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QUOTA PRICES AS INDICATORS OF COMPARATIVE ADVANTAGE IN SUPPLY MANAGED INDUSTRIES

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Abstract

The Canadian Farm Products Agencies Act (2012) requires that comparative advantage be used to guide the allocation of new quota under supply management. This requirement, however, has not been met in practice. Agricultural economists have proposed several ways of making this legal requirement operational. We review and evaluate these proposed approaches and find that quota prices are the only direct measure of comparative advantage in supply managed industries. We develop an agent-based general equilibrium model of quota exchange to illustrate the use of quota prices as indicators of comparative advantage. Our approach complements the proposal by Meilke (2009) to use quota prices as indicators of comparative advantage in supply managed industries and also addresses the concerns of Larue and Gervais (2008) that quota prices may not be theoretically consistent with comparative advantage. We also discuss potential practical challenges of using quota prices as indicators of comparative advantage in the Canadian supply managed industries. Finally, we provide an example of calculating provincial shares of new quota using recent quota price data according to two prototype decision rules.

Key Words: comparative advantage, supply management, quota prices, economic calculation

JEL Classifications: F 11, L 11, P11, P16, P21, Q18

INTRODUCTION

Production and marketing of milk, eggs and poultry in Canada are regulated under a policy framework that sets farm level prices with a formula and that allocates farm level production levels and raw milk distributions to processors through a quota system. Changes in domestic market demand conditions are accommodated through adjustments in the amount of quota available. Under the Canadian Farm Products Agencies Act (2012), the allocation of additional quota (also called over-base quota) to accommodate increased product demand is required to reflect conditions of comparative advantage in primary production across Canada. This requirement, however, has not been met in practice.[1] This has led to legal disputes, for example, when the Province of Saskatchewan demanded reevaluation of the provincial egg quota allocations on the basis of comparative advantage. The Farm products Council of Canada (2010) anticipates more disputes of this type. Under a policy regime in which prices are set by formulas and are not determined through the interaction of supply and demand, the measurement of comparative advantage faces significant informational hurdles. Although this literature has not generally perceived the problem in this way, this situation has much in common with the literature on the economic calculation debate[2] in that we are confronted with a situation where specific price information is not available to inform resource allocation.

The economic calculation debate resulted in important conclusions by Hayek (1945, 2002) that market prices reveal otherwise unobservable time- and place- specific information, and that competition is the necessary process for the discovery of this information. This time- and place-specific information, according to Hayek, includes knowledge of people, local conditions and special circumstances, knowledge of better alternative techniques, and temporary opportunities or local differences of commodity prices. This information exists as bits of incomplete, continuously changing, and dispersed individual knowledge not directly available to others. Barnett (1992) spells out the logic behind the transformation of this dispersed individual knowledge into market prices. He explains the two-fold function of market exchanges. First, in a market exchange, a buyer of a good or a service (1) freely acts upon his or her own personal and local knowledge, and (2) takes into account personal and local knowledge of the seller by offering in exchange something the seller values more. The resulting exchange ratio (or price) reveals this otherwise unobservable information possessed by the buyer and the seller to others. The implication is that restrictions on market exchanges reduce the informational content of market prices. In the extreme case when exchange of property is completely outlawed, there would be no market prices. Consequently, there would be no mechanism that would translate individual time- and place-specific knowledge into a form observable to others. In this context, the Canadian supply management system represents a set of restrictions on market exchanges. These restrictions reduce the informational content of output, and potentially, input prices in supply managed industries.

[1] In the dairy industry, for example, new quota is allocated according to the so-called 10/90 rule, where 10% of the new quota in a province is based on the province's historical share of the national production, and 90% is based on population.

[2] Pasour (1982, 1983) has developed the implications of the economic calculation debate in the context of policies intended to limit the conversion of agricultural land to non-agricultural uses.

Agricultural economists have proposed several approaches to addressing the problem of measuring comparative advantage under supply management. This work has focused on the Canadian egg industry. Doyon (2007) suggested a number of indicators of comparative advantage, including farm cash receipts, farm size, inflation rates, partial productivity measures, input prices, enterprise budget data, and transportation costs. Meilke (2009) has criticized Doyon's proposed indicators on the basis that they are either theoretically inconsistent or empirically biased and suggests that production quota prices should be considered as the primary indicators of comparative advantage. Larue and Gervais (2008), while pointing out that quota prices are worth considering, express reservations as to whether they measure competitive advantage rather than comparative advantage. They characterize competitive advantage as an industry-level concept and comparative advantage as an economy-level concept.

Katz et al (2008) propose an index called the Relative Output Advantage (ROA). This index is based on the share of agricultural production in the total economic activity occurring in a province (in terms of total dollar value of output) for each province. Sarker (2008) and Mussell et al (2009) doubt the validity of this indicator and argue that comparative advantage can differ across agricultural industries within a province. Bruneau and Schmitz (2009) defend the Katz et al (2008) approach as being imperfect but still the best alternative because it is based on well established economic principles, it is easily understandable and transparent and the data are readily available. Larue and Gervais (2008) argue that an indicator called the Domestic Resource Cost (DRC) index is potentially a better alternative than the ROA index. The DRC index is interpreted as the domestic marginal opportunity cost divided by the domestic marginal value added of an additional unit of output.

The main differences between the DRC index and the ROA index lie in the level of aggregation and in the assumptions about the aggregate technology. The DRC index is calculated for a specific industry (i.e., eggs). A fixed proportions aggregate production function is assumed. The ROA index is calculated for the whole agricultural sector without invoking any specific aggregate technological relationship. Larue and Gervais argue that the ROA index for the Prairie Provinces may be driven by the grains, oilseeds and beef sectors, which would be an indication of comparative advantage in these industries but not necessarily in eggs, poultry or dairy.

Previous literature has proposed four approaches to identifying comparative advantage in the Canadian egg industry: (1) the multiple indicator approach proposed by Doyon (2007); (2) the ROA index approach proposed by Katz et al (2008) and Bruneau and Schmitz (2009), (3) the DRC index approach proposed Larue and Gervais (2008) and (4) the quota price approach proposed by Meilke (2009). These approaches are based on using different economic data and arithmetic procedures to construct indicators of comparative advantage. Table 1 lists all the indicators used in the four approaches, explains briefly what each one means and provides a general outline of how these indicators are calculated. We will proceed to evaluate these four general approaches based on their (1) consistency with the generally used theories, (2) internal consistency of arguments, (3) consistency of arguments with empirical observations, and (4) practical feasibility (i.e., availability of appropriate data). We concluded that most of the indicators proposed by Doyon (2007) and the two indicators proposed by Katz et al (2008) and Larue and Gervais (2008) boil down to different indirect ways of inferring opportunity costs of

Table 1. Summary of the previously proposed indicators of comparative advantage for the Canadian egg industry

Author and approach	Indicator	Indicator description
(1) Doyon (2007) Multiple indicator approach	Agricultural diversification	Distribution of provincial cash receipts for cattle and calves, eggs, cash crops, fruits and vegetables, hogs, dairy and hens and chickens
	Inflation rates	Overall Consumer Price Index (CPI)
	Average size of egg farm	Output in dozens of eggs per farm per year
	Availability and prices of major inputs	Feed cost per dozen eggs, farmland prices, and manufacturing wages
	Costs of production	
	Average unit cost of production	Prices of inputs weighted by the quantities of the respective inputs required to produce a unit of output
	Hen to population ratio	Number of hens per person
	Ratio of industrial to total egg sales	Total value of industrial egg sales divided by the total value of all egg sales
	Single factor productivity	
	Rate of lay	Number of eggs per hen produced per unit of time
	Percentage change in the rate of lay	Percentage change in the number of eggs per hen produced per unit of time
(2) Katz et al (2008) Revealed Output Advantage (ROA) index approach	ROA index	Share of agriculture in the value of output for the goods sectors in a province divided by the share of agriculture in the value of output for the goods sectors for all other provinces
(3) Larue and Gervais (2008) Domestic Resource Cost (DRC) index approach	DRC index	Provincial average cost of immobile inputs per unit of output of a supply-managed commodity divided by the provincial revenues added by an additional unit of output of that commodity
(4) Meilke (2009) Quota prices approach	Production quota prices	Provincial price of an additional unit of production quota

inputs and the value of output in different industries. Under the approach proposed by Meilke, the price of production quota is the indicator of comparative advantage. We argue that quota prices are the only direct, and thus the only relevant, indicator of opportunity costs and value of alternative uses of resources and that quota prices reveal otherwise unobservable time- and place-specific information on comparative advantage in supply managed industries. Next, we present an agent-based, general equilibrium model of quota exchange as a means of identifying comparative advantage in supply managed industries. This theoretical illustration of quota exchange complements Meilke's quota price approach and addresses the concerns of Larue and Gervais (2008) that quota prices may not be theoretically consistent with comparative advantage. Then, we discuss adjustments to observed quota prices and present two possible methods that could be used to link quota prices to the allocation of over-base quota in the Canadian dairy industry. We use 2010-2011 dairy quota prices to demonstrate the two methods.

