied sectors. Ordinary Least Squares regressions using these groupings will provide some sense for regional and sectoral comparisons of industry development and trends. All data used in this study is supplied by Statistics Canada, and the study period consists of years 1965 through 1995.

Value-added and variable cost data is collected from Statistics Canada's (1965-95) Principal Statistics on the Forest Industry. Aggregate value-added in each region consists of summing the value-added production in logging, wood (shingle and shake, veneer and plywood, sash, door and planning, wooden box, coffin and casket, and 'other' wood products), and paper&allied (pulp & paper, and 'other' paper products) sectors. Similarly, aggregate variable costs in each region consist of summing the total labour and energy costs in each of these sectors. The value-added and variable cost data is converted to constant values (base year = 1992) using the Industrial Products Price Index (IPPI) found on Statistics Canada's CANSIM database (matrix 1870).

Output scale is composed of both operation scale (average output of a firm) and network scale (the number of firms in a sector). Statistics Canada (1965-95) provides the required data on the number of firms in each forest sector. Average output per firm is calculated by first dividing the value of shipments in each sector (logging, wood, and pulp & allied) of a regional industry by its associated price, and then dividing by the number of firms in the associated sector.[20] Data for shipment values and the number of firms were collected from Statistics Canada's (1965-95) Principal Statistics on the Forest Industry. Forest product prices were collected from Statistics Canada's CANSIM

[20] Since information was not available on actual firm sizes (required for a detailed analysis of scale economies), the analysis in this study is limited to measuring the average sized firm in any region.

database (matrices 1873 and 1878) at the national level since regional prices were not available.[21] The basic operational scale calculations are revealed as follows:

$$SOL_{i,t} = \frac{\left[\dfrac{SVL_{i,t}}{PL_t}\right]}{SNL_{i,t}},\quad SOW_{i,t} = \frac{\left[\dfrac{SVW_{i,t}}{PW_t}\right]}{SNW_{i,t}},\quad SOP_{i,t} = \frac{\left[\dfrac{SVP_{i,t}}{PP_t}\right]}{SNP_{i,t}}, \qquad (7)$$

where *SVL, SVW,* and *SVP* denote shipment values of lumber, wood, and pulp & allied sectors, respectively, *PL, PW*, and *PP* denote output prices of the lumber, wood, and pulp & allied sectors, respectively.

The value-added price variable in each region is calculated as a weighted average forest product price index across each sector in the region (according to sector shipment value shares).[22] Given (as described above) that national product prices are used, it is assumed that all regions face the same product prices (however, the calculated value-added price series will differ between regions since product price indices are weighted by shipment value shares and then summed across sector in the region). The following describes the calculations for this series:

$$PO_{i,VA,t} = PL_t \frac{SVL_{it}}{SVT_{it}} + PW_t \frac{SVW_{it}}{SVT_{it}} + PP_t \frac{SVP_{it}}{SVT_{it}} \qquad (8)$$

where *SVL, SVW, SVP*, and *SVT* represent shipment values of logging, wood, paper & allied, and total sectors, respectively.

The variable cost price series are calculated for each region as indices of labour and energy prices. Regional, average hourly wage rates for the logging, wood, and paper & allied sectors were weighted (according to sectoral shares in total labour costs) and summed together to form the labour price variable. National prices of petroleum and coal were used as the energy price variable since regional energy prices were not available. The data for these price calculations are taken from Statistics Canada's CANSIM database (matrices 1440, 1465, 1470, 1475, 1495, 1878, 4310, 4340, 4352, 4366, 4380, 4422, and 4436). All prices are converted to constant values using the IPPI, as described previously. The (weighted) labour price variable calculation is shown as follows:

$$PLA_{i,VC,t} = PLAL_{i,t} \frac{LCL_{i,t}}{LCT_{i,t}} + PLAW_{i,t} \frac{LCW_{i,t}}{LCT_{i,t}} + PLAP_{i,t} \frac{LCP_{i,t}}{LCT_{i,t}} \qquad (9)$$

where *PLAL, PLAW, and PLAP* denote the price of labour in the logging, wood, and paper & allied sectors, respectively, and LC*L, LCW, LCP,* and LC*T* denote the labour cost of the respective forest sectors.

