THE MEASUREMENT OF INEQUALITY IN CANADIAN AND U.S. AGRICULTURAL INCOME BY COMPONENTS OF NET VALUE ADDED

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Abstract

This paper examines changes in net value added generated through Canadian and U.S. farm production, 1970-2000. We consider how the structural changes in Canadian and U.S. agriculture have affected the size and distribution of net value added and its components: rent, capital, labor, and to net farm income. We use the Theil Measure of Inequality (TMI) to compare and explain changes in 1) the between and within-region distribution of net value added, and 2) changes in the distribution of factor shares of net value added in Canada and in the U.S. Results show that in Canada (1960-2000), net value added has become somewhat more equally distributed relative to the number of farms per province, but has varied widely from 1972-1988. Between-region inequality in net value added accounted for from 0.5 to 85.5 percent of this inequality from 1960-2000. In the U.S. (1949-2000), net value added has become more unequally distributed. About half of the variation in net value added in the U.S. is due to between-region variation and about half to within-region variation in net value added. We find that most of the variation in the components of net value added (returns to capital, labor, nonoperator landlords, and to farm operators) in Canada and the United States is due to variations across regions, rather than to variations in the components of net value added themselves. These variations have generally been due to macroeconomic differences in regions, such as shifts in enterprise specialization, urbanization, changes in government programs, and to other structural changes in agriculture.

Key words: inequality, Theil's entropy, net value added, regional decomposition, factors of production, factor shares.

The Measurement of Inequality in Canadian and U.S. Agricultural Income by Components of Net Value Added

Besides contributing to the livelihood of farmers and ranchers (Ahearn, Johnson, and Strickland, 1985), production agriculture contributes income to others who participate in commodity production. The sweeping structural changes (Carter and Johnston, 1978; Gardner, 1992; Hallam, 1993; Boehlje, 1999) in production agriculture provoke questions about changes in these contributions. Does consolidation of farms in Canada and the United States mean that in some regions production agriculture generates less income than before? How has the distribution of income generated by production agriculture changed in Canada and in the U.S.? Have landlords and lenders captured a greater share in some regions? How have structural changes in Canada and the U.S. affected the size, distribution, and variability of net value added and its components (rent, interest, labor, and net farm income) over time and across regions? What accounts for these changes in the distribution of net value added?

The history of economic thought recognizes two research approaches on income distribution (Dagum, 1999). The Ricardian, or functional distribution of income approach (Ricardo, 1817) deals with the income distribution among the owners of the factors of production and the price determination of each productive factor. It purports to account for factor price formation, such as rent, wages and profit, and the share that the corresponding factors of production (e.g., land, labor, capital, and management) have in national income. The Pareto approach is concerned with the size distribution of income among a set of economic units and studies the shape of the income distribution and their corresponding measure of inequality. It considers the total income received by each economic unit regardless of the factors of production.

Until the 1960's, both functional and personal income distribution research followed two separate tracks. But in the 1970's economists began linking or integrating the functional to the personal distribution of income. This study draws on methodology and concepts from both tracks. It uses the Theil Measure of Inequality (TMI) to examine inter-temporal and inter-regional changes in net value added in Canada and the United States (size distribution of income approach). Also, it draws on Ricardian rent theory to explain these changes (functional distribution of income approach).

We estimate net value-added generated through U.S. and Canadian farm production, 1970-2000. We then use the Theil Measure of Inequality (TMI) to examine, compare, and explain changes in the between and within-region distribution of net value added, and in the distribution of factor shares in Canada and in the U.S., for the period 1950-2000.

We use an informational approach to measure and to explain changes in the inequality of total net value added (hired labor, net rent to non-operator landlords, interest expenses, and net farm income) by region, from 1970 to 2000. We then discuss how changes in the structure and organization of U.S. and Canadian agriculture account for convergence or divergence in returns to factors of agricultural production.

Structural Changes in Canadian and U.S. Production Agriculture

The Canadian and U.S. farm sectors have experienced considerable structural change in size and number of farms in each size class during the last century. The number of farms in Canada has steadily declined from 366,110 in 1961 to 276,548 in 1996, while the value of products sold has increased from $4.3 billion in 1970 to $31.7 billion in 2000 (Statistics Canada, Agriculture Division). In contrast to a decrease in the number of farms in Canada, the area of farmland has remained relatively stable over the last 35 years (172.5 million acres in 1961 and 168.2 million acres in 1996). The result is that Canadian farms are, on average, 69 percent larger than 35 years ago. In 1996, the average farm size was about 608 acres compared to 359 acres in 1961. Also, farm size in Canada varies from province to province. Newfoundland reported average farm acreage at 146 acres in 1996, while Saskatchewan reported an average farm size of 1,152 acres. The number of farms in the U.S. has declined from 3,962,520 in 1960 to 2,172,080 in 2000, while the value of products sold has increased from $7.7 billion in 1910 to $218.6 billion in 2000. Average farm size has risen from 296.7 acres per farm in 1960 to 441.5 acres per farm in 2000. This trend towards fewer, but larger farms accelerated during the 1950's and 1960's, but slowed somewhat since the 1970's. Farm size in the U.S. also varies widely across the states and regions. The total amount of cropland in the U.S. has remained relatively constant. Since 1945 total cropland in the Northeast, Lake States, Appalachia, Southeast, and Delta States regions has decreased. Cropland in the Corn Belt, Northern Plains, and Pacific regions has increased. Thus, U.S. farms have become fewer and larger. The movement toward greater concentration in the Corn Belt and west of the Mississippi River has been a persistent feature of production agriculture (Vesterby and Krupa, 2001).

The topic of farm structure (Schultz, 1974; Carter and Johnston, 1978; Babb, 1979; Hoppe et al., 2001; Offutt, 2001; Chavas, 2002) includes 1) farm numbers and size, returns to scale, and concentration of production (Lowenberg-DeBoer and Boehlje, 1986; Hallam, 1991; Stanton et al. 1993; Peterson, 1995), 2) economies of scope and diversification (Purdy et al., 1997; Chavas, 2002), 3) technology and farm organization (Gardner and Pope, 1978;), 4) ownership and control of productive farm resources including land (Harrington et al, 1998), 5) enterprise and regional specialization of production, contractual linkages with other farms and nonfarm businesses (Harrington, op. cit.), and 6) the characteristics of farmers and their households. (Hoppe, 2001).

Factors that affect the structure of agriculture in Canada and the U.S. include technological change, economies of size and scope, farm policy and programs, tax laws, credit and income programs, transaction costs, market imperfections, access to markets, pecuniary economies, risk exposure, uncertainty about product quality in agriculture, and compliance with environmental rules and regulations (Ball et al., 1997; Chavas, 1991; Tweeten, 1993; Huff, 1997; Floyd, 1965).

The economic contributions of agriculture are traditionally measured with U.S. Department of Agriculture and Statistics Canada's' statistical series on farm income. These estimates reflect the value-added to the economy by farmer-operator production factors (land, capital, and labor, and operators' management). When these accounts were first established over 50 years ago, farm operators and their families owned most of the factors of production. Farm operators obtained the services of some production factors by paying input suppliers who had little or no role in production decisions and did not share the "risks of production." Consequently, these payments were treated as production expenses in the farm income accounts. Thus, net farm income was legitimately viewed as a measure of the net income that farm families received from their farms and as an indicator of the net value of the farm sector's production of goods and services.

