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REACTT: An Algorithm for Solving Spatial Equilibrium Problems

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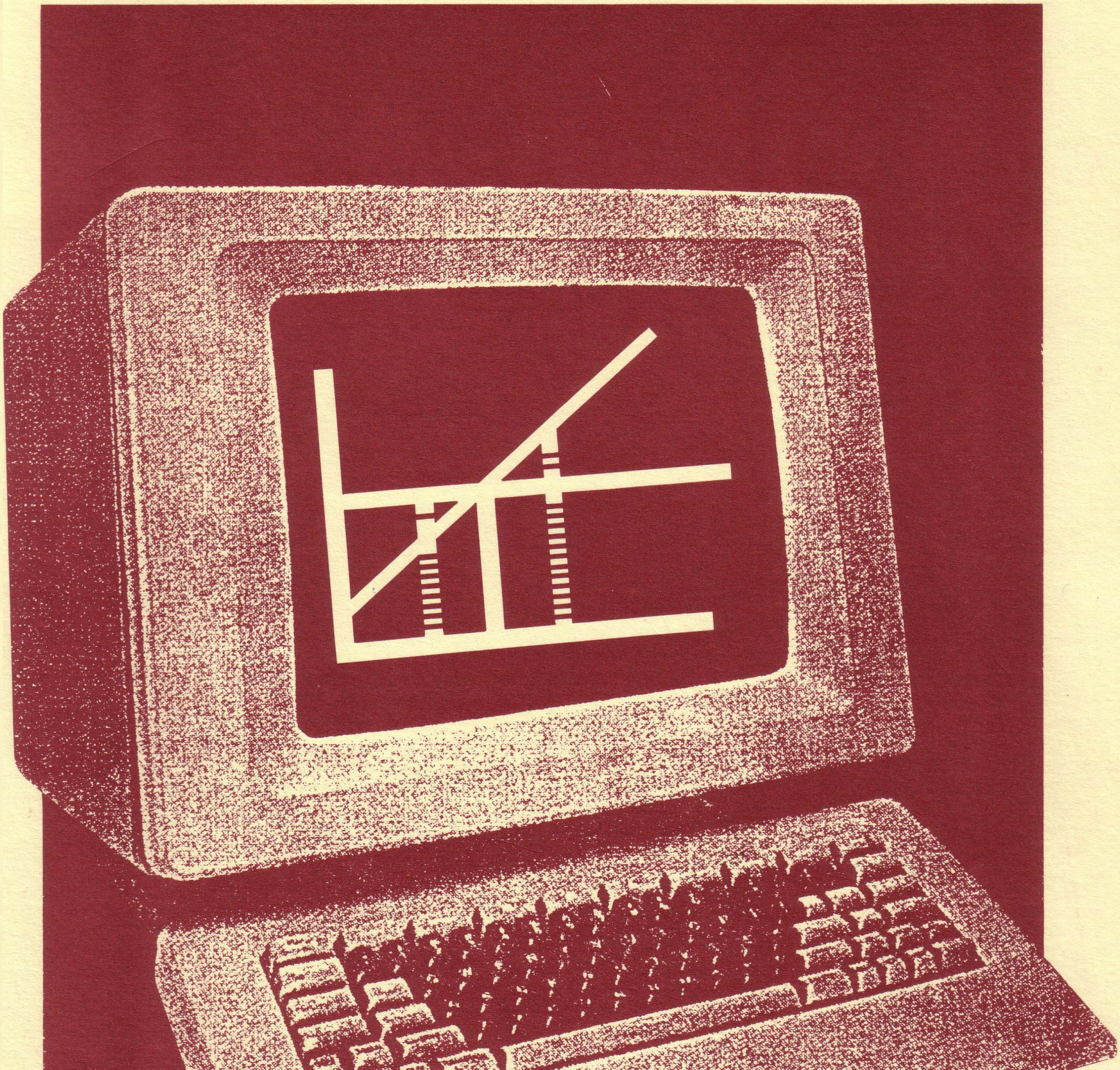

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Abstract

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The problem of determining equilibrium prices and quantities in spatially separated markets is reviewed. Algorithms that compute spatial equilibria are discussed. A computer program using the reactive programming algorithm for solving spatial equilibrium problems that involve multiple commodities is presented, along with detailed documentation. A sample data set, program output, and a partial program listing are also provided.