PREVIOUSLY SUGGESTED INDICATORS

The previously suggested indicators of comparative advantage by Doyon (2007), Katz et al (2008), and Larue and Gervais (2008) in the egg industry are based on the formulations of comparative advantage by Ricardo (1821), Stolper and Samuelson (1941), Heckscher (1991) and Ohlin (1991). All of these characterizations follow what we will describe as an aggregate approach to the conceptualization of comparative advantage. The question of which province or provinces have a comparative advantage in production in industry X, at the aggregate level, means: In which province or provinces does an increase in the aggregate value of output of industry X involve the least decrease in the aggregate value of output of all other industries resulting from the reallocation of resources from these industries into industry X? This will be the case in the province where the sum of marginal value products of all inputs in industry X, relative to other industries, is the highest compared to other provinces. Thus, the key component of identifying the degree of provincial comparative advantage in a particular industry is getting information on the marginal productivities of all inputs in different industries across provinces. The Heckscher-Ohlin model suggests that this information is reflected in the price ratios of aggregate outputs and inputs, at least if product and input markets are not distorted. The problem under supply management is that prices are set through a formula, and output and potentially input prices are not reliable indicators of the marginal value products of inputs and hence of comparative advantage.

Doyon (2007) proposed 11 indicators of provincial comparative advantage in egg production grouped in six categories. The six categories are (1) agricultural diversification, (2) inflation rates, (3) average size of egg farm, (4) single factor productivity, (5) availability and prices of major inputs and (6) costs of production. Doyon uses farm cash receipts by commodity as a measure of agricultural diversification, consumer price index (CPI) as a measure of inflation rates and egg output per farm as a measure of farm size. He proposes two indicators as measures of single factor productivity: rate of lay (egg output per hen) and the percentage change in the rate of lay over time. Availability and prices of major inputs are measured by three indicators within Doyon's framework: feed cost, land prices and manufacturing wages. Doyon uses three indicators: cost of production, ratio of industrial to total egg sales and hen to human population ratio in the costs of production category. In addition, he acknowledges transportation costs as a separate factor that may interact with comparative advantage. In his summary of all indicators, Doyon shows that different indicators generally produce different rankings of provinces with respect to comparative advantage and concludes that multiple indicators should be combined into a single measure through an unspecified weighting procedure. He points this out as the major unresolved drawback of the multiple indicator approach.

Meilke (2009) rejects Doyon's agricultural diversification, inflation rates, farm size, ratio of industrial to total egg sales, and hen to human population ratio indicators as theoretically inconsistent with comparative advantage. Cost of production is, according to Meilke, a replication of the availability and prices of major inputs indicator category, while the rate of lay, feed cost, and manufacturing wages, are "only weakly related to comparative advantage" (p. 20) in the sense that they reflect absolute rather than comparative advantage.

Our view is that Doyon's approach to measuring comparative advantage involves indirect and sometimes overlapping measures of average production costs. Three noteworthy exceptions are agricultural diversification, the hen to human population ratio and the ratio of industrial to total egg sales. The first of these three indicators, agricultural diversification, or the number of alternative agricultural activities that take place in a jurisdiction, does not reveal the extent to which different activities are profitable or otherwise advantageous for firms in that jurisdiction. Strong comparative advantage in wheat and grain production, and an agricultural sector specialized in these commodities, may not tell us anything useful about comparative advantage in egg or milk production. The hen to human population ratio and the ratio of industrial to total egg sales indicators can be affected by supply management administration and differences in preferences to the extent that renders them not indicative of the average production cost. For example, a high hen to human population ratio could, among other factors, be a consequence of a low egg output per hen or strong consumer preferences for eggs. In the first case, this indicator would be an indirect measure of a higher average production cost, but, in the latter case, there is no way to tell whether average production cost is high or low based on a high hen to human population ratio. Meilke (2009) provides a discussion on how the ratio of industrial to total eggs sales in a province is determined by supply-management agencies rather than production costs. The CPI is a partial indicator of increases in the average cost of production provided that the increases in the CPI are not dominated by other CPI components unrelated to farm input prices. Farm size is an indirect indicator of cost of production since larger farm sizes are sustained by increasing returns to size, which implies lower unit costs. When it comes to single factor productivity in the context of measurement of comparative advantage, the relevant role of productivity differences is their effect on opportunity costs, which is reflected in the average cost of production. Input prices, combined with input quantity data, are used in cost of production calculations. However, Doyon proposes cost of production as a separate indicator of comparative advantage. As was the case with the previously discussed indicators, average transportation cost fits into the average per unit production cost framework, on a c.i.f. basis.

While using average cost of production as a measure of comparative advantage can solve the problem of conflicting rankings of provinces under the multiple indicator approach, average production cost suffers from two related problems. First, as Buchanan (1969) and others have explained, production costs are endogenous with respect to output prices. Production costs rise to the level of product prices less a competitive margin. So higher prices set by administrative formulas, over time, put upward pressure on production costs, pressure that renders average production costs unreliable measures of comparative advantage.

Secondly, estimates of average production costs for supply managed commodities in Canada, when compared to farm prices, are difficult to reconcile with transactions in quota markets. The national average milk price paid by processors for the dairy year[3] 2010-2011 reported by the Canadian Dairy Information Centre (CDIC) (2012a) was $75.37 per hectolitre, while, according to the Canadian Dairy Commission (CDC) (2012) Cost of Production Survey, average farm level cost of production (including administrative, marketing and other levies and the return to labour and management) at the national level was $73.71 per hectolitre. The $1.66 per hectolitre margin between the milk price and the average cost of production can be used to purchase additional quota. Using this $1.66 per hectolitre margin (after the necessary measurement unit transformations[4]) in the standard formula for calculating dairy quota values (additional net revenue divided by a discount rate) with the range of discount rates for the Ontario dairy industry derived by Cairns and Meilke (2012) (8.6% to 10.4% per year), we obtain quota values that range from $1,957 to $1,618 per kg of butterfat per day. These values are in sharp contrast with the actual quota prices reported by the CDIC (2012b), which are in the range of $30,000 per kg of butterfat per day.

As an alternative to Doyon's approach, Katz et al (2008) proposed a modification of the Balassa index proposed by Bowen (1983, 1985, 1986), which they called the Revealed Output Advantage (ROA) index. Katz et al calculate the ROA index using the Canadian National Accounts sectoral output data as:

$$ROA_i = \frac{\frac{x_i}{G_i}}{\frac{x_R}{G_R}} \tag{1}$$

where

ROA_i is the Revealed Output Advantage index for province i,

x_i is the *Sectoral Gross Output for Agriculture*[5] in province i,

G_i is the *Total Goods Output* in province i,

x_R is the *Sectoral Gross Output for Agriculture* for all other provinces,

G_R is the *Total Goods Output* for all other provinces.

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[3] A dairy year is from August 1st to July 31st the following calendar year.

[4] Production quota is sold as a license to produce a certain quantity of milk butterfat per day. Since there are 3.6 kg of butterfat in a hectolitre of milk, adding a kilogram of butterfat per day in production quota is equivalent to adding 0.28 hectoliters of milk per day to the existing output or $0.45 per day to the net revenue.

[5] The variable names in italicized font are the original names used by Katz et al (2008).

The numerator of Equation (1) is the share of agriculture in the value of output for the goods sectors in province i. The denominator is the average share of agriculture in the value of output for the goods sectors in the remaining provinces. A province with an ROA index greater than 1 has a share of agriculture in the provincial value of output for the goods sectors greater than the national average. Katz et al view using the agricultural sector aggregate as an appropriate means of mitigating output and price distortions caused by the supply management system. Provinces with a higher ROA index compared to other provinces are said to have a higher degree of comparative advantage in the egg industry. Using this interpretation of the ROA index, Katz et al argue that Saskatchewan has the highest degree of comparative advantage in the production of eggs relative to all other provinces.

Sarker (2008), Mussell et al (2009) and Larue and Gervais (2008) raise several issues related to the degree of aggregation involved in calculating the ROA index. Sarker (2008) and Mussell et al (2009) point out that countries, regions or provinces with a small agricultural sector relative to the rest of their economy can still have a comparative advantage in some agricultural industries. Sarker argues that Canada has an overall comparative advantage in agriculture relative to New Zealand, while New Zealand has a comparative advantage in dairy production. As a remedy for output and price distortions caused by supply management, Sarker proposes calculating the ROA index using data from the period prior to supply management. But, in the case of the Canadian dairy industry, these data would be 40 years old.

Mussel et al (2009) demonstrate that the ROA index values depend on the choice of agricultural industries included in the x_i and x_R aggregates in Equation (1). They propose calculating the ROA index by using the percentage of the supply-managed industry in the provincial value of agricultural output. As pointed out by Bruneau and Schmitz (2009) and others, however, this measure would be biased because of the output distortions caused by supply management, and the approach would omit non-agricultural industries.