[21] Statistics Canada does not provide log prices prior to 1981, and therefore lumber prices were used to approximate this series.
[22] A more accurate calculation of the value-added price variable would be to incorporate stumpage rates. However, as explained previously, this data is not readily available.

5. Results:

5.1 Regression Results:

Regression results for value-added production and variable costs in the Canadian forest industry regions are presented in Tables 1 and 2, respectively. Adjusted R^2 values range from a low of 0.827 in the Atlantic region's value-added equation to a high of 0.97 in the Prairie region's variable cost equation. All F-statistics reveal that the independent variables are jointly significant, giving support for these specifications.

Table 1.
Coefficient Estimates for Regional Value-Added (VA) Production in the Canadian Forest Industry (1965-95)[a, b]

Parameter	Atlantic	Quebec	Ontario	Prairies	BC
$\alpha_{i,VA}$ **(const)**	-144.161 (-1.240)	-1261.23*** (-7.532)	-851.809*** (-6.075)	-254.855*** (-3.845)	-850.518*** (-4.994)
$\gamma_{i,VA,1}$ **(scale oper. log)**	129.398*** (2.854)	268.804*** (3.014)	219.438** (2.791)	232.301** (2.649)	-274.400 (-0.993)
$\gamma_{i,VA,2}$ **(scale oper. wood)**	427.350** (2.973)	321.851** (2.175)	250.258* (1.789)	188.938** (2.394)	182.565** (2.075)
$\gamma_{i,VA,3}$ **(scale oper. p&all)**	8.043* (1.871)	140.296*** (5.069)	143.227*** (4.906)	35.720*** (4.583)	104.161*** (4.669)
$\gamma_{i,VA,4}$ **(scale net. log)**	18.935*** (4.719)	5.436*** (3.299)	24.118*** (4.339)	18.265*** (4.174)	-12.497 (-1.346)
$\gamma_{i,VA,5}$ **(scale net. wood)**	6.411 (0.906)	18.547*** (3.478)	17.032* (2.034)	27.908*** (3.959)	43.112*** (3.604)
$\gamma_{i,VA,6}$ **(scale net. p&all)**	47.093 (0.805)	200.399*** (3.488)	35.430 (1.434)	72.100** (2.157)	902.183*** (5.019)
$\Phi_{i,VA}$ **(technology)**	-248.356** (-2.094)	-450.027*** (-3.479)	-432.622*** (-2.892)	-174.580** (-2.065)	-598.963** (-2.703)
$\beta_{i,VA,1}$ **(price of output)**	187.223*** (3.620)	782.729*** (10.088)	790.673*** (10.210)	161.773*** (5.816)	433.589*** (5.631)
F-stat	18.941***	78.289***	64.094***	104.271***	50.926***
Adj. R^2	0.827	0.954	0.944	0.965	0.930

[a] Asterisks ***, **, * indicate significance at the 0.01, 0.05, and 0.10 level of significance, respectively.
[b] Values in curved brackets are t-statistics.

Table 2.
Parameter Estimates for Regional Variable Costs (VC) in the Canadian Forest Industry (1965-95)[a, b]

Parameter	Atlantic	Quebec	Ontario	Prairies	BC
$\alpha_{i,VC}$ **(const)**	32.448 (0.844)	-402.929*** (-3.462)	-174.698* (-2.055)	-7845.497** (-5.444)	-187.317*** (-3.517)
$\gamma_{i,VC,1}$ **(scale oper. log)**	15.108 (1.053)	135.712** (2.194)	-63.974 (-0.999)	38.041 (1.377)	-156.328* (-1.797)
$\gamma_{i,VC,2}$ **(scale oper. wood)**	132.666** (2.308)	242.024** (2.371)	282.184** (2.758)	18.815 (0.657)	114.416*** (3.963)
$\gamma_{i,VC,3}$ **(scale oper. p&all)**	10.882*** (8.215)	63.980*** (3.383)	56.372** (2.328)	4.802* (1.736)	25.527*** (3.791)
$\gamma_{i,VC,4}$ **(scale net. log)**	-0.052 (-0.037)	1.236 (1.030)	-8.956* (-1.893)	-0.493 (-0.281)	-4.456 (-1.564)
$\gamma_{i,VC,5}$ **(scale net. wood)**	0.186 (0.068)	11.258*** (3.156)	13.092* (1.905)	1.077 (0.350)	21.746*** (4.041)
$\gamma_{i,VC,6}$ **(scale net. p&all)**	78.147*** (4.174)	155.353*** (3.816)	69.948*** (4.004)	16.191 (1.282)	230.956*** (4.164)
$\Phi_{i,VC}$ **(technology)**	-117.527* (-1.857)	-407.238** (-2.626)	-243.829* (-1.816)	114.745** (2.450)	-419.790*** (-3.712)
$\beta_{i,VC,1}$ **(price of labour)**	106.029 (0.839)	1812.97*** (3.909)	1084.556*** (2.829)	9.2136 (0.771)	225.278*** (5.278)
$\beta_{i,VC,2}$ **(price of energy)**	19.979*** (3.639)	3.347 (0.266)	-12.488 (-0.908)	-12.123*** (-3.629)	-1.212 (-0.076)
F-stat	42.300***	45.588***	26.750***	108.528***	104.532***
Adj. R^2	0.925	0.930	0.885	0.970	0.969