Today many farms, particularly larger operations, have multiple operators. Entities sharing in the risks of production include not only individual proprietors or operators, but also a myriad of individuals and legal entities that contribute at-risk capital in many forms. These include owners of animals placed in feedlots for finishing, passive investors contributing only capital in expectation of receiving dividends, partners, and contractors. Net farm income includes the net returns to all these nonoperator equity holders, as well as the returns to traditional operators. Also, the proportion of land, labor and capital, which is owned by non-equity holders and paid without contingencies for their services, has increased over time. Therefore, the changing structure of U.S. and Canadian farming requires new measures of the value created through production activities (Hobbs, 2001; Morrison, 2000).

Net Value Added

Value-added is a more accurate indicator of the farm sector's total output of goods and services because it is a broader measure reflecting the contribution of all factors of production regardless of form of ownership (Strickland and Johnson, 1992 and Strickland and Steele, 1997). It includes the contributions of (1) farm real estate rented from individuals who were not equity-holders in the business, (2) returns on outside capital (borrowed capital from the perspective of a farm operator), and (3) hired labor provided by all equity-holders, i.e., land, capital, labor and management of farm operators and others (net farm income).

The presence of more disaggregated components under the value-added format makes it much easier to discern what forces are driving the changes and trends in farm income. Changes in commodity production are the cause of most of the volatility in the income accounts, and much more detail is available to the reader in the value-added format.

Net value added represents the total value of the farm sector's output of goods and services, less payments to other (nonfarm) sectors of the economy. It reflects production agriculture's addition to national economic product. Economic Research Service (ERS) value-added estimates are used by the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, for the National Income and Product Accounts and by the Organization of Economic Cooperation and Development (OECD) in its international agricultural accounts. The value added approach to sector accounting is the format accepted and used internationally. This enables comparisons across countries. These cross-country comparisons have become more important with the sweeping changes in government agricultural commodity programs enacted under Canada's broad farm income safety net framework (Crop insurance, National Income and Stabilization Act, Canadian Farm Income Program) and the U.S.'s Federal Agriculture Improvement and Reform Act (FAIR) of 1996 and the new 2002 farm bill legislation pending in Congress (Harvey, 2002).

Net value added is estimated as:

Final crop output
+ Final animal output
+ Services and forestry
= Final agricultural sector output (gross value of the commodities and services produced within a year)
- Intermediate consumption outlays
  Farm origin (feed, livestock and poultry, seed purchased)
  Manufactured inputs (fertilizers and lime, pesticides, petroleum fuels and oils, electricity)
  Other intermediate expenses
+ Net government transactions
- Capital consumption (see Appendix 1)
= Net value added
- Factor payments
  Employee compensation (total hired labor)
  Net rent received by nonoperator landlords
  Real and nonreal estate interest
= Net farm income (operators' share of income from the sector's production activities)

Figures 1 and 2 show how net value added and its components (factor shares) have increased over time, as factors of production beyond those owned by the farm operator and other equity-holders such as lenders, non-operator landlords, and hired labor, have increased. For Canada and the U.S., factor income to labor, non-operator landlords, and to lenders have steadily increased. Factor income to farm operators has shown greater variability both for Canada and the U.S. Tables 1 and 2 summarize the distribution of farms by farm type and by state/province for Canada and the U.S.

Data and Methods

Statistics Canada's Agriculture Division and the U.S. Department of Agriculture's Economic Research Service (ERS) develop, interpret, and disseminate farm sector accounts information. This includes estimates of farm income, net value added, the farm business balance sheet, and farm sector financial ratios. For the farm income and balance sheet series, the farm sector is considered as a single entity, with no adjustment made for differences in ownership or business arrangements among farms or other entities comprising the sector. Estimates generated by the farm sector national accounts program are also used to measure changes in farm sector performance and well-being.

We use provincial and state data (U.S. Department of Agriculture, Economic Research Service and Statistics Canada, Agriculture Division, Farm Income and Prices Section) for net value added and its components, 1970-2000. We group the Canadian Provinces (Figure 3) into three regions: Eastern Canada (Newfoundland, Prince Edward Island, Nova Scotia, and New Brunswick), Central Canada (Quebec and Ontario), and Western Canada (Manitoba, Saskatchewan, Alberta, and British Columbia). We group the States (excluding Alaska and Hawaii) into ten ERS production regions (Figure 4).

Specifically, net value added is the sector-wide measure of returns to land (net rents to non-operator landlords), labor (wages earned by hired farm workers), capital (interest expenses) and net farm income to equity-holders for their land, labor, capital and risk management.

First, we use the Theil measure of inequality (TMI) to examine changes in net value added in the U.S. and Canada, 1970-2000. The entropy-based measure quantifies the inequality of net value added by state and by province. The TMI decomposes the national inequality into between-region and within-region differences. Second, we examine changes in the distribution of the components of net value added across regions and over time.

Theil's Measure of Inequality (TMI) and Information Theory

The use of entropy in statistics has its origin in information theory. Shannon's (1948) measure of uncertainty was introduced as a measure of dispersion. Theil's measure of inequality (TMI) expands the basic concept of information by using Shannon's third requirement, additivity of the information index. To obtain the dispersion index for a distribution, we use class frequencies or probabilities.

Theil's inequality is a statistical measure of dispersion or entropy where entropy is the expected information in a message or signal. Let p be the probability, $0 \geq p \geq 1$, of an event E. Suppose that a signal is received that E did occur. The information contained in that signal is inversely related to p. If an event is unlikely (has a smaller p) then that E occurred provides more information than an event occurring that is more likely (has a large p). For example, if the probability is 0.95 and information is received that the event occurred then that information carries little information. But if the probability were 0.05 then the information that the event did indeed occur would contain a great deal of information.

Assume a set of mutually exclusive events $E_1, E_2, \ldots E_n$ with initial probabilities $p_1, p_2, \ldots p_n$. Given a second set of probabilities, probabilities $q_1, q_2, \ldots q_n$, that are analogous to the posterior probabilities from Bayesian statistics. Given two sets of probabilities, the TMI (Theil 1967) is

$$I(p,q) = \sum_{i=1}^{N} p_i \ln\left(\frac{p_i}{q_i}\right) \quad (1)$$

Intuitively, TMI captures the expected value of the information in the second signal. If the first and second probabilities are equal for all events, then $I(p,q)=0$. This implies that there is no information in the second signal not contained in the first. As the two probabilities diverge, the natural log of their ratios becomes different from zero. If the initial probability is large relative to the second probability, $p_i > q_i$, then the natural log of the ratio is positive. Alternatively, if the first probability is smaller than the second probability, $p_i < q_i$, then the natural log of the ratio is negative. However, due to the concavity of ln*(X)* the TMI has a lower bound at zero and no upper bound.

The TMI is consistent with basic income inequality measures, such as the Lorenz measure. A measure of inequality must satisfy certain basic properties. First, the inequality measure must increase when wealth is transferred from poor to rich. Also, the measure should be symmetric and homogeneous of degree zero. The TMI satisfies these basic criteria. Other dispersion measures, such as the coefficient of variation or the variance of logarithms, fail to satisfy all of the criteria. In addition, the decomposability property of TMI makes the TMI unique among all measures that satisfy the basic criteria.

The application of TMI in the current situation follows the basic inequality studies of Theil (1967) and others. The p_i is the probability that a farm is from a given state or province, measured simply as the number of farms in that state divided by the total number of farms in the country. The q_i is the probability that a dollar of net value added is from a given state or province, which is the dollars of net value added from that state or province, divided by the national amount of net value added. If the probability based on the farm numbers is close to the probability based on net value added, then there is little additional information and the TMI is small. Finally, a small inequality means that the distribution of net value added is uniform across states and vice versa. Further, additivity of the measure allows for the analysis of inequality between regions of the country. This section of the paper focuses on the national, regional, and average within region inequality of net value added in the U.S. and Canada.