Keywords: Computer programs/programing, models, supply/demand (forest products).

Contents

Introduction

Computer models of supply and demand for commodities in spatially separated markets have been widely used to examine the behavior of producers and consumers and to investigate market equilibrium conditions under alternative policies. But in spite of their fu ndamental importance, methods of model solution are seldom discussed in any detail when analytical results are presented. This practice can be partially attributed to descriptive parsimony by researchers and partially to disinterest in much of the audience.

The solution method, nevertheless, determines many of the essential characteristics of any model of market behavior and should be given attention. Among the characteristics determined by the solution method are the permissible form (or forms) of the functional relationships of a model and the model's endogenous and exogenous variables. Some solution methods impose restrictions on the behavioral relationships of a model. The solution method also has an effect on the ease with which repeated solutions can be reached, either for sensitivity analysis or for policy analysis. A solution method that is either computationally difficult or expensive can provide a correct answer but may severely limit the usefulness of a model.

This report provides a general introduction to the spatial equilibrium problem and documents a multiregion, multicommodity, spatial equilibrium solution algorithm that is a revision of the "reactive programming" approach first developed by Tramel and Seale (1959). This algorithm has undergone many revisions since it was first presented, revisions that have improved its performance and expanded its capabilities. Reactive programming is an inexpensive, simple, and flexible solution algorithm. Yet, in spite of these desirable characteristics, it has not been widely used. The version of reactive programming reported here incorporates the contributions of many individuals and illustrates some of the extensions to the technique envisaged by Tramel and Seale (1959) over two decades ago.

Spatial Price Equilibrium

The conditions for spatial price equilibrium for multiple products can be stated formally as follows.

Let P_{jk} indicate the price of product k in market j (k=1 ,K; j=1 ,M); X_{jk} is the quantity of product k consumed in market j; C_{ik} is the supply price (production cost) for product k in supply region i (i=1 ,N); PT_{ik} is the quantity of product k produced in supply region i; q_{ijk} is the quantity of product k shipped from region i to market j; TC_{ijk} is the unit cost for shipping product k from i to j; and t_{ijk} is the ad valorem tariff imposed by market j on shipments of product k from supply region i.

Demand functions (equation 1) express the price of each product as a function of the consumption of that product and all other products; supply functions (equation 2) express the cost of each product as a function of the production of that product and all other products:

$$P_{jk} = p(X_{j1},\ldots,X_{jk})\ ;\text{and} \qquad (1)$$

$$C_{ik} = c(PT_{i1},\ldots,PT_{jk})\,. \qquad (2)$$

Consumption in any market must be less than or equal to the sum of shipments from all producing regions; production in any region must be greater than or equal to the sum of shipments to all markets. Taken together, equations (3) and (4) hold as strict equalities and impose an accounting balance on shipments:

$$X_{jk} \leq \sum_{i} q_{ijk}\ ;\ \text{and} \qquad (3)$$

$$PT_{ik} \geq \sum_{j} q_{ijk}\,. \qquad (4)$$

An important characteristic of competitive markets in equilibrium is that excess profit for all suppliers will be zero. Excess profit (or quasi-rent) is a phenomenon of shortrun disequilibrium and can be defined as a return to a producer that is greater than the production (opportunity) cost. The return to a producer- is the price in any market minus transportation cost, tariff charges, and production cost. The supply function (equation 2) is defined such that the cost (Cik) includes all relevant costs, including normal profit. Equations (5) and (6) express the competitive market equilibrium condition:

$$P_{jk} - TC_{ijk} - C_{ik} - t_{ijk}C_{ik} \leq 0\ ;\ \text{and} \qquad (5)$$

$$\sum_{i}\sum_{j}\sum_{k} (P_{jk} - TC_{ijk} - C_{ik} - t_{ijk}C_{ik})q_{ijk} = 0\,. \qquad (6)$$