[a] Asterisks ***, **, * indicate significance at the 0.01, 0.05, and 0.10 level of significance, respectively.
[b] Values in curved brackets are t-statistics.

Findings in the value-added regressions (Table 1) indicate that the operational scale effects ($\gamma_{i,VA,1}$, $\gamma_{i,VA,2}$, and $\gamma_{i,VA,3}$) are (i) statistically significant at a minimum of a 95% level of confidence in most regions; and (ii) materials/supplies cost saving in these regions. More specifically, as the operational scale of a firm (in most sectors) increases, shipment values increase greater than material/supplies costs, leading to increases in value-added production. In the Atlantic region, for example, a 1% increase in firm-level output in the logging sector will increase aggregate value-added in the region by 0.495%.[23] This value is the largest operational scale effect in the logging sectors across Canada for value-added (British Columbia has the smallest effect, with an insignificant value). The Atlantic region also exhibits the largest operational scale effect in the wood sectors across Canada where a 1% increase in firm-level output in this regions' wood sector causes value-added to increase by 0.957% (British Columbia, Ontario, and Quebec exhibit the lowest values at 0.392%, 0.314%, and 0.317%, respectively). In the

[23] This relationship has been calculated by standardizing the units of measure.

pulp&allied sector it is British Columbia who exhibits the greatest operational scale effects where a 1% increase in firm-level pulp&allied output in this region causes value-added to increase by 0.812% (the Prairie region exhibits the smallest effect, with an insignificant value).

Regional network scale effect estimates in the value-added regressions ($\gamma_{i,VA,4}$, $\gamma_{i,VA,5}$, and $\gamma_{i,VA,6}$) follow closely with those of operational scale. Specifically, many estimates tend to be statistically significant (however, fewer are so) and indicate the existence of materials/supplies cost savings (however, to a lesser degree). The Atlantic region exhibits the largest network scale effect in the logging sector. A 1% increase in the number of firms causes a 0.667% increase in value-added (British Columbia and the Prairie region exhibit the smallest effects with insignificant values). In the wood sector, British Columbia exhibits the largest network scale effect where a 1% increase in the number of firms causes a 0.289% increase in value-added. Interestingly, the Prairie region exhibits a negative network scale effect in the wood sector. This finding is questionable, and may be a result of poor data collection for this region (this is discussed more fully in the conclusion to this paper). Lastly, in the pulp&allied sectors of Canada, British Columbia exhibits the largest network scale effect. A 1% increase in the number of firms causes a 0.548% increase in value-added (the Atlantic, Ontario, and Prairie regions exhibit the smallest effects with insignificant values).

An interesting outcome has emerged from the above analysis of operational and network scale effects. First, the results indicate that the pulp&allied sector has the most materials/cost savings from increased network scale in all regions. Second, this sector also has the most materials/cost savings from increased operational scale in most major producing regions of Canada (which include the British Columbia, Ontario, and Quebec regions). These two findings make a strong case for concluding that the pulp&allied industry exhibits the greatest overall economies of scale potential of any sector in the Canadian forest industry.