Distribution of Net Value Added over Time and Across: Regional Decomposition

The basic notion of decomposition of the inequality measure (TMI) is that the total inequality can be decomposed into inequality between regions and the average inequality within each region. Alternatively, Theil and Moss (1999) decompose the inequality of components of total expenditures into inequality between regions and the average inequality within expenditure categories. Specifically, define P_f and Q_f to be

$$P_f = \sum_{i \in f} p_i \text{ and } Q_f = \sum_{i \in f} q_i \tag{2}$$

where P_f is the probability of farm numbers and Q_f is the probability of net value added for a given region, that is, the state within the farming regions. Additionally, inequality across regions can be defined from equation 1 as

$$I_R = \sum_{f=1}^{F} P_f \ln\left(\frac{P_f}{Q_f}\right) \tag{3}$$

The measure of inequality within each farming region can then be defined as

$$I_f = \sum_{i \in f} \left(\frac{p_i}{P_f}\right) \ln\left(\left(\frac{p_i}{P_f}\right) \Big/ \left(\frac{q_i}{Q_f}\right)\right) \tag{4}$$

Finally, overall inequality in equation 1 can be decomposed as: $I = I_R + I_A$ where I_A=3 P_f I_f is the average inequality within regions. There are two major advantages of TMI over other measures of inequality. First, the TMI provides a descriptive measure of the distribution of net value added that measures inequality of net value added per farm weighted by the number of farms. This is particularly important given structural changes in the agricultural sector. Second, the TMI enables empirical decomposition of national-level inequality. The measures of between-regions inequality, I_R, and the average-within region inequality, I_A, indicate whether the national inequality in the distribution of net value added is due to variation between states, within regions or between the individual regions. In the next section we apply the TMI to decompose the national-level inequality into average within-region and between-regions inequality for Canada and the United States.

Canada and U.S. Distribution of Net Value Added

Figures 5 and 6 show the average-within, between-regions, and national inequalities of the TMI for selected years. In general, the distribution of net value added in Canada has become somewhat more consistent with the distribution of farms by province in the 1990s, but varied widely from 1972-1988. However, from 1960-2000 the distribution of net value added in the U.S. has become more consistent with the distribution of farms by state. In Canada, convergence in net value added only began in 1989. However in the U.S., convergence has occurred throughout the 1960-2000 period. During this period steadily rising farm incomes, particularly in areas with supply management programs (e.g., dairy), resulted in a more equal distribution of net value added, both nationally and regionally. Growing farm exports and accommodating farm credit policies also contributed to this convergence.

Variations by states/provinces within regions, where states/provinces tend to be more homogeneous, tend to reflect microeconomic conditions. Variations between regions tend to reflect inherent macroeconomic differences, such as farm structural changes (changes in size distribution of farms, changes in production methods, etc.) and government price support and credit programs. In Canada, the average within-region variation in net value added accounted for over 60 percent of the total national variation in net value added in 16 of the 25 years from 1972-1996 (Figure 5). However, in the U.S., the average within-region variation in net value added accounted for from 31 to 50 percent of the total national variation in net value added from 1960-2000 (Figure 6). Therefore most of the reduction in national inequality was due to a reduction in between-regions inequality.

Between-Region Inequality

In Canada variation in between-region inequality (I_R) accounted for from 0.5 to 85.4 percent of total national variation in net value added (Figures 5 and 6). By comparison, variation in between-region inequality accounted for from 49.9 to 68.5 percent of total national variation in net value added in the U.S.

We need to examine our results more thoroughly in order to understand and interpret these findings for Canada. The U.S. results are more consistent and therefore easier to interpret. U.S. agriculture has experienced significant structural change from 1960-2000. The number of farms declined and the average size of farm increased (through consolidation). This expansion/consolidation of agriculture resulted in a more even distribution of net value added across the states relative to the number of farms in each state. The between region results show that about half of this increased equality was due to a between-region move toward equality in net value added and about half was due to within-region factors. Between-region variations are generally due to macroeconomic differences among regions whereas within-region variations are due to microeconomic differences.

Within-Region Inequality

Estimates of within-region inequality of net value added, I_f (equation 4) for 10 regions are presented in Figures 7, 8, and 9. Figure 7 presents the change in inequality in net value added in the three main farming regions in Canada (Eastern Canada, Central Canada, and Western Canada). Within-region inequality was greatest in Eastern Canada, and generally more equally distributed in Central Canada and Western Canada. One notable exception is Western Canada in 1988.

Within-region inequality varied considerably less across the U.S. production regions. Figure 8 shows the within-region inequality for five selected regions: Northeast, Lake States, Corn Belt, Northern Plains, and Appalachia. Appalachia showed the greatest within-region variability, increasing since 1980. The four remaining regions showed considerably less variation from 1949-2000. Figure 9 shows the within-region inequality for five other regions: Southeast, Delta, Southern Plains, Mountain States, and Pacific. The Southeast, Pacific, and Mountain States showed the most within-region variation. The Southern Plains and Delta regions, with 2 and 3 states respectively, had considerably less variation in inequality of net value added over the 1949-2000 time period.

Distribution of Components of Net Value Added across Regions and Over Time

The Theil Measure of Inequality (TMI) is not only useful in understanding changes in the between and within region distribution of net value added, but also may be used to examine and explain changes in the distribution of components of income or expenditures.

Following Theil and Moss (1999) let there be *N* regions and n components of net value added (total factor income). Net value added is composed of four income claimants or components: labor, net rent to non-operator landlords, interest, and net farm income. B_{ck} represents the net value added (NVA) from net value added component *k* for region *c*, measured as the fraction of total net value added (land, rent, interest, and net farm income) on all *n* components of net value added over *N* regions.

We measure the inequality of net value added (NVA) by the log of the ratio of arithmetic mean NVA to geometric mean NVA. When this is applied to factor *k*, we obtain

$$J_k = -\log N - \frac{1}{N}\sum_{c=1}^{N}\log\frac{B_{ck}}{B_{.k}} \quad \left(B_{.k} = \sum_{c=1}^{N} B_{ck}\right).$$ When it is applied to all *n* factors of production jointly, we obtain $J = -\log N - \frac{1}{N}\sum_{c=1}^{N}\log B_{.k}$. It is easily verified that $J = \bar{J} - \bar{I}$ where $\bar{J} = \sum_k B_{.k} J_k$ is the average inequality of the net value added (total factor returns) to the *n* factors of production (weighted according to their shares in total income) and $\bar{I} = \left(\frac{1}{N}\right)\sum_c I_c$ with I_c defined as

$$I_c = \sum_{k=1}^{n} B_{.k} \log\frac{B_{.k}}{(B_{ck}/B_{c.})} \qquad \left(B_{c.} = \sum_{k=1}^{n} B_{ck}\right),$$

where I_c is the average inequality of the components of net value added. I_c is the expected information of the message that transforms the shares of net value added in region c, $B_{c1}/B_{c.},....,B_{cn}/B_{c.,}$, into the corresponding aggregate shares of net value added. We have $I_c = 0$ if all regional shares of this factor of production agree with these aggregate shares, and $I_c > 0$ otherwise. That is, if returns to labor in each region contribute equally to variation in total net value added, then $I_c = 0$. Otherwise, if $I_c > 0$ for a given factor of production, then the greater is I_c, the more that factor contributes of the total variation in net value added. Theil and Moss (1999) note that this components of income approach is mathematically equivalent to the components of total expenditure income approach described by Theil (1979).