Larue and Gervais (2008) argue that the ROA index for provinces in which a larger share of the agricultural industry is supply managed is biased downward. According to Larue and Gervais, agricultural output in these provinces is constrained by the supply management policy more than in other provinces. From this, Larue and Gervais conclude that provinces with higher shares of supply managed industries would have lower ROA index values compared to the case in which this share is the same for all provinces because output controls under supply management limit aggregate production. While the point about output distortions leading to biased calculations is well taken, note that this effect would be ambiguous when industry size is measured in the dollar value of output rather than by physical units, since supply managed industries receive higher output prices.

Larue and Gervais (2008) suggest that an indicator called Domestic Resource Cost (DRC) index is potentially a better measure of comparative advantage than the ROA index. The suggested formula for calculating the DRC index for a commodity j in a province i is:

$$DRC_{ij} = \frac{\sum_{k=1}^{n} a_{ijk} r_{ik}}{p_{ij}^{*} - \sum_{k=n+1}^{K} a_{ijk} p_{ik}} \qquad (2)$$

where

a_{ijk} is the quantity of input k required to produce an additional unit of output j in province i,

r_{ik} is the undistorted price of input k in province i, where input k is assumed to be immobile across provinces,

p^*_{ij} is the undistorted price of commodity j in province i,

p_{ik} is the undistorted price of input k in province i, where input k is assumed to be mobile across provinces,

n is the number of immobile inputs, and

K is the total number of inputs.

The numerator in the above ratio is the cost of immobile inputs required to produce an additional unit of output j in province i. The denominator is the difference between the undistorted price of output and the cost of mobile inputs (at undistorted prices) required to produce and additional unit of that output in province i. Larue and Gervais interpret this difference as the domestic marginal value added by an additional unit of output j. They interpret the numerator in Equation (2) as the domestic opportunity cost of an additional unit of output j. If province i has a domestic value added that is higher than the domestic opportunity cost of an additional unit of output of good j, this province has a DRC index less than 1, and it is said to have a comparative advantage in good j. The lower is the provincial DRC index, according to this interpretation, the higher is the degree of provincial comparative advantage in good j.

Larue and Gervais hold the view that distortions in agricultural markets are pervasive and that, no matter how one accounts for these distortions, any actual DRC index calculations will inevitably embody an unknown degree of price distortion. This, in their view, weakens the reliability of this indicator to some extent but they still view the DRC index as at least as reliable as the ROA index because, they argue, unlike the ROA index, the DRC index is not affected by output distortions. They were unable to access the required data to make their approach operational, however. Larue and Gervais close their argument by offering guidelines on data sources and aggregation methods for potential future DRC index calculations based on provincial average input-output ratios. One of these guidelines is to assume Leontief (fixed proportion) aggregate production technology. Under this assumption, marginal and average physical products are equal for all inputs for all products and the provincial statistics on average input-output ratios can be used to calibrate the marginal input productivities in Equation (2).

A problem with using a fixed proportion aggregate technology is that this assumption is inconsistent with the generally observed incomplete specialization of countries and regions, that is, when a country or a region produces and imports the same commodity. Most of the comparative advantage literature since Ohlin's 1924 paper, including Stolper and Samuelson (1941), Jones (1957), Vanek (1963, 1968), Mussa (1978), Leamer (1992, 1995), and Copeland

and Taylor (2004), uses variable proportion technology to model incomplete specialization at the aggregate level. If the actual input-output relationship is a variable proportion relationship and the DRC index is calculated using average input productivities, these DRC indexes may be misleading. If we think that variable proportion technologies are generally the case, then we would have to abandon the DRC approach to measuring comparative advantage, unless we had access to detailed empirical information about farm level production functions.

COMPARATIVE ADVANTAGE AND QUOTA EXCANGE

Meilke (2009) suggests provincial quota prices as a more direct indicator of comparative advantage than the indicators proposed by Doyon (2007), Katz et al (2008) and Larue and Gervais (2008). Meilke's justification for this view is based on the idea that quota prices "show the present value of the discounted stream of benefits (valued at opportunity costs) producers expect to receive from buying production quota" (p. 18). While not disagreeing with Meilke, our view is that there is additional theoretical support for using quota prices, albeit quota prices adjusted for distortions in quota markets, as the measure of comparative advantage to guide allocation of additional quota among provinces. This theoretical support is derived from Hayek's (1945, 2002) insights into the knowledge transformation functions of market exchanges and competition.

Larue and Gervais (2008), however, reject quota prices as indicators of comparative advantage because, in their view, quota purchases in supply managed industries are "sector-specific [and] as such, quota values tend to reflect the absolute or competitive advantage of producers in a given province" (p. 14). According to this argument, the opportunity costs reflected in quota prices are industry-specific. This implies that quota purchase and sale decisions are shaped only by the opportunity costs within the supply managed industry.

Our view is that Larue and Gervais have imposed an arbitrary segmentation on the investment decisions of dairy farmers. Prospective quota buyers and sellers have no reason to limit their asset purchasing and selling decisions to opportunities in their supply managed industries. The funds used to purchase additional quota could have been used to purchase land or other real or financial assets. And sellers may or may not invest the proceeds from quota sales in assets specific to the dairy industry. So investment opportunities in other industries and sectors are always available to dairy farmers. This means that quota buyers expect greater benefits from buying quota than, say, buying an asset or lending money to an entrepreneur in some other industry. But the foregone returns in this wide range of assets represent the opportunity cost of investment in additional quota. For the seller, the advantage of continuing to own quota is outweighed by the perceived opportunities made available by the liquidation of his or her holdings. And sellers of quota may make their sales decision based on their expectations of investment returns for a range of assets.

Appreciating quota selling and purchasing decisions in this light also makes it clear that that quota prices are categorically different from the previously proposed indirect indicators of comparative advantage. Quota prices are a direct outcome of exchanges among producers. These exchanges are governed by the opportunity costs of alternative uses of resources. Quota prices represent demonstrated preferences (see Rothbard, 1956) of producers. Since individual preferences are subjective and not directly observable by others, quota prices are the only indicator that transforms otherwise unobservable, subjective underlying economic information on comparative advantage into an objectively observable form.

A General Equilibrium Illustration of Quota Exchange

To illustrate how quota exchanges and quota prices depend on the marginal evaluations of alternative opportunities in a supply managed industry relative to an alternative industry, we have developed an agent-based general equilibrium model. While we focus primarily on the role of quota exchange in the adjustments to a temporary disequilibrium, let us first describe the initial equilibrium.

There are two goods, food and clothing, produced by n individuals with convex preferences who own equal quantities of a natural resource and human capital. Each individual uses a fixed proportion production technology to transform the natural resource into food and clothing. The natural resource and individual human capital vary in quality. This variation in quality gives rise to differences in individual productivity in the two goods and therefore the slopes of linear individual production possibilities frontiers in the food-clothing space vary from individual to individual. In exchange equilibrium, individuals specialize in either of the two goods and exchange surplus output. By construction, the equilibrium exchange ratio between food and clothing equates the sum of individual quantities of food and clothing supplied and demanded and each individual is no worse off compared to being self-sufficient in both goods.

In the remaining analysis, we focus on three individuals and assume that the production possibilities and the preferences of the remaining n – 3 individuals remain unchanged. The rationale for this approach is to simplify the analysis of quota exchange. However, as we will show in the following exposition, the result about the function of quota exchange in revealing changes in individual production possibilities can be generalized to any number of individuals. Figure 1 shows three diagrams in the food-clothing space representing the production and consumption decisions of two producers of food, Smith and Jones, and one producer of clothing, Hicks, in market-clearing equilibrium. The bold solid downward sloping lines connecting the axes in each diagram represent the production possibilities frontiers for the three individuals. The slope of the line P (i.e., the price line) represents the market clearing exchange ratio between food and clothing. The preferences of the three individuals are represented by the indifference curves, U_S^0, U_J^0 and U_H^0.