Finally, all quantities and prices must be nonnegative:

$$q_{ijk}, P_{jk}, C_{ik}, X_{jk}, PT_{ik} \geq 0\,. \qquad (7)$$

The adjustment process that leads competitive markets to an equilibrium position with zero excess profit is illustrated in figure 1. Each producer is a price-taker, and market demand, DM, is perfectly elastic at market price pM. For expositional simplicity, transportation costs and tariffs are assumed to be zero. Market supply is indicated by S^M. At quantity q1' positive excess profits exist, and producers will increase supply (with increasing marginal cost) until an additional unit of output costs more to produce than consumers are willing to pay. At quantity q2' production costs exceed the market price, and producers will reduce output until excess profit is nonnegative. Quantity adjustment is the only option available to producers in a competitive market.

Samuelson (1952) describes (for a single product) how the spatial equilibrium problem can be set up as a maximization problem and be solved using linear programming. He

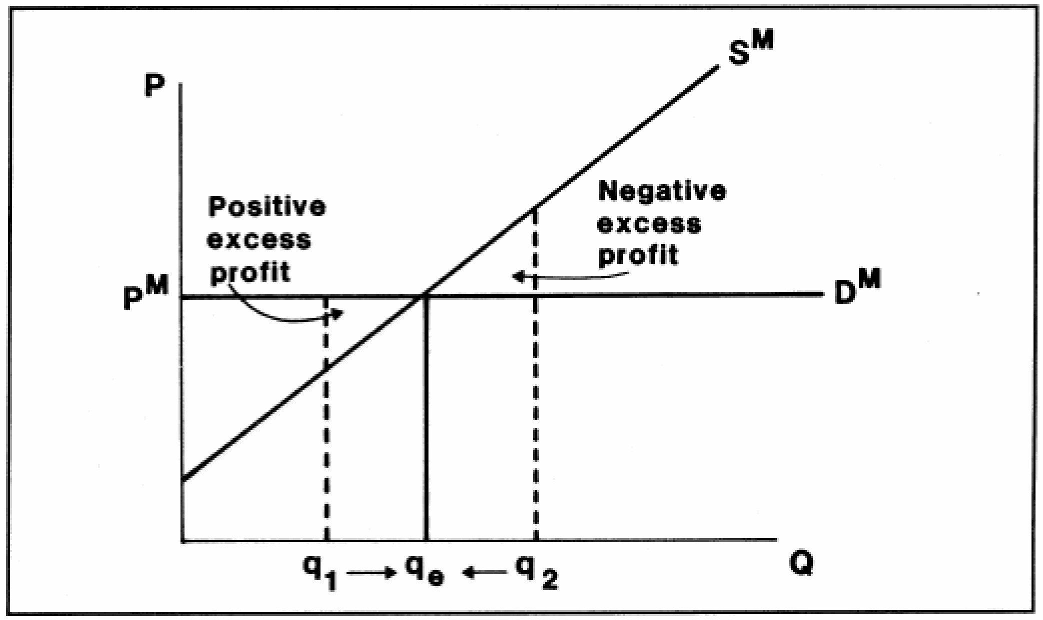

Figure 1—Quantity adjustment by suppliers in a competitive market.

defines the quantity to be maximized as the "net social payoff" (NSP), which is equivalent to the sum of producer and consumer surpluses minus transportation costs. Producer surplus is the area bounded by the supply curve and market price; consumer surplus is the area bounded by the demand curve and market price. Samuelson (1952) shows the correspondence between the maximum of the NSP function and multiregion equilibrium conditions. The NSP function is artificial in the sense that no participants in the market have any reason to be aware of it; Samuelson (1952) notes the similarity between this maximization and Adam Smith's "invisible hand."