Canada and U.S. Inequality of Agricultural Income by Components of Net Value Added

Tables 3 and 4 summarize the inequality in factor shares of net value added for Canada and the United States. For Canada, average inequality of net value added has increased during the years 1990-2000. Most of the variation in total net value added (*J*) is due to variation in net value added across regions ($\bar{J}$) rather than to variation in the components of net value added, or $\bar{I}$ (Table 3). Furthermore, we found that between-region differences in net value added (which tend to be associated with structural changes, including government programs) rather than within-region differences account for most of this variation. For the U.S., average inequality of net value added has also increased, with most of the variation also due to variation in net value added across regions ($\bar{J}$) rather than to variation in the components of net value added. As with Canada, between-region differences rather than within-region variation account for most of this variation.

Tables 5 and 6 show the inequality of the components of net value added for Canada and the U.S. In Canada, most of the variation in the components of net value added has been due to variation in rent payments. Since land is the most fixed factor, this result is consistent with Ricardian rent theory. Since labor and capital are somewhat more mobile, returns to these factors are expected to be somewhat less variable over time. In the United States, returns to the most fixed factor, land, were highest in the 1960s and the 1990s. However, returns to land (rents) were relatively stable in the 1970s and 1980s, whereas returns to the other factors were somewhat more variable. This could be due to institutional factors. Specifically, although land rents are related to (variable) expected returns, they are also negotiated between landlords and renters (either as cash or share rents). Therefore, rental payments are somewhat stabilized, at least in the short run. Furthermore, financial market de-regulation began in the 1980s, increasing capital mobility. Also, labor mobility may have increased as off-farm employment opportunities expanded. Returns to farm operators, although stabilized by government payments, were still affected by instability of farm commodity prices. Factor shares to non-equity holders in Canada and the United States such as lenders, non-operator landlords, and hired labor, have increased (Figures 1 and 2).

What accounts for this structural shift in the distribution of net value added from equity holders to non-equity holders? First, the relative importance of each factor (land, labor, capital, and farm entrepreuership) varies from region to region. Structural analysis of the sector's ownership forms, capital formation strategies, and of factor markets (including technical change, factor mobility and elasticity) helps explain this shift. For example, renting land rather than purchasing has become an alternative strategy in acquiring the use of capital, as evidenced by the increase in real dollars paid to nonoperator landlords (Harrington et al., 1998; Ryan, Barnard, and Collender, 2001). Census Data from Statistics Canada indicate that the area of farmland owned by operators declined by nearly 13 percent from 1971-1996, while the area of farmland rented by operators increased by nearly 30 percent. Also, farmers' reliance on financial markets and credit as a source of capital has increased as farmers began purchasing more inputs and as production methods evolved (Drabenstott and Barkema, 1998). Strickland and Johnson (1992) have noted the impacts of technical change on factor returns. For example, the production of fruits, vegetables, and greenhouse and nursery are labor intensive. These commodities generate a high value-added per unit of land. However, increased employment of labor in these crops has been offset by a dramatic substitution of capital for labor in producing traditional crops such as cotton, tobacco, corn and hay. Also, interest expenses for borrowed capital measured in real dollars have not increased much in the past 25 years. This reflects changing strategies for gaining access to capital. Contractual arrangements between equity-holders require much of the capital and intermediate inputs to be provided by the nonoperator equity-holders. This lessens financial and marketing risks for the operator.

Conclusion

Distribution of net value added by factor shares

The distribution of net value added in Canada and the U.S. by factor shares has changed since 1960, reflecting major structural changes in the agricultural sectors of each country. We found that net value added and its components have increased over time as factors of production beyond those owned by the farm operator and other equity holders such as lenders, non-operator landlords and hired labor have increased.

Inequality of net value added by regions

We examined changes in net value added that have occurred across states and regions within the U.S. between 1950 and 1999. Specifically, we applied Theil's measure of income inequality to U.S. state and Canadian provincial-level net value added data to measure the variation in net value added across States/Provinces and production regions. In general, the distribution of net value added in Canada has become somewhat more consistent with the distribution of farms by Province in the 1990s, but varied widely from 1972-1988. In Canada, convergence in net value added only began in 1989. In the U.S., the national inequality in net value added has approximately doubled since 1960. About half of the variation in net value added is due to within-region variation and about half to within-region variation in net value added.

Inequality of net value added by components (rent, interest, labor, and net farm income)

In Canada, average inequality of net value added has increased during the 1990-2000 period. Most of the variation in total net value added (J) is due to variation in net value added across regions rather than to variation in the components of net value added. In the U.S., average inequality of net value added has also increased, with most of the variation also due to variation across regions rather than to variation in the components of net value added.

Explaining these changes in the distribution of net value added

John E. Floyd (December 1965) examined the cost and differential effects on factor returns of the Canadian and U.S. farm policies in the northern Great Plains and concluded that the power of government to influence economic variables is not nearly as strong in relation to the underlying natural forces of change as one might expect.

Another key factor that has influenced the distribution of factor returns to capital, labor, rents, and net farm income is technological change. Ahearn, Yee, Ball and Nehring (1998) have noted that productivity in the U.S. farm sector has grown at an average annual rate of 1.94 percent from 1948 to 1994. This reflects an annual growth in output of 1.88 percent per year and an actual decline in agricultural inputs of 0.06 percent per year.

Evenson and Huffman (1997) note that there has been a long history of structural change and total factor productivity change. Using state aggregate data starting in 1950, they found that input prices, public and private research, public extension and government commodity programs directly and indirectly cause change in U.S. farm structure and in total factor productivity (TFP). Their results suggest that changes in farm size have been dominated by input price changes rather than by technology or government programs.

Coxhead and Warr (1991) investigated the distributional effects of technical progress in agriculture using a small computable general equilibruim (CGE) model and found that technical change produces distributional outcomes which are highly sensitive to intersectoral factor mobility, heterogeneity in the quality of specific inputs such as land, labor, and capital, and factor bias of technical progress.

In order to more fully interpret these results for Canada and the United States, we will need to more thoroughly examine relative factor price changes and changes in factor demand and supply at a more disaggregated level. Our finding that generally most of the variation in net value added across regions is due to differences between regions rather than to differences in the components of net value added themselves is consistent with the notion that differences in the quality and productivity of inputs across regions play a key role in the growth and distribution of income to land, labor, capital, and farm operators.

Studies since Griliches (1960) have recognized the importance of quality differences in measuring agricultural inputs such as land, labor, and capital. The USDA-ERS is improving its estimates of farm inputs by adjusting for the hedonic characteristics of inputs (Ball, Gollop, Kelly-Hawke, and Swinand, 1999). These improvements in the estimates of input prices will help us explain and understand changes in the distribution of net value added and in returns to its components over time.

Measurement Issues/Measuring Value Added at the Farm Level

There are specific measurement issues association with net value added and income that the U.S. Department of Agriculture, Economic Research Service and Statistics Canada are resolving using data from the Agricultural Resource Management Study (ARMS). For example, sector aggregate measures of value-added do not currently treat breeding stock as a capital item. Instead, purchases of all livestock are included as an expense item. The value of orchards and other trees have not been included in capital stock and depreciated. Instead, trees have most likely been included in the value of land. This means that the value of trees has been included in asset values and in balance sheets prepared for the sector and for farms. Annual expenditures for tree stock have been included as an expense instead of having been added to capital stock and being depreciated over a measure of useful life. Also, another primary issue for sector level measurements is that both net value added and net farm income accrue to persons or entities other than the farm operator. Data collection steps have been taken through the ARMS to remedy this data shortcoming by accounting for multiple households and contract arrangements.