Smith produces A_S units of food and exchanges $A_S G_S$ units for H_S units of clothing, while Jones produces A_J units of food and exchanges $A_J G_J$ units for H_J units of clothing. Hicks, on the other hand, produces D_H units of clothing and exchanges $D_H H_H$ units for G_H units of food. The slope of each individual's production possibilities frontier represents the trade-off between food and clothing measured in units of food that each individual would need to give up in order to produce an additional unit of clothing if he were self-sufficient in both goods. For Smith and Jones, this trade off is higher than the market price. This means they can obtain more clothing per unit of food through market exchange than if they tried to produce their own clothing. For, Hicks, however, this trade off is identical to the market price by construction. Hicks is thus

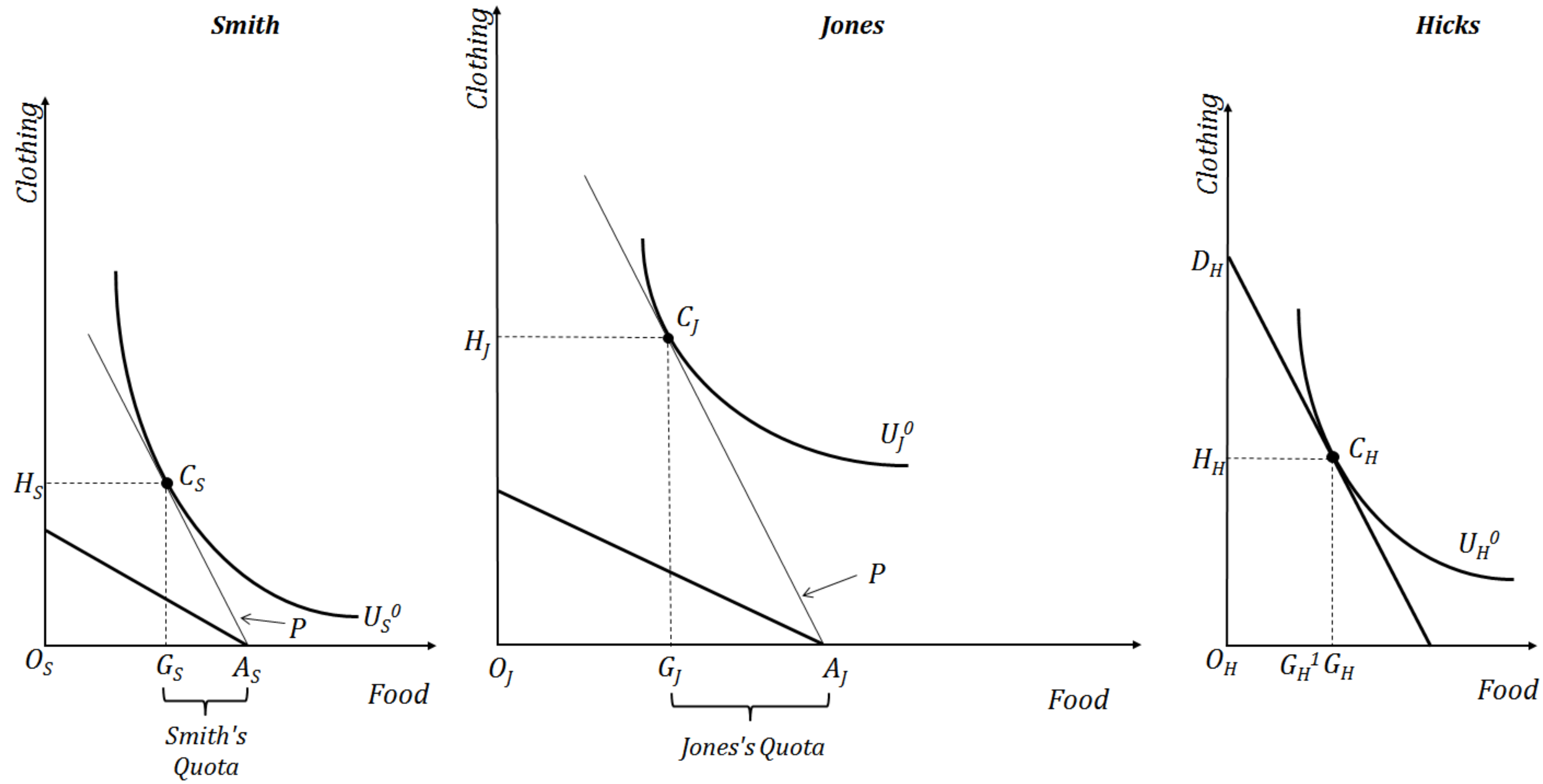


Figure 1. Individual specialization and consumption decisions in a two-good, general equilibrium model of individual comparative advantage

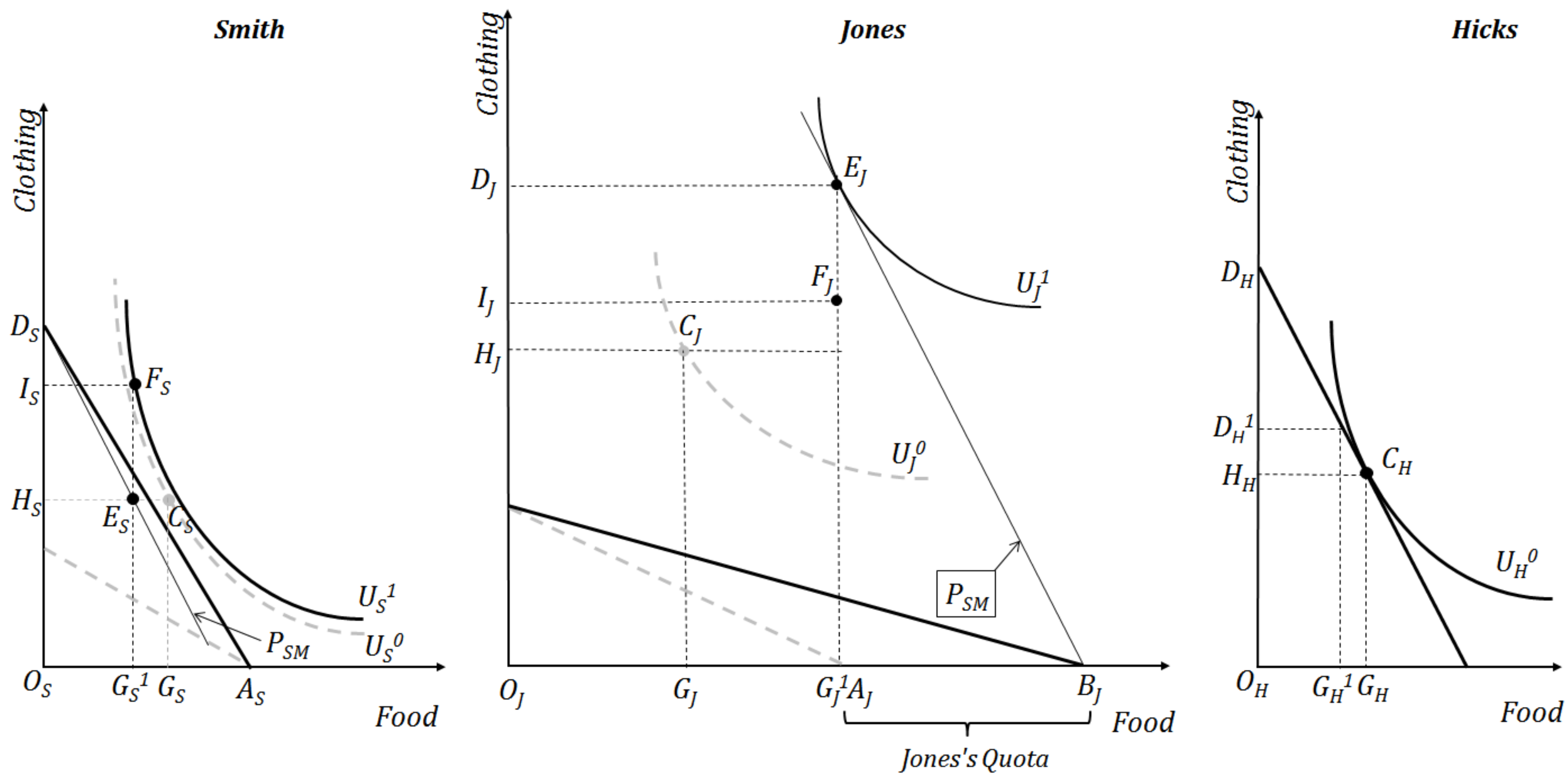
indifferent between specializing in either of the two goods and self-sufficiency. By assumption, Hicks specializes in clothing, which makes him a marginal producer of clothing. This outcome can be interpreted as Smith and Jones having a comparative advantage in food relative to Hicks, and Hicks having a comparative advantage in clothing relative to Smith and Jones.

Next, a quota system in food production is set up so that each individual's quota level is identical to the prior quantity of food supplied by that individual. Under this system, no food producer is allowed to increase his or her food supply on the market without an equal decrease in food supply by someone else. This means that Smith and Jones are not allowed to sell more than $A_S G_S$ and $A_J G_J$ units of food, respectively, unless someone else is willing to reduce his or her own quantity of food supplied. As a result, the pre-existing market-clearing equilibrium price is set as the price under the quota system.

Figure 2 illustrates the effect of changes in individual production possibilities on the decision to buy or sell production quota. Suppose that Jones discovers a new way of using his natural resource and human capital in the production of food. This increases the productivity of the portion of his inputs used in the production of food at any given level of clothing. This increase is represented by the pivotal shift of Jones's production possibilities frontier from point A_J to point B_J. This shift reduces the slope of Jones's production possibilities frontier, which means that the quantity of food he needs to forego to obtain a unit of clothing by reallocating his own resources is larger than prior to the shift. This can be interpreted as an increase in the opportunity cost of switching from food to clothing for Jones or as an increase in his comparative advantage in food.