It is also interesting to note that the logging sector consistently exhibits the least materials/supplies cost savings from increased operational scale in all Canadian regions. Additionally this sector exhibits the least materials/supplies cost savings from increased network scale in many regions. These findings, along with those of the previous paragraph, generally support the literature discussed in Section 4 that indicates secondary manufacturing sectors exhibit the greatest potential economies of scale.

The technique effect coefficient in the value added regressions ($\Phi_{i,VA}$) are significant at the 95% level of confidence (or more) and exhibit a negative slope in all regions. These findings send out a strong message: technological degradation in value-added production is occurring over time. A rationale behind this finding is that that fiber is becoming increasingly scarce in supply over time. This result is most evident in the Atlantic region estimation, where a 1% increase in time-dependant technological change (over the sample period) creates a 0.69% decrease in value-added. The Prairie and British Columbia regions exhibit the least technological degradation where a 1% increase in time-dependant technological change creates a 0.38 and 0.42% decrease in value-added, respectively. These results are consistent with the literature cited in Section 4.

Findings in the variable cost regressions (Table 2) indicate that many of the operational scale effects ($\gamma_{i,VC,1}$, $\gamma_{i,VC,2}$, and $\gamma_{i,VC,3}$) and network scale effects ($\gamma_{i,VC,4}$, $\gamma_{i,VC,5}$, and $\gamma_{i,VC,6}$) are (i) statistically significant at a minimum of a 95% level of confidence (this includes 18 out of 30 coefficients); and (ii) labour and/or energy cost saving in these regions (the only exception is in British Columbia's logging sector where operational scale increases are labour and/or energy cost using). More specifically, in many regions, as the operational scale of a firm increases, variable costs increase in less proportion. For example, in the Atlantic region, a 1% increase in the operational scale of a firm in the paper&allied sector will increase aggregate variable costs by 0.667%. This cost increase is the largest of all significant variable cost scale effects. At the other end of the spectrum, a 1% increase in the operational scale of a firm in the British Columbia logging sector will decrease aggregate variable costs by 0.242%. This finding may be a result of firms substituting more capital for labour as scale expansions occur.

The technology effect ($\Phi_{i,VC}$) and price effects ($\beta_{i,VC,1}$, $\beta_{i,VC,2}$) in the variable cost estimations exhibit their negative and positive expected values. In general, most regions find their variable costs increasing with price increases and decreasing with technology changes over time. Exceptions to this generalization occur in the Prairie region where technological changes tend to increase variable costs and in a few other regions where energy prices are found to be insignificant. These results, as explained in the next section, may be a result of poor data availability.

5.2 Value-Added and Variable Cost Trajectories:

Using the estimates provided in Tables 1 and 2, the predicted point estimates of the model can be plotted, both within and outside of the sample period. More specifically, I have plotted these estimates at five-year intervals through the sample period (from 1965 to 1995) and, using the growth trends of the independent variables over the sample, have projected future values (from 2000 to 2030). This provides some indication as to the ability of the estimates to replicate the observations and may provide insight as to where value-added and variable cost trends are headed in the future. Below, I detail the calculations required for this procedure and report the findings.

Future independent variable values (including the operational scale effects, the network scale effects, and the price effects) were estimated by first plotting, at 5-year intervals, each independent variable over the sample period. A linear time trend was then used in the calculation of all independent variable values in future 5-year periods. Independent variable growth rates over the sample period are provided in Table 3. It should be noted here that when the original value-added and variable cost regressions (Tables 1 and 2) indicated that an independent variable is insignificant at the 95% level of confidence, the growth rate of this variable is assumed to be zero (and constant at 1995 levels for all time periods into the future).

Table 3.
Annual Growth Rates of Independent Variables used in Projecting Future Values[a]

Variable	Atlantic	Quebec	Ontario	Prairies	BC
SOL	6.1%	-1.0%	1.5%	2.8%	2.1%
SOW	6.5%	6.3%	4.7%	8.8%	4.9%
SOP	1.8%	2.2%	1.2%	5.0%	1.6%
SNL	6.4%	4.5%	1.5%	5.2%	1.1%
SNW	-2.2%	-0.5%	-0.7%	-1.2%	-1.1%
SNP	1.2%	-0.002%	0.5%	1.1%	1.5%
PO[b]	0.9%	0.9%	0.9%	0.9%	0.9%
PLA	2.0%	2.0%	1.8%	2.4%	1.7%
PE[b]	1.7%	1.7%	1.7%	1.7%	1.7%

[a] Annual growth rates are estimated every 5 years over the sample period (1965-1995).
[b] Growth rates of the output price variable (used in value-added estimations) and the energy price variable (used in the variable cost estimations) are identical across regions because national prices were used.