ERS has traditionally estimated income of the farm sector as a whole. However, ERS has a project that combines value-added measurement concepts with farm-level production and input acquisition information from the ARMS to develop a value-added account for each farm. Resulting estimates of value added generated by farm business establishments will be used to assess the relative distribution of farm business returns among suppliers of the factors of production. (http://www.ers.usda.gov/Briefing/FarmIncome/overview.htm)

Finally, Boehlje states that the structure of an industry is typically defined in terms of size, financial characteristics, resource ownership, technology, and similar characteristics. But these descriptive statistics are relatively sterile in describing and understanding changes in an industry. Boehlje notes that the most dramatic changes occurring in the agricultural industries might best be described in terms of changes in the ways of doing business. These include 1) the development of food supply or value chains from genetics to end user/consumer and 2) the adoption of process control technology and a manufacturing mentality throughout the entire food chain but especially in production agriculture. Agriculture is being transformed from a sector that produces and processes commodities to one that manufactures specific attribute products for unique end-use markets.

> *Farming is being transformed from growing stuff to manufacturing biologically based specific attribute raw materials* (Boehlje, 1999, pp. 1028-29.

Explanations for these cross-country, within and between-region changes in net value added and in factor shares to rent, capital, labor, and farm operators will have to include an expanded view of farm structure and performance in order to better measure, analyze and understand these changes. Such a view would synthesize and draw lessons from the economics of agricultural policy (Schmitz, Furtan, and Baylis, 2002 forthcoming).

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Appendix 1. Capital consumption in the U.S. farm accounts

In determining capital consumption in the farm income accounts for the agricultural sector, the concept used is replacement value. This is in contrast to income tax accounting where depreciation is based on purchase price/book value. For tax accounting, you take the cost at the time of purchase and distribute that over the time period that you prefer from among the range permitted by law, using a distribution that you prefer from among those permitted by law. Neither may necessarily closely approximate the distribution at which the asset is consumed.

While the concept employed in book-value depreciation is to allow the recapture of the cost of the asset, it does not allow for the maintenance of the capital stock in inflationary periods because the portion of the asset purchased can't be replaced at its previous cost. In effect, the cost of doing business is being underestimated and income is being overestimated. However, the Internal Revenue Service (IRS) probably wouldn't want to get into allowing farmers or other businessmen the flexibility to determine replacement cost. That would be subjective, open to endless debate, and probably abused. A cost of purchase is a concrete number and documented.

Sector accounting is more of an academic/theoretical approach that does not involve a voluminous number of individual accounts and with no motivation to bias the numbers. Thus, the concept of capital consumption is employed instead of depreciation. The portion (quantity) of the asset consumed is estimated but is then valued at the replacement cost in the year of consumption to ensure that the capital stock is maintained and not cannibalized or eroded away by inflation.

In sector accounting one can't run a depreciation account on each piece of equipment in the national inventory. We maintain a value of capital stock in constant dollars for several categories of assets. We take the capital expenditures, deflate them, and add them to the constant-dollar capital stock. We use a declining balance method for computing consumption (depreciation) based on the assumption that assets yield more utility in the early years and have a long tail. A new tractor is used to do the heavy pulling in the early years but it gets relegated to pulling manure spreaders and trailers late in its useful life when a new tractor is purchased for the heavy pulling.

Based on the percentage selected as appropriate for the declining balance form of depreciation, we compute an amount of the constant-dollar capital stock estimated to have been consumed in a given year and then re-inflate it to a current-dollar value. That is our capital consumption. There is small factor added in to account for capital stock lost through accidental damage (pretty much the same definition for qualifying for indemnity payments from insurance).
Just as the deflated value of annual capital expenditures are added to the constant-dollar capital stock, that portion estimated to have been consumed from the existing constant-dollar stock is deducted to maintain a running total. Thus there is a net change in the capital stock each year, which may be positive or negative.

Table 1. Distribution of Farms by Farm Type and Province: Canada, 1998

Farm Type	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Total
Grain & Oilseed		3.1		2.1	11.3	29.5	51.7	75.8	37.7	7.1	41.5
Cattle		26.3	26.0	28.4	17.1	24.8	30.8	18.0	44.1	30.4	27.5
Dairy	18.5	21.6	16.0	18.0	33.1	14.2	3.1	0.7	1.5	8.3	8.8
Hog		6.3	4.5	3.8	7.6	4.9	3.9	0.6	1.8	1.1	3.1
Poultry & Egg	13.0	1.9	4.5	2.9	3.4	3.1	1.5	0.2	0.7	5.8	1.8
Fruit & Vegetable	27.8	4.1	22.5	11.5	6.5	5.6	0.2	0.1	0.1	20.5	3.4
Greenhouse & Nursery	13.0		3.9	2.4	3.2	2.7	0.4	0.2	0.8	5.8	1.6
Potato		28.4		15.6	0.8	0.4	0.6		0.2	0.7	0.7
Other	16.7	7.5	21.6	15.0	17.1	14.8	7.8	4.3	13.0	20.3	11.6
All Farms	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Farm Income and Adaptation Policy Directorate, Agriculture and Agri-Food Canada, Economic Overview of Farm Incomes – All Farms, Publication No. 2048/B.

Table 2. Distribution of Farms by Farm Type and State: United States, 2000

Farm Type	NE	LK	CB	NP	AP	SE	DL	SP	MT	PC	48-state Total
General Cash grain		5.4	10.2	12.1			1.4				4.1
Wheat				1.2				1.6	4.7		2.0
Corn		9.8	14.4	11.9							5.3
Soybean		5.3	11.5	3.0	1.5		2.2				3.6
General crop	19.6	23.4	15.9	16.3	33.2	11.0	18.7	12.1	24.9	20.2	19.5
Fruit and tree nuts						7.2				21.5	3.3
Vegetables	3.1								1.2	4.6	1.7
Nursery and greenhouse	10.5		1.6		1.1	2.5				3.2	2.3
Beef cattle	17.5	20.6	26.9	35.1	40.9	51.9	57.0	63.3	35.6	23.5	37.4
Hogs		2.2	2.7		0.2						1.2
Poultry	1.3		0.2		2.0	4.7	4.7	0.5			1.3
Dairy	13.3	14.2	2.9		1.3	0.4		0.6	2.2	2.4	3.6
General livestock	24.6	11.0	10.1	8.2	16.1	18.9	10.7	14.3	24.9	17.9	14.7
All Farms 1/	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1/ Totals may not add due to rounding.

Source: USDA, Agricultural Resource Management Study (ARMS)

Table 3. Inequality in Factor Shares of Net Value Added --- Canada

Years	Average inequality of Net Value Added 1/ $\bar{J}$	Inequality of Total Net Value Added 2/ J	Average inequality of components of net value added 3/ $\bar{I}$
1972-1979	0.8961	0.8176	0.0786
1980-1989	0.9571	0.8680	0.0892
1990-2000	0.8359	0.7398	0.0961

Table 4. Inequality in Factor Shares of Net Value Added --- United States

Years	Average inequality of Net Value Added 1/ $\bar{J}$	Inequality of Total Net Value Added 2/ J	Average inequality of components of net value added /3 $\bar{I}$
1960-1969	0.0971	0.0749	0.0222
1970-1979	0.0897	0.1007	-0.0110
1980-1989	0.0657	0.1005	-0.0348
1990-2000	0.1517	0.1012	0.0505

1/ $\bar{J} = \sum_k B_{.k} J_k$ is the average inequality of the net value added (total factor returns) to the *n* factors of production (weighted according to their shares in net value added).

2/ $J = -\log N - \frac{1}{N}\sum_{c=1}^{N} \log B_{.k}$ is the inequality of net value added applied to all four components of NVA (capital, labor, rent and net farm income).

3/ $\bar{I} = (1/N)\sum_c I_c$ where $I_c = \sum_{k=1}^{n} B_{.k} \log \frac{B_{.k}}{(B_{ck}/B_{c.})}$ $\left(B_{c.} = \sum_{k=1}^{n} B_{ck}\right)$.

I_c is the average inequality of the components of net value added.