Suppose also that Smith discovers a new way of using his natural resource and human capital in the production of clothing, thus increasing the potential productivity of the portion of Smith's inputs used in the production of clothing for any given output level of food. This increase is represented by the pivotal shift of Smith's production possibilities frontier to the point D_S. This shift increases the slope of Smith's production possibilities frontier, which means that, if he were to reallocate his own resources into the production of clothing, he could obtain a greater quantity of clothing per unit of food than prior to the shift. This can be interpreted as a decline in the opportunity cost of switching from food to clothing for Smith or as a decline in his comparative advantage in food. Hicks's production possibilities did not change.

The Figure indicates that both Smith and Jones would be better off if Smith sold his food quota holding, $A_S G_S$, to Jones in exchange for $D_J I_J$ units of clothing. Jones could then expand his food output to B_J and exchange $B_J G_J^1$ units of food for D_J units of clothing. Of these D_J units of clothing, Jones uses $D_J I_J$ units for purchasing Smith's quota. As a result, Jones's consumption bundle expands from C_J to F_J, to a higher indifference curve, U_j^1, relative to his initial indifference curve, U_j^0. Smith would, in turn, switch from food to clothing, produce D_S units of clothing, exchange $D_S H_S$ units at the current food price for G_S^1 units of food and collect quota payment $I_S H_S$ from Jones. As a result, Smith acquires a consumption bundle above the initial indifference curve, U_S^0. The G_S^1 units of food that Smith now buys instead of producing them are made possible by the increase in Jones' supply of food, $B_J G_J^1 - G_J A_J$. By construction, this increase in Jones's supply of food is equal to the amount of quota previously held by Smith,



$A_S G_S = A_J B_J - B_J G_J$

$O_S G_S^1 = O_H G_H^1$

$D_S H_S = D_H D_H^1$

$D_H D_H^1 = D_J H_J$

$I_S H_S = D_J I_J$

Changes in Quantities Supplied and Demanded

	Food		Clothing	
	Supply	Demand	Supply	Demand
Smith	$-A_S G_S$	$O_S G_S^1$	$D_S H_S$	$-D_S H_S$
Jones	$A_J B_J - B_J G_J$	0	0	$D_J H_J$
Hicks	0	$-O_H G_H^1$	$-D_H D_H^1$	0
Net	0	0	0	0

Figure 2. Quota exchange as a consequence of changes in individual production possibilities in a two-good model of individual comparative advantage

$A_S G_S$. This maintains the total amount of quota unchanged. Jones's increased demand for clothing, $D_J H_J$, is met by Smith's supply of clothing. However, at the market level, there is still excess demand for food because Smith is not supplying $A_S G_S$ units of food anymore. Similarly, there is excess supply of clothing because Smith is not buying H_S units of clothing anymore. Since the slope of Hicks' production possibilities frontier by construction coincides with the slope of the price line, P_{SM}, the excess supply of clothing and the excess demand for food can be brought to zero if Hicks, as a marginal producer of clothing and a marginal consumer of food, reduces his output of clothing from D_H to D_H^1 along his production possibilities frontier. [6] This also reduces Hicks's demand for food by $O_H G_H^1$, which offsets the excess demand for food, $A_S G_S$.[7] As a result of this exchange, Smith sold $A_S G_S$ units of food quota at a per unit price of $\frac{D_J I_J}{A_S G_S}$ units of clothing. Similarly, Jones bought $A_S G_S$ units of food quota at the said price, and Hicks diversified into producing both food and clothing.

This illustration shows the link between changes in individual production possibilities and quota exchange in a hypothetical context. Quota exchange makes it possible for individuals to adjust their production decisions to their newly discovered production possibilities. These newly discovered production possibilities changed the degree of Smith's and Jones's comparative advantage in food. The degree of Jones's comparative advantage in food increased and this provided the motivation for him to buy additional quota. Smith, on the other hand, experienced a decline in his comparative advantage in food, which provided the incentives for him to sell quota and switch to producing clothing. Thus, the resulting quota price is the direct outcome of the underlying change in the comparative advantage of the quota buyer, Jones, and the seller, Smith.

In this hypothetical context, all relevant underlying economic information is assumed to be given to everyone. To gain appreciation of the informational content of quota prices in actual quota markets, let us recall Hayek's (1945, 2002) ideas that, in reality, prices reflect otherwise unobservable individual knowledge and that this knowledge is discovered through competition as a process. In the context of quota exchange, this knowledge refers to production possibilities and preferences of each individual. Each individual knows his or her production possibilities and preferences but this knowledge is not directly available to others. Thus, the purpose of offering a bid to buy quota in actual markets is a means of discovering the seller's and other potential buyers' production possibilities and preferences. This means that quota prices discovered through a competitive process represent transformation of subjective, time- and place-specific knowledge of the individuals participating in the exchange (including the observers that choose not to enter the exchange) into objective knowledge available to others.

These insights imply that the most direct method of applying the principle of comparative advantage to allocating additional quota to provinces is offering quota at an auction

[6] An alternative way of clearing the excess demand for food and the excess supply of clothing is that the supply management authority changes the exchange ratio between food and clothing so that more clothing is exchanged for a unit of food. However, modeling this scenario requires specifying production possibilities and preferences for all n individuals, and this goes beyond the intended purpose of this illustration.

[7] Note that, at this point, Hicks is not fully specialized because he produces G_H^1units of food and D_H^1 units of clothing, but, since he is a net buyer of food, he does not supply food on the market and does not need to acquire production quota.

open to producers from all provinces. However, considering the historical experience with interprovincial quota markets[8], this method may meet formidable political hurdles. In this case, we propose using provincial quota prices as indicators for guiding the allocation of new quota.

ALLOCATING NEW QUOTA USING QUOTA PRICES

Adjusting Quota Prices for Policy Distortions in Quota Markets

There are important institutional aspects of quota markets that need to be taken into account if we are to use actual historical quota prices as meaningful measures of comparative advantage. In addition to differences in underlying production possibilities and preferences, quota prices may reflect differences in the policies set by provincial supply management marketing boards. In the dairy industry, the quantity of the provincial fluid milk quota is under the jurisdiction of provincial marketing boards while the industrial milk quota is under the national jurisdiction. The provincial boards have some control over provincial quota prices indirectly by controlling the provincial milk prices and the quantity of provincial fluid milk quota. In addition, both provincial and national milk supply management authorities price-discriminate between raw milk classes based of the end product.[9] Depending on the utilization ratios of different milk classes, this can result in different milk prices received by farmers in different provinces. For example, according the CDIC (2012a), average gross[10] farm gate prices in the 2010-2011 dairy year ranged between $73.48 per hectolitre in Quebec and an average of $78.46 per hectolitre in the Atlantic Provinces. If quota buyers and sellers in different provinces face different farm gate prices for their output, some differences in quota prices might arise. As such quota price differences are a result of interplay between the supply management policy and the underlying production possibilities and preferences, calculations of comparative advantage based on quota prices should account for these policy effects.

Provincial marketing boards also have imposed restrictions on quota exchanges. Katz et al (2008), quoting Rosaasen et al (1995), argue that poultry quota prices in Saskatchewan and Manitoba may be lower than they would otherwise have been because quota could historically only be bought and sold together with other assets, not as a separate asset. This, however, no longer seems to be the case for poultry quota in these two provinces. According to the Order 55/11 by the Chicken Farmers of Saskatchewan on chicken quota transfers under the Saskatchewan Agri-Food Act (2004), and according to the Saskatchewan Chicken Marketing Plan Regulations (2011), quota exchange is not conditional on the exchange of assets. No such restrictions can be found in the Manitoba Chicken Broilers Quota Order (2006) either. The prices and quantities of broiler and hen quota exchanged are made publicly available by the Manitoba Chicken Producers (2012). However, to the extent to which exchange of quota was linked to exchange of other assets in the past, this would have had an impact on observed quota

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[8] The Dairy Farmers of Ontario (DFO) (2012) reports that Ontario withdrew from an interprovincial quota exchange program with Quebec and Nova Scotia six months after the program's inception in September 1997. Larue (2012) reports that there is currently no interprovincial quota exchange in the supply managed industries.

[9] Raw milk used for the production of, say, cheese is priced differently than the milk used in the production of skim milk.