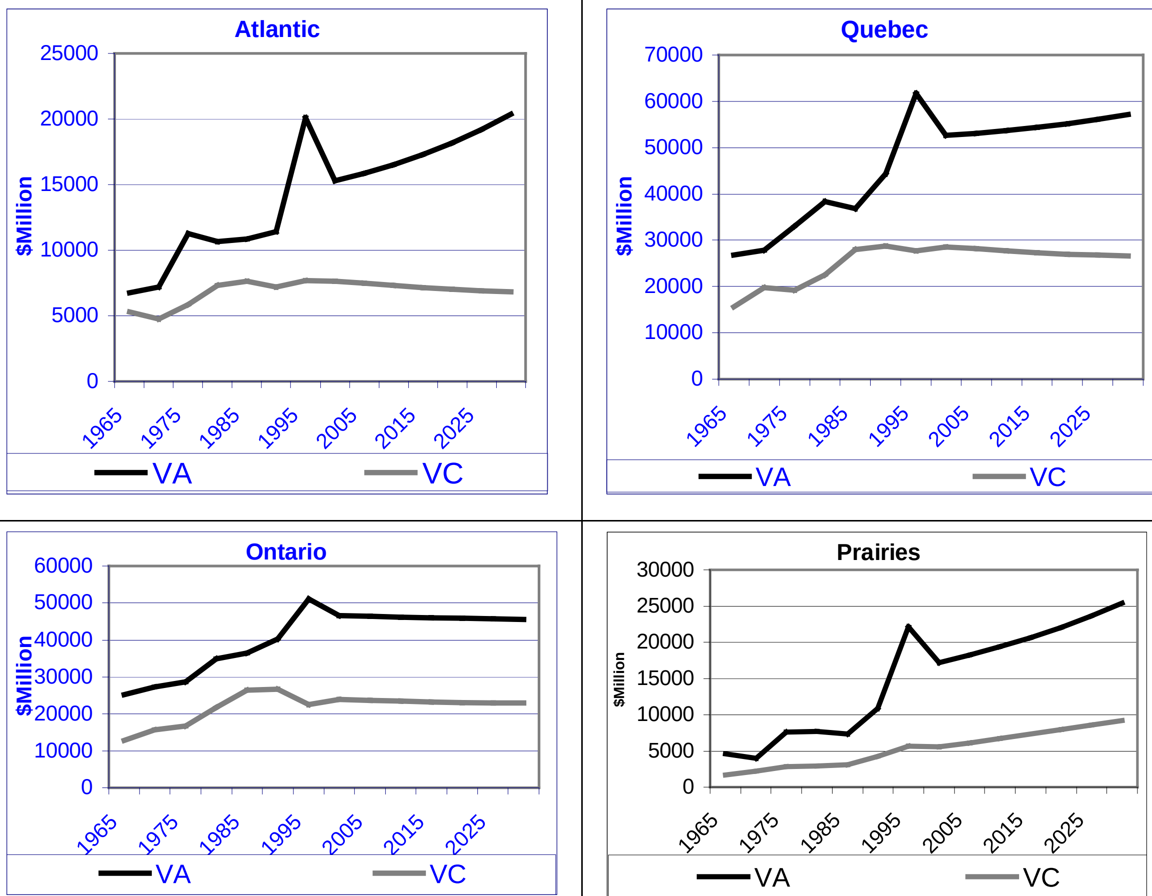
Figure 2 illustrates the estimated value-added and variable cost trajectories of the model. In general, the trajectories over the sample period (1965 to 1995) capture the general paths of the data illustrated in Figure 1.[24] Projecting into future periods, some interesting results emerge. There is a downturn estimated in all regions between the 1995 to 2000 period. This result has emerged, from the trending process for the independent variables into the future. Since there was no a priori reason for assuming otherwise, all 2000 values for the independent variables were set at the trend level.[25]