Table 5. Inequality by Components of Net Value Added --- Canada

Years	Labor	Rent	Interest	Net Farm Income
1972-1979	0.6384	1.4714	0.9267	0.8822
1980-1989	0.6315	1.4698	1.0222	0.9704
1990-2000	0.6028	1.2890	0.8846	0.8359

source: Agriculture and Agri-Food Canada, Economic and Policy Analysis Directorate.

Table 6. Inequality by Components of Net Value Added --- United States

Years	Labor	Rent	Interest	Net Farm Income
1960-1969	0.0817	0.2931	0.0996	0.0763
1970-1979	0.1153	-0.0281	0.1000	0.1003
1980-1989	0.1249	-0.0181	0.1057	0.0254
1990-2000	0.1963	0.2952	0.1107	0.0857

source: U.S. Department of Agriculture, Economic Research Service.

Figure 1. Canada --- Net Value Added and Factor Shares, 1970-2000

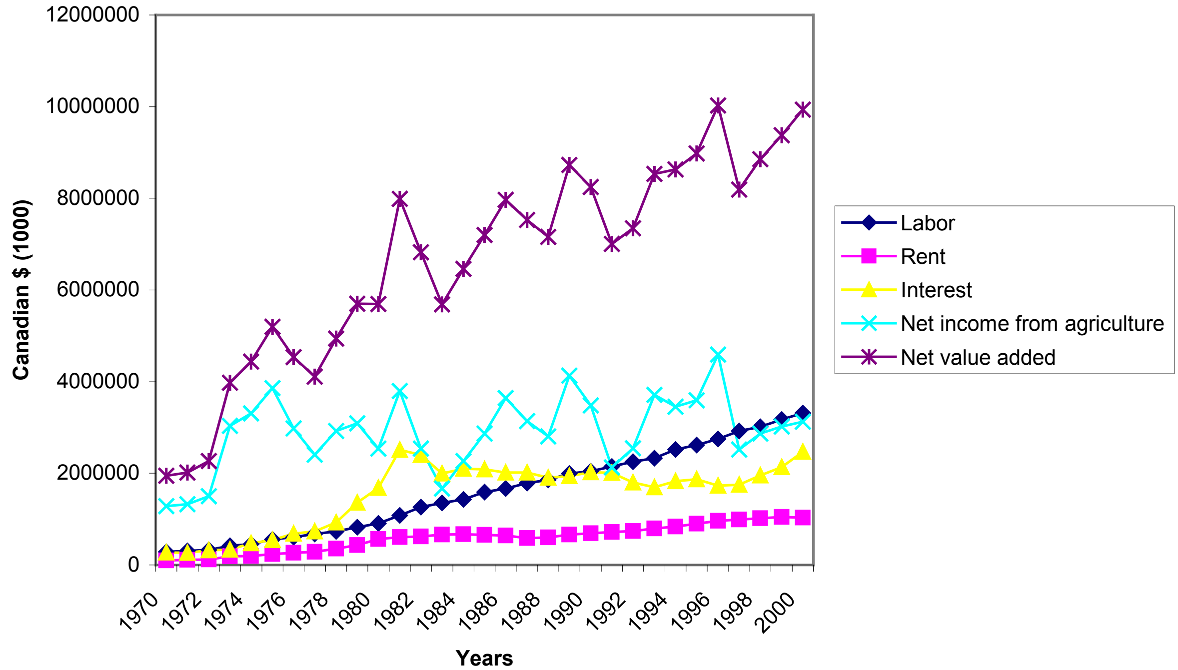

Figure 2. U.S. --- Net Value Added and Factor Shares, 1960-2000

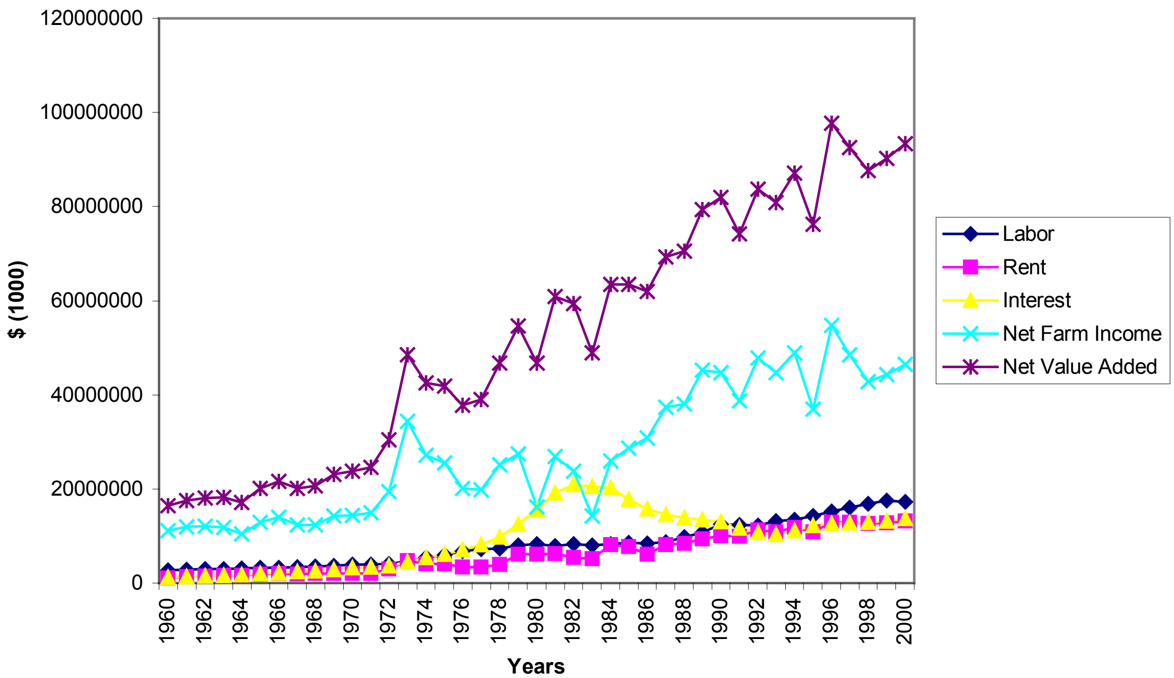

Figure 3. Canada Regions

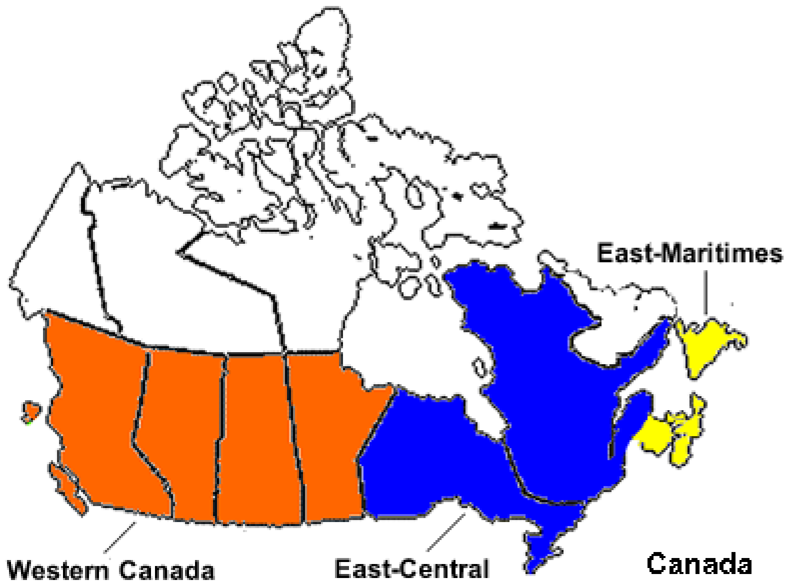

Figure 4. U.S. Regions

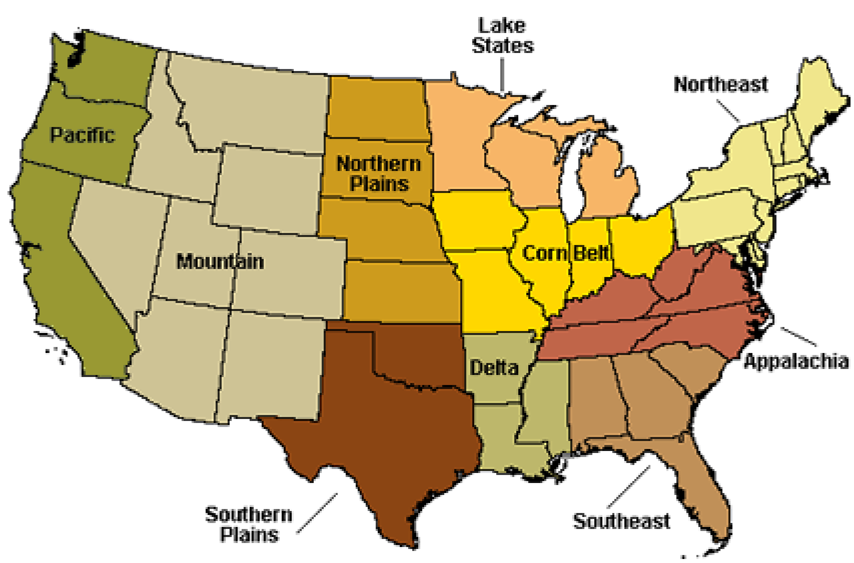

Figure 5. Canada: National, Between-Regions, and Average Within-Region Inequality in Net Value Added, 1972-1996

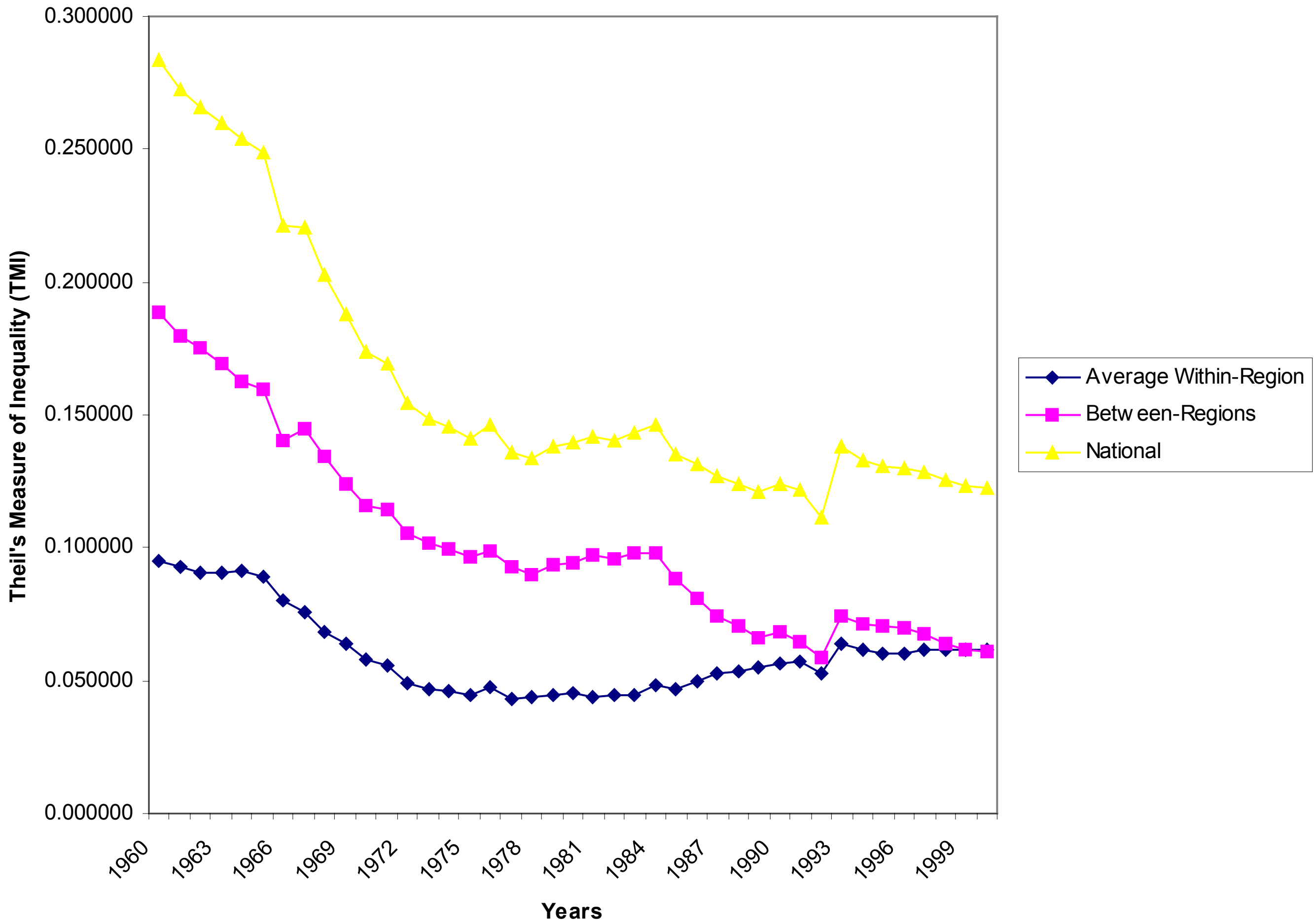

Figure 6. United States: National, Between-Regions, and Average Within-Region Inequality in Net Value Added, 1949-2000