[10] Marketing fees charged by the provincial boards are not subtracted from these farm gate prices.

prices in the relevant jurisdictions. Although there are no ties of milk quota exchange to other assets in the dairy industry, it has its own restrictive policies. In 2009, the milk marketing boards in Ontario and Quebec imposed milk quota price ceilings of $25,000 per kg of butterfat per day.[11]

Lending conditions may also affect quota prices if quota purchases are financed by borrowing money. Rosaasen et al (1995) reported that the Farm Credit Corporation (FCC) accepted quota as loan security in Quebec but not in Saskatchewan. Katz et al (2008) assert that this has raised prices of supply management quota in Quebec. More recent data by Agricultural Law NetLetter (2011) show that using broiler quota as security for FCC loans is currently a common practice in Saskatchewan. In addition, other financial institutions with nation-wide branches, like TD Canada Trust (2012), report accepting supply management quota as security for loans. This indicates that there has been a general equalization trend in the borrowing opportunities across provinces. In addition, since more recent prices reflect the current economic conditions better than the prices further in the past, using more recent quota prices, with the exception of the currently capped dairy quota prices in Ontario and Quebec, would produce more reliable calculations of comparative advantage.

We will now illustrate how provincial quota prices can be used to calculate provincial over-base quota allocations for the dairy industry. First, we describe the adjustments to take into account interprovincial differences in milk prices and provincial quota price ceilings.

Accounting for Interprovincial Differences in Administered Milk Prices

To account for interprovincial variation in milk prices paid to farmers by the supply management marketing boards, we use the standard formula used by Moschini and Meilke (1988) and others for the maximum price a quota buyer would be willing to pay for quota:

$$V(R,\delta) = \frac{R}{\delta} \tag{3}$$

where

V is the price per unit of milk production quota,

R is the annual return on an additional unit of milk production quota,

δ is the discount rate.

[11] Doyon et al (2010) proposed an implementation of a truncated k-double auction instead of price ceilings as means of reducing quota prices in supply managed industries. The major feature of a truncated k-double auction described by Doyon et al (2010) is that it prevents the highest bidders from buying quota while making it possible for the lowest bidders to acquire quota when there is excess demand for quota. As with the effects of output prices on quota prices, calculations of provincial comparative advantage need to account for distortions from price ceilings or a potential implementation of a truncated k-double auction in some provinces.

Moschini (1988) estimates R to be about $0.15P_m$, where P_m is the raw milk price. To generalize, let R be αP_m, where α can vary between 0 and 1. Let there be two provinces with milk prices P_{m_1} and P_{m_2}, discount rates, δ_1 and δ_2, and the coefficients on the annual return on a unit of milk quota α_1 and α_2. The quota prices in province 1 and province 2 are V_1 and V_2, respectively. If $P_{m_2} = \beta P_{m_1}$, where β is any positive real number, the quota price in province 2 under the milk price P_{m_1}, $V_2(\alpha_2, P_{m_1}, \delta_2)$, is:

$$V_2^1(\alpha_2, P_{m_1}, \delta_2) = \frac{\alpha_2 P_{m_1}}{\delta_2} = \frac{V_2}{\beta} \tag{4}$$

The quota price $\frac{V_2}{\beta}$ is the maximum price of quota that a buyer in province 2 would be willing to pay if he or she was facing the milk price from province 1, P_{m_1}.[12] Thus, to get an estimate of the quota price in province 2 under identical milk prices in both provinces, the quota price in province 2 needs to be divided by β, which is the ratio of milk prices in the two provinces, $\frac{P_{m_2}}{P_{m_1}}$.

Accounting for Quota Price Ceilings

One potential method of accounting for quota price ceilings in Ontario and Quebec is to assume that the pre-ceiling price would not have changed over time in the absence of the ceiling.[13] An alternative method that would potentially account for some of the underlying economic changes that had their origin in the preceding years is to assume that the pre-ceiling price time trend would have continued in the absence of the ceiling. We use the latter method and first estimate a linear OLS regression using pre-ceiling quota prices:

$$V_t = c + \mu Y_t + \varepsilon \tag{5}$$

where V_t is quota price in year t, Y_t is year t, c and μ are regression coefficients, and ε is the error term. Then, using the estimated regression coefficients, we calculate the fitted quota prices for the post-ceiling years.

Calculating Provincial Over-base Quota Shares

Here we present two prototype methods of translating provincial quota prices, adjusted for differences in farm gate milk prices and quota price ceilings, into shares of new national yearly over-base quota: (1) Quota Price Ratio (QPR) method and (2) Quota Price Difference Ratio (QPDR) method. The first method uses the ratios of adjusted provincial quota prices while the second method uses the ratios of interprovincial price differences as the allocation criterion. These two methods are by no means exhaustive. Their main purpose is to serve as illustrations of how quota prices could be used to allocate over-base quota. Both methods preserve the

[12] Note here that we are not adjusting quota prices for differences in the annual return on a unit of quota, R, and the discount rate, δ. These variables are algebraic representations of the time- and place-specific, subjective elements of individual knowledge directly related to individual comparative advantage. These elements of individual knowledge are not directly available to others but are reflected in quota prices.

[13] The most recent quota prices before the price ceilings were imposed are from 2008.

original ranking of provinces set by the adjusted provincial quota prices. This leaves space to the political authorities for choosing the preferred method based on other criteria they may find relevant.

Quota Price Ratio (QPR) Method

If there are N provinces, and V_i and V_j are quota prices for provinces i and j, adjusted for quota price ceilings and for variations in the administered provincial milk prices, the respective provincial shares, S_i and S_j, of the national over-base quota allocation under the QPR method are determined by:

$$\frac{S_i}{S_j} = \frac{V_i}{V_j} \tag{6}$$

and

$$S_i + S_j + \ ... + S_N = 1 \tag{7}$$

Equation (6) states that the provincial shares in the national over-base quota allocation are proportional to the adjusted provincial quota prices. A province with a higher price compared to another province will have a higher share in the total over-base quota allocation. Substituting Equation (7) into Equation (6) yields Equation (8)

$$S_i = \frac{V_i}{V_i + V_j + \ ... + V_N} = \frac{V_i}{N\bar{V}} \tag{8}$$

where

$\bar{V}$ is the average quota price across all N provinces.

Equation (8) states that each province's share in the national over-base quota allocation is equal to the respective province's share in the sum of all provincial quota prices. For provinces in which the adjusted price of quota is equal to the national average, the provincial share S_i will be $1/_N$. For provinces in which the adjusted quota price is higher (lower) than the national average, the provincial share will be larger (smaller) than $1/_N$.

To illustrate this, suppose that there are three provinces, A, B, and C, and the respective provincial quota prices are $30,000, $25,000 and $20,000 per kg of butterfat per day, respectively. The respective over-base quota shares of provinces A, B, and C, calculated using Equation (8) would be 0.40, 0.33, and 0.26. The average interprovincial price is $25,000 per kg of butterfat per day, and the number of provinces, N, is 3. In this case $1/_N$ is 0.33, which is also the quota share of province B, in which quota price is equal to the interprovincial average price. The quota price in province A is above the interprovincial average. Consequently, the quota share for province A is greater than 0.33. The opposite applies for province C.

Quota Price Difference Ratio (QPDR) Method

If there are N provinces, and V_i and V_j are the adjusted quota prices for provinces i and j, the respective provincial shares, S_i^- and S_j^-, in the national over-base quota allocation under the QPDR method are determined by:

$$\frac{S_i^-}{S_j^-} = \frac{V_i - V_l}{V_j - V_l} \tag{9}$$

and

$$S_i^- + S_j^- + \ ... + S_N^- = 1 \tag{10}$$

where

V_l is the lowest adjusted quota price across all provinces.

Equation (9) sets the ratio of provincial shares in the national over-base quota allocation equal to the ratio of the respective differences between each province's quota price and the lowest provincial price. Substituting Equation (10) into Equation (9) yields Equation (11).

$$S_i^- = \frac{V_i - V_l}{(V_i + V_j + \ ... + V_N) - NV_l} = \frac{V_i - V_l}{N\bar{V} - NV_l} \tag{11}$$

Compared to the QPR method, the QPDR method puts more weight on the provinces with the highest prices. This can be verified by setting $S_i = S_i^-$, which is equivalent to Equation (12):

$$\frac{V_i}{N\bar{V}} = \frac{V_i - V_l}{N\bar{V} - NV_l} \tag{12}$$

Equation (12) can be reduced to Equation (13):

$$V_i = \bar{V} \tag{13}$$

Equation (13) states that the provincial shares calculated using QPR method and QPDR method are equal for provinces in which the quota price, V_i, equals the national average price, $\bar{V}$. For $V_i > \bar{V}$, S_i is greater than S_i^-, and for $V_i < \bar{V}$, S_i is less than S_i^-. In other words, compared to the QPR method, provinces with adjusted quota prices above the national average receive a higher share of national over-base quota if the QPDR method is used. Similarly, provinces with below-average adjusted quota prices get a smaller share of the national over-base quota under the QPDR method compared to the QPR method. Under the QPDR method, no additional quota is allocated to the province with the lowest quota price.

To illustrate this, consider the previous 3-province example. Province C has the lowest adjusted quota price, \$20,000 per kg of butterfat per day. Thus, V_l is \$20,000 per kg of butterfat per day, and province C does not receive any over-base quota. The share received by province A, which has an above-average quota price, is 0.66. This is higher compared to the share for province A under the QPR method (0.40). The quota share for the province with quota price equal to the interprovincial average, province B, remained 0.33, the same as under the QPR method.