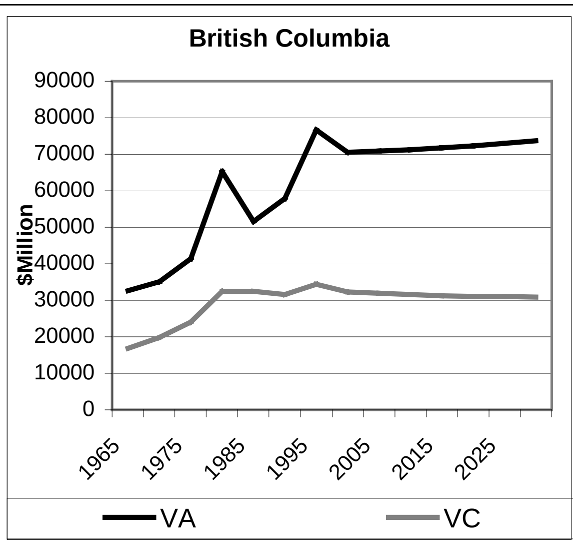
In all regions but Ontario, value-added is expected to continue increasing. For Ontario, value-added is expected to remain constant, or even decline marginally. This result occurs due to a combination of relatively slow growth in firm operational scale, firm networks, and large sensitivity to technological degradation (refer to Table 3). Regions such as Atlantic Canada and Quebec show the most promise in terms of increased value added in the future.

Variable costs are expected to decline in all regions except the Prairies where they are expected to remain constant or even increase marginally. The increasing variable cost finding in the Prairie region has occurred due to the relatively high rate of growth in expected labour costs in the future (refer to Table 3). The greatest decline in variable costs occur within the regions of Atlantic Canada and Quebec. This prediction, combined with the above value-added expectations, leaves these two eastern provinces in the best position to become industry leaders in the future.

[24] Since five-year intervals are used, an exact replication is not expected.
[25] This assumption may be augmented if there was more information available about a particular industry.

Figure 2.
Estimated Value-Added and Variable Cost Trends in the Canadian Forest Industry (five year intervals)[a]





[a] Projections made from 2000 to 2025 are based on the trend growth rates of significant independent variables over the period 1965 to 1995.

6. Conclusions:

By decomposing value-added production and variable costs into scale, technique, and price effects, a more thorough understanding of past and future trends in the Canadian forest industry has resulted. Regression analysis for the Atlantic, Quebec, Ontario, Prairie, and British Columbian forest industries indicates that many of the above 'effects' have played important roles in shaping both value-added and variable cost trends in each region over time. In most regions, the operational and network scale effects are significantly positive. Additionally, value-added and variable cost technique effects are significantly negative and positive, respectively, for most regions. This indicates that technologies have degraded for value-added production and improved for variable costs. Technological worsening in the value-added regressions has been be explained in the literature as a realization that fiber costs increase over time as supply constraints become binding in this industry.

Ringe and Hoover (1987) provide further insight into the finding of technological degredation for value-added production in the forest industry. They suggest that the technological changes occurring in the North American forest industry tend to reinforce the dependency between resource size/quality and product size/quality, rather than removing it. Meil (1990) suggests that, in order to return the industry to past profit levels (note his point of reference), an elimination or minimization of the interdependencies between products and resources is required. It is clear from the results presented above that technological advances still tend to reinforce the product-resource dependency.

As mentioned in the beginning of this paper, development planners tend to target value-added secondary wood processing as a means of not only offering increased profitability through higher margins and greater profits, but also through the encouragement of employment through the establishment of a local companies (Vlosky et al., 1998). The findings revealed here indicate that efforts to promote secondary wood product manufacturers will be rewarding in particular because of the potential material/supplies and variable cost savings that exist in these sectors. However, this study reveals that certain regional forest sectors have more potential for expansion than others. More specifically, the regions of Atlantic Canada and Quebec show the most promise in expanding value-added production while at the same time facing declining variable costs of production.

Future investigations might begin with refining the data sources. This is especially true in the case of the Prairie region where Statistics Canada has not reported data for some of these provinces for particular years. Additionally, the energy price variable was insignificant in many variable cost regressions, and may require augmentations to better capture energy costs faced by firms in this industry.

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