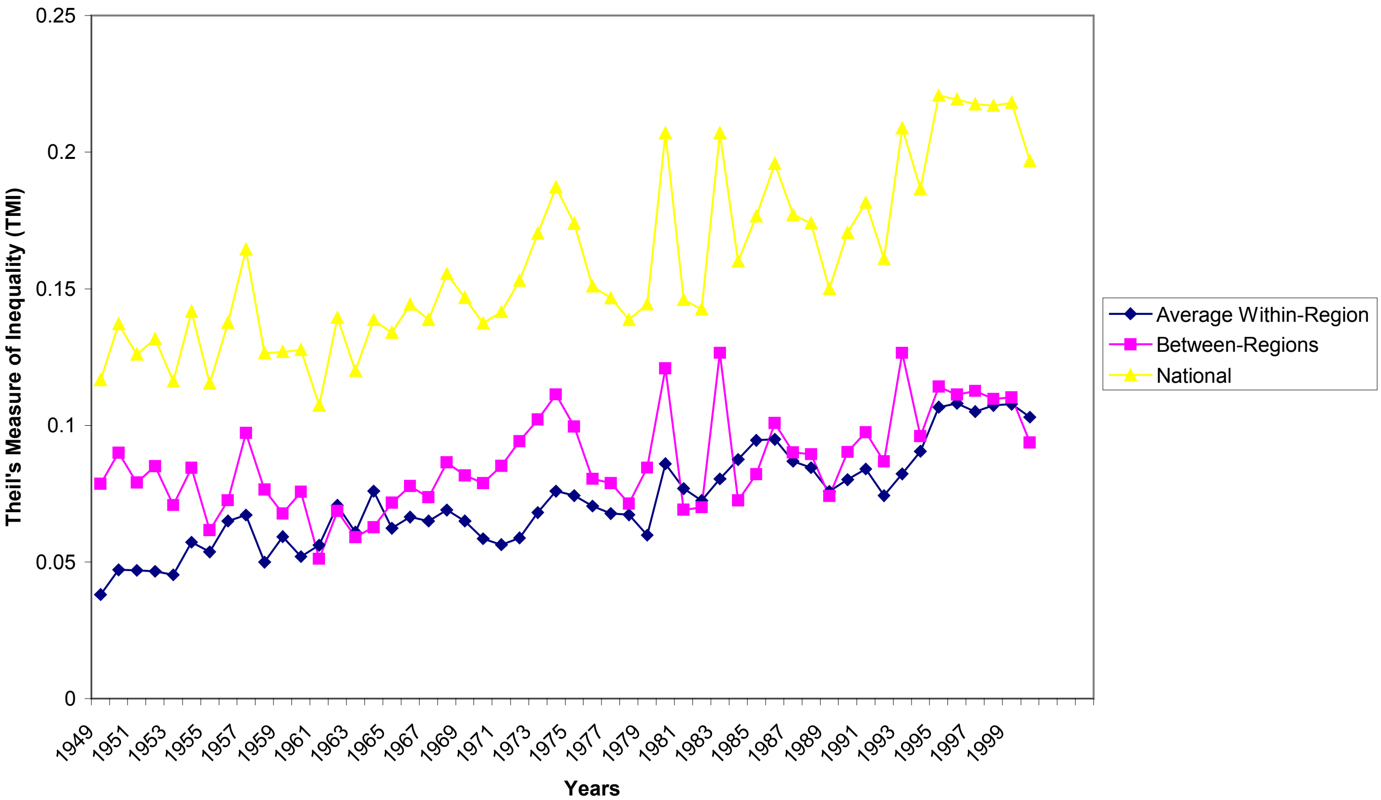

Figure 7. Within-region Inequality in Net Value Added for Canada Regions

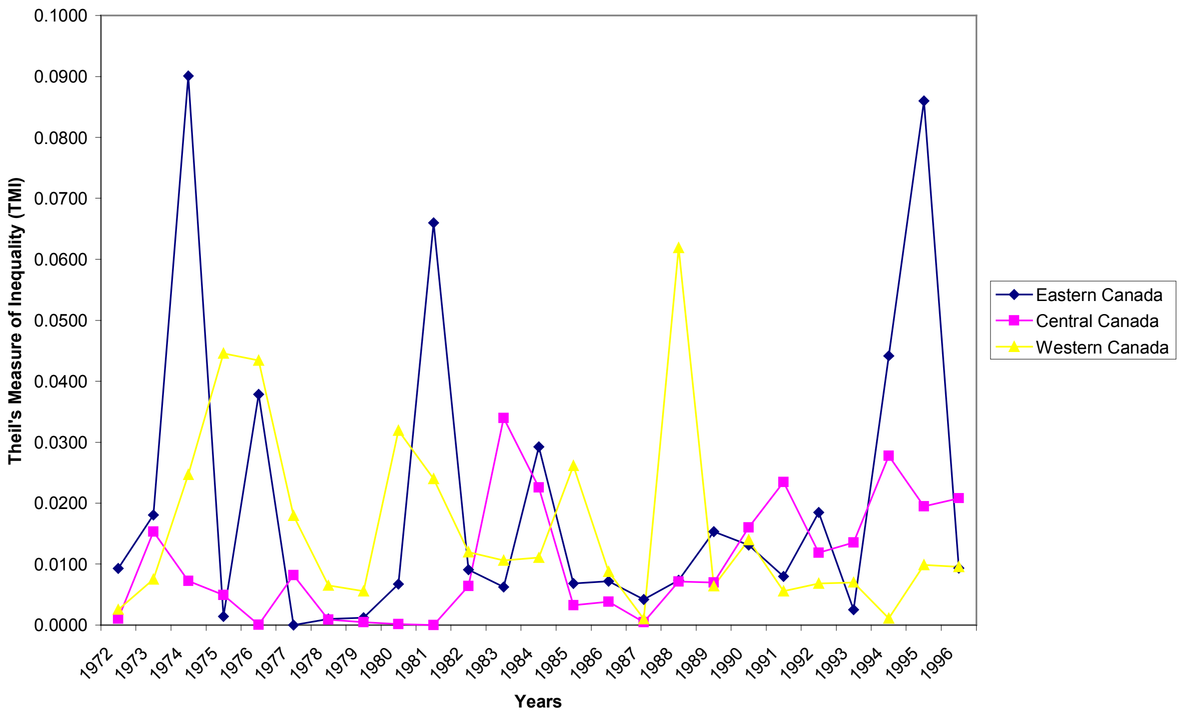

Figure 8. Within-region Inequality in Net Value Added for Selected U.S. Regions, 1949-2000

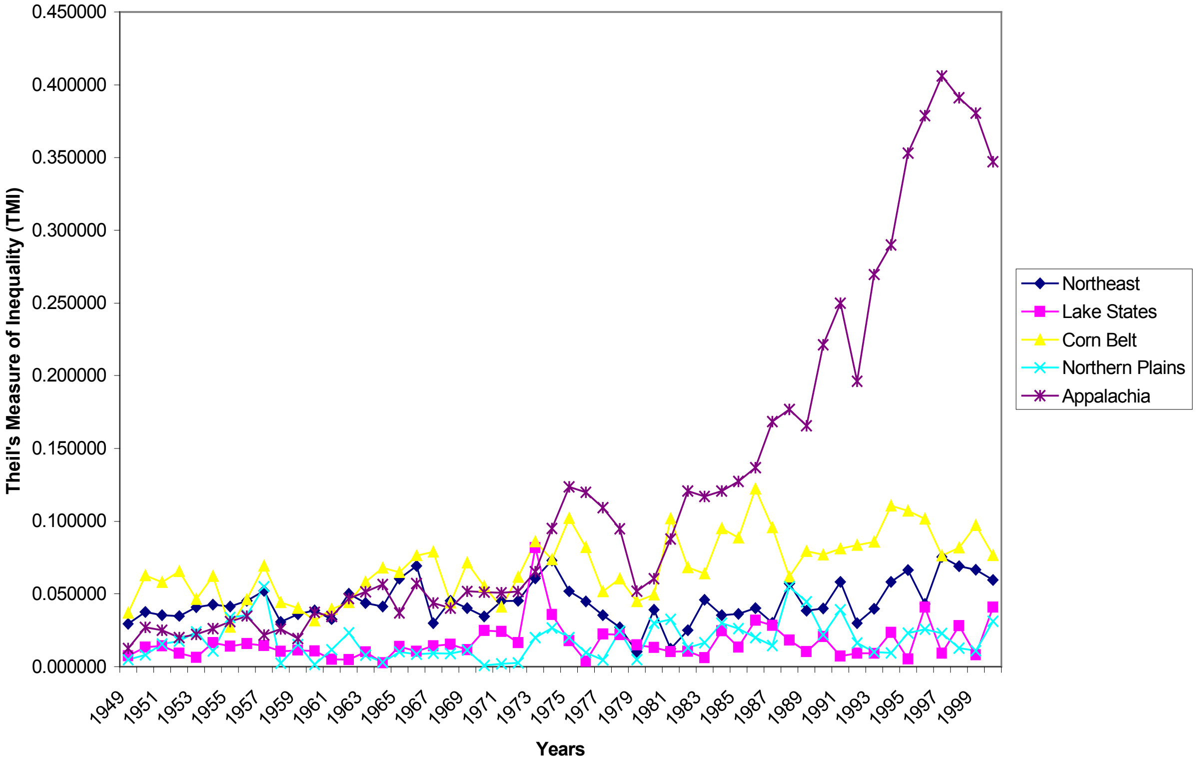

Figure 9. Within-region Inequality in Net Value Added for Selected Regions, 1949-2000