Calculated Provincial Quota Shares

Table 2 summarizes the calculated over-base quota shares for the 2010-2011 dairy year for Canadian provinces, excluding Newfoundland[14], under the QPR method and the QPDR method. The Table also lists the actual provincial shares in the national quota increase for 2009-2010 and 2010-2011 calculated using the total provincial yearly quota data reported by Agriculture and Agri-Food Canada (AAFC) (2011, 2012). In addition, the Table shows provincial shares based on the Revealed Output Advantage Index suggested by Katz et al (2008).

The first row in Table 2 shows provincial milk prices for the dairy year 2010-2011. We calculated the milk prices for British Columbia, Alberta, Saskatchewan, Ontario, Quebec, New Brunswick and Nova Scotia as the sum of milk component prices (protein, butterfat, and other solids), reported either by the provincial marketing boards or the provincial ministries of agriculture, weighted by the content of each component in a standard hectolitre[15] of milk. The farmer component prices for Manitoba and Prince Edward Island were not publicly available, so we used the milk component prices paid by processors for different milk classes[16] reported by the CDIC (2012a) weighted by the utilization shares for the respective milk classes. The second row lists the (simple) average of the monthly quota prices reported by the CDIC (2012b) for the dairy year 2010-2011 for all provinces except for the provinces with quota price ceilings, Ontario and Quebec. For these two provinces, we used a linear projection of the quota prices (converted to 2011 dollars) for dairy years 2003-2004 through 2007-2008[17] reported by the CDIC (2012b). Appendix A shows the graphical representation of these data, their linear projections and reports the estimated regression equations for the two linear projections. The third row shows the adjustment factor, P_{m_i}/P_{m_l}, where P_{m_i} is the provincial milk price net of marketing board levies[18], and P_l is the lowest net price across all provinces. The lowest net milk price was in Ontario—\$66.72 per standard hectolitre. Manitoba and British Columbia had the highest prices—\$73.52 and \$72.76 per standard hectolitre, respectively. Thus, these are the provinces with the highest adjustment factor among all provinces, 1.10 and 1.09, respectively. The adjusted quota prices, V_i, shown in the fourth row of Table 2, were calculated by dividing the

[14] The data for Newfoundland were not reported in the CDIC data set.
[15] The standard hectolitre contains 3.6000 kg of butterfat, 3.2326 kg of protein and 5.6851 kg of other solids.
[16] Each of the three milk components can be used either as industrial or fluid milk. Industrial milk is divided into four classes based on the end product.
[17] This is the period in which the rise in quota prices in both provinces slowed down compared to earlier years. Thus, using the prices prior to 2003-2004 for linear extrapolation may overstate the potential prices in 2010-2011.
[18] Appendix B lists the components of the provincial marketing levies obtained from the provincial marketing boards. The Appendix also lists the assumptions used to estimate the components for which data were not available

Table 2. Provincial over-base quota allocations for 2010-2011 calculated using the Quota Price Ratio Method, the Quota Price Difference Ratio Method, the Revealed Output Advantage Index, and the actual 2009-2010 and 2010-2011 allocation

	BC	AB	SK	MB	ON[a]	QC[a]	NB	NS	PE
2010-2011 Quota Price Adjusted for Quota Price Ceilings ($/kg butterfat/day)[b]	39,063	36,713	26,653	29,491	33,015	27,711	27,399	27,317	27,375
2010-2011 Net Milk Price (P_{m_i}) ($/hl)[c]	73.52	68.83	70.43	72.76	66.72	67.14	70.29	67.53	70.55
Milk Price Adjustment Factor (P_{m_i}/P_{m_l})	1.10	1.03	1.06	1.09	1.00	1.01	1.05	1.01	1.06
Quota Price Adjusted for Quota Price Ceilings and Milk Price Variations (V_i) ($/kg butterfat/day)	35,452	35,588	25,250	27,044	33,015	27,538	26,009	26,992	25,890
$V_i - V_l$ ($/kg butterfat/day)	10,202	10,338	0	1,794	7,765	2,288	759	1,742	640
	Provincial Quota Share (% of national over-base allocation)								
Quota Price Ratio (QPR) Method	13.49	13.54	9.61	10.29	12.56	10.48	9.90	10.27	9.85
Quota Price Difference Ratio (QPDR) Method	28.71	29.10	0.00	5.05	21.86	6.44	2.14	4.90	1.80
2009-2010 Actual Allocation	2.37	1.58	0.00	0.00	31.09	59.47	2.11	2.11	3.42
2010-2011 Actual Allocation	11.11	29.22	0.00	0.00	25.11	29.11	1.33	1.78	1.00
Revealed Output Advantage (ROA) Index Method	3.32	6.46	29.01	17.92	3.44	6.12	4.68	3.75	24.27

Sources: Agriculture and Agri-Food Canada (AAFC) (2011, 2012), Bank of Canada (2012), Canadian Dairy Information Centre (CDIC) (2012a, 2012b), British Columbia Milk Marketing Board (2011), Alberta Milk (2011a), Saskatchewan Milk Marketing Board (2011), Dairy Farmers of Ontario (2011), Fédération des producteurs de lait du Québec (2010), Dairy Farmers of New Brunswick (2011) and Dairy Farmers of Nova Scotia (2011); Katz et al (2008).

[a]For Ontario and Quebec, linear projections of the 2003-2004 to 2007-2008 (real, 2011 dollars) quota prices were used. We used the average Canadian 2001 – 2011 quarterly CPI increase (2.1%) reported by the Bank of Canada as the discount factor for converting the nominal into real prices.

[b]The quota prices for the dairy year 2010-2011 is the (simple) average of the monthly prices reported by the CDIC.

[c]The net milk prices in provinces other than Manitoba and Prince Edward Island were calculated using farmer component prices as reported in April 2011. The milk prices for Manitoba and prince Edward Island were calculated using the CDIC reported prices paid by processors for different milk classes and components weighted by the utilization shares for the respective milk classes.

quota prices in the first row with the respective adjustment factors, P_{m_i}/P_{m_l}, for each province. Saskatchewan had the lowest adjusted quota price, $25,250 per kg of butterfat per day, while Alberta and British Columbia had the highest adjusted quota prices, $35,452 and $35,588 per kg of butterfat per day, respectively. Ontario was next with a price of $33,015 per kg of butterfat per day, followed by Quebec, Manitoba, Nova Scotia, New Brunswick, and Prince Edward Island, with prices ranging between $27,538 and $25,890 per kg of butterfat per day. The difference between the adjusted quota price in each province, V_i, and the lowest adjusted quota price, across all provinces, V_l, is in the fifth row of Table 2.

As described by Equations (6) through (11), the relative magnitudes of the adjusted quota prices determine each province's quota share in the total national over-base quota allocation. Compared to the QPR method, the QPDR method puts more weight on the provinces with high adjusted quota prices. For example, under the QPR method, the shares of the total national over-base quota going to the provinces with the highest adjusted quota prices, British Columbia and Alberta are around 13%. Under the QPDR method, the respective shares are almost 30%. On the other hand, the provinces with the lowest adjusted quota prices, Saskatchewan and Prince Edward Island, receive slightly under 10% of the national over-base quota allocation under the QPR method. But, under the QPDR method, these two provinces receive only 1.80% and 0%, respectively.

The actual shares of the national quota increase for the dairy year 2009-2010 received by provinces stand in sharp contrast with the ones calculated using the QPDR method. Quebec received almost 60% of the national quota increase. Ontario received about 31%, while none of the remaining provinces received more than 4% of this additional quota. In contrast, Ontario and Quebec together would have received only about 26% of the national over-base quota under the QPDR method. However, the shares of new quota received by British Columbia and Alberta for the dairy year 2010-2011 were 11.11% and 29.22%, respectively. Ontario and Quebec received 25.11% and 29.11% of the new quota, respectively. The Atlantic Provinces' shares were in the range of 1% to 2%, while Manitoba and Saskatchewan did not receive any additional quota. These numbers indicate that the actual quota increase across provinces for 2010-2011 resemble, to some extent, the shares derived using our QPDR method for that year.

The shares calculated using the ROA index method of allocating over-base quota suggested by Katz et al (2008) are shown in the last row. This method puts most emphasis on the provinces with relatively high shares of agriculture in the value of output for the goods sectors. For example, Saskatchewan would receive 30.5% of the national over-base quota under this allocation method. Prince Edward Island would end up with 20.5% and Manitoba would get 19.9% of the national quota increase, while Alberta and British Columbia would receive about 9.5% and 4.6%, respectively. This indicates that the ROA index does not match either of the two potential allocation methods we proposed. Moreover, the ROA index method does not corresponded with the actual allocation of new quota for 2010-2011.

CONCLUSIONS

The objective of this paper was to review and evaluate proposed indicators of comparative advantage for industries regulated under supply management. We conclude that, superficial impressions to the contrary, several leading proposed methods for measuring comparative advantage in these industries represent proxy approaches for average cost of production. We further argue that cost of production, whether measured directly or by proxy, is an unreliable indicator of comparative advantage when output prices are set by an administrative formula and production is allocated among firms through production quotas. We defend Meilke's proposal that quota prices are a more reliable indicator of comparative advantage under this type of policy regime, subject to some important adjustments to historical quota prices required by the policy-imposed constraints on the operations of quota exchanges.

In addition to defending Meilke's proposal for using quota prices as indicators of comparative advantage in supply managed industries, we provide a more fully articulated theoretical foundation for this proposal, using an agent-based general equilibrium model of quota exchange. This model shows (1) how quota exchange facilitates the implementation of changes in individual comparative advantage in supply managed industries and (2) that quota prices reveal otherwise unobservable underlying valuations and production possibilities of quota buyers and sellers. As such, quota prices are the only direct measures of comparative advantage in supply managed industries.

We demonstrate the practical application of quota prices as indicators of comparative advantage by using two prototype methods for calculating provincial shares of additional quota based on the 2010-2011 quota prices. We account for the effect of provincial farm gate output pricing policies on quota prices by using well established economic theory and extrapolate the most recent quota prices in Ontario and Quebec to account for the quota price ceilings in these provinces.

The potential practical challenges with using quota prices as indicators of comparative advantage stem from the effect of differences in provincial output and quota pricing policies on provincial quota prices. By removing elements of information on comparative advantage contained in quota prices, restrictions on quota exchange are implicitly in conflict with the legal requirement of using comparative advantage as a guide for allocating new quota. Putting more emphasis on quota prices in provincial quota allocation may mitigate these challenges and provide stronger incentives to provincial marketing boards for loosening restrictions on quota exchange. This suggests that using quota prices as indicators of provincial comparative advantage in supply managed industries has the theoretical basis and the practical potential of meeting the requirements of the Canadian Farm Products Agencies Act.

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APPENDIX A

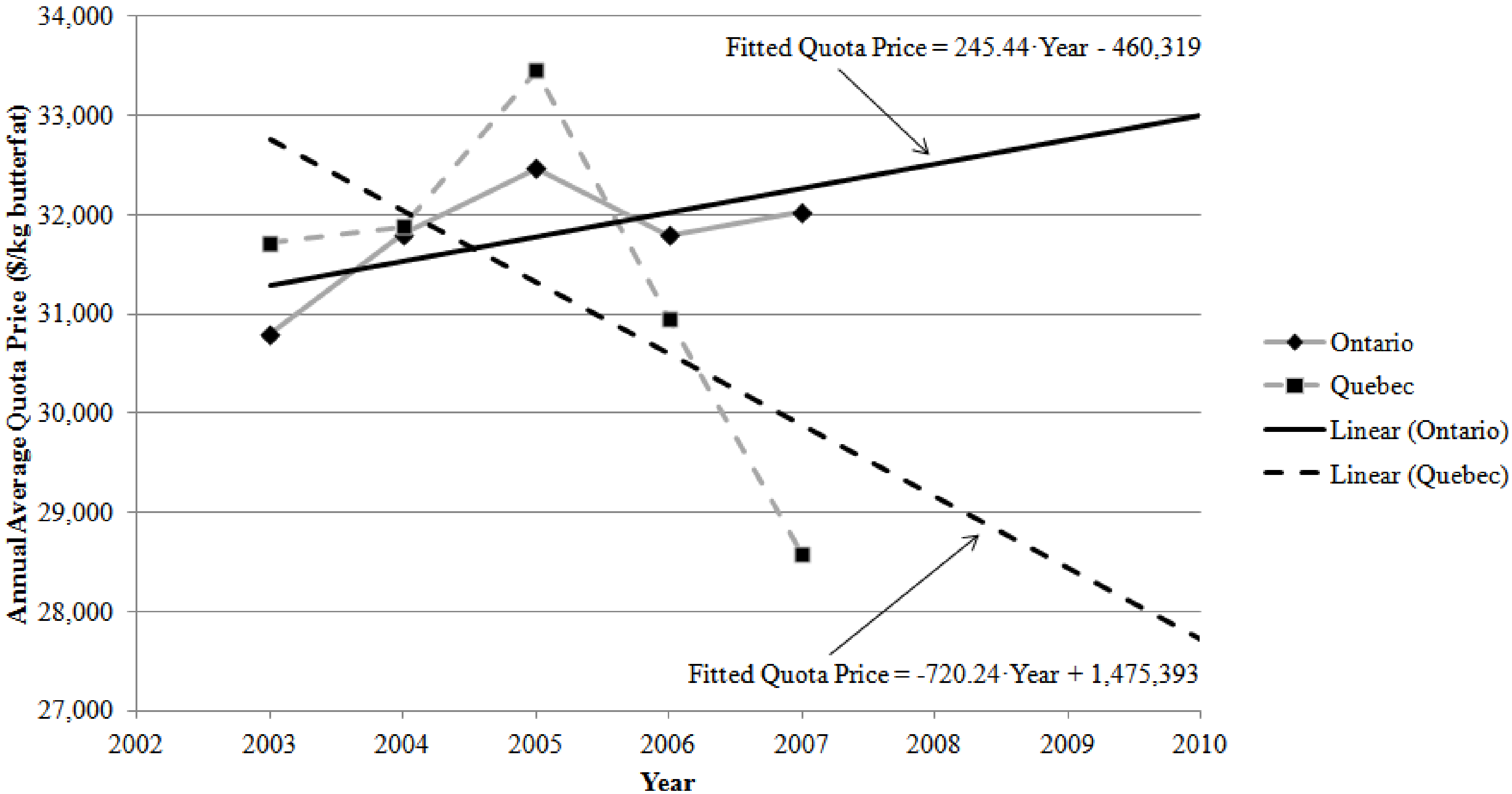

Figure A1. Estimating fitted quota prices for the dairy year 2010-2011 as linear projections of the 2003-2004 to 2007-2008 real (2011 dollars) quota prices

Source: Canadian Dairy Information Centre (2012b)

Note: The years on the horizontal axis denote the beginning year for each dairy year (i.e., the last year on the axis, 2010, represents the dairy year 2010-2011).

APPENDIX B

Table B1. Levies paid by farmers to provincial milk marketing boards in 2010 ($/hl) (estimates based on most recent available data)									
Item	BC[a]	AB	SK	MB	ON	QC	NB[b]	NS	PE[c]
General administration of the Board	NA	0.34	0.65	0.68	0.53	0.66[d]	0.76	0.66[d]	0.69
Dairy industry research	NA	0.05	0.05	0.05	0.04	0.03[d]	0.02	0.03[d]	0.04
Product promotion	NA	1.29	1.06	1.14	1.30	1.26[d]	1.28	1.26[d]	1.20
Dairy Herd Improvement (DHI)[e]	NA	0.03	0.03	0.03	0.06	0.04[d]	0.02	0.04[d]	0.04
Transportation	NA	2.26	2.08	2.08	2.48	2.53[d]	2.54	2.57	2.53
Canadian Quality Milk (CQM)[f] Program	NA	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Total	3.71	3.99	3.89	4.00	4.43	4.54	4.61	4.58	4.52

Sources: British Columbia Ministry of Agriculture, Food and Fisheries (2001), Alberta Milk (2011b), Saskatchewan Milk Marketing Board (2010), Manitoba Agriculture, Food and Rural Initiatives (2005), Ontario Ministry of Food, Agriculture and Rural Affairs (2011), Dairy Farmers of New Brunswick (2011), Dairy Farmers of Nova Scotia (2011), Dairy Farmers of Prince Edward Island (2010) and Bank of Canada (2012).

[a]Data on individual items were not available for British Columbia. The total 2010 levy was obtained by adjusting the 2001 levy for price inflation using the 2001 – 2011 average quarterly CPI increase of 2.1%.

[b]The levy values were reported in $/kg of total solids. We converted this into $/hl by multiplying the reported levy value by the coefficients for the composition of a standard hectolitre of milk (3.6000 kg/hl of butterfat, 3.2326 kg/hl of protein and 5.6851/hl kg of other solids) and adding up the three values.

[c]The values were reported in $/kg butterfat. We converted this into $/hl using the 3.6 kg butterfat/hl coefficient.

[d]The actual value was not available. We assumed that the Quebec and Nova Scotia levies are equal to the P5 pool provinces (Ontario, Quebec, Prince Edward Island, New Brunswick and Nova Scotia) average.

[e]The actual amount was not available. We assumed a uniform DHI levy for the Western Pool provinces (British Columbia, Alberta, Saskatchewan and Manitoba) equal to the DHI levy reported by Alberta Milk ($0.03/hl).

[f]The exact amount was available only for Ontario. We assumed a uniform CQM levy for all of Canada equal to the CQM levy reported by OMAFRA ($0.02/hl).