Samuelson (1952) also points out that maximizing the NSP function will result in a pattern of shipments that minimizes transportation costs. Smith (1963) demonstrates the formal equivalence between the dual of this maximization problem and the conditions of competitive equilibrium. That is, in competitive markets excess profit (quasi--rent) is minimized because it is eliminated.

Takayama and Judge (1964) extend Samuelson's (1952) results to the multiproduct case and solve the resulting problem using quadratic programming techniques. McCarl and others (1984) provide documentation on an algorithm that solves spatial equilibriium problems formulated in this manner. As Zusman (1969) and Zusman and others (1969) point out, however, the symmetry conditions imposed by the Takayama and Judge (1964) formulation are a severe restriction, particularly in terms of the demand equations. Zusman (1969) questions the merits of formulating the spatial equilibrium problem as an extremum problem, given this restriction. Adams and

Haynes (in press) also discuss limits to the applicability of the Takayama and Judge (1964) formulation, and they provide a survey of some alternative approaches to formulating the maximization problem.

Reactive Programming

Tramel and Seale (1959) define "reactive programming" as a means of obtaining equilibrium values for prices, quantities, and trade flows given supply and demand functions (equations 1 and 2), and transportation costs (TC_{ijk}). Their approach has been termed a "market-simulating" procedure because the iterative means by which the equilibrium values are computed corresponds to the adjustment process in actual markets (Zusman and others 1969).

Reactive programming is a less restrictive method of obtaining the equilibrium solution to the spatial market problem than is quadratic programming because reactive programming requires only that the market adjustment process be stable (Zusman and others 1969). Stability (convergence to an equilibrium, such as q_e in fig. 1) is assured if supply equations do not slope downward and demand equations do not slope upward; that is, if supply and demand equations exhibit normal behavior. Supply and demand functions can have any (differentiable) form, and symmetry of cross-partial derivatives is not required (Zusman 1969). Zusman and others (1969) derive the formal conditions for stability.

There is no explicit objective function in the reactive programming algorithm as there is in Samuelson's (1952) solution method. In reactive programming, the market equilibrium is computed by adjusting production and shipments for each producer until no producer can increase net revenue by altering either output or the pattern of shipments. Given an initial set of shipments, reactive programming maximizes net revenue for one producer, in all markets, by holding production and shipments from other regions constant. Each producing region is examined in sequence, and this sequence is repeated until the equilibrium conditions are satisfied within the specified tolerance. The value of the (user-specified) tolerance is substituted for zero on the right side of equation (5).

Takayama and Judge (1963) refer to this iterative procedure as a "gradient" method and offer two major criticisms of it: first, that convergence to an equilibrium is not assured, and second, that an exact solution cannot be achieved in a finite number of iterations. Tramel (1965), Zusman and others (1969), and King and Ho (1972) offer counter arguments to both criticisms. Zusman and others (1969) argue that the stability of the market adjustment process ensures the convergence of a market-simulating computational procedure. Zusman (1969) also points out that the "stability approach," as illustrated by reactive programming, results in greater flexibility than the Takayama and Judge (1964) approach (it is applicable to a wider array of market conditions) with very little loss of analytical rigor. [1]

[1] A direct comparison of reactive programming and quadratic programming is provided in appendix 1.

Tramel (1965) responds to the second criticism about an exact solution by conceding that reactive programming converges to a solution asymptotically, but he argues that this does not lead necessarily to excessively long computation time. He points out that shortcuts can be introduced to speed the solution process. King and Ho (1972) confirm Tramel's experience with solution times, and they introduce to the algorithm additional revisions designed to reduce solution time even further.

Reactive Programming Solution Procedure

The reactive programming algorithm was introduced by Tramel and Seale (1959). Tramel and Seale (1963) and Tramel (1965) describe the algorithm in more detail, including methods for reducing computing time. Many of these methods are used in the version of reactive programming described here, called REACTT. The general structure of reactive programming is illustrated in figure 2.

The procedure for computing an equilibrium begins at a basis that satisfies the shipments balance restrictions in equations (3) and (4). This starting point can be arbitrary, but the equilibrium solution can be computed faster by choosing the set of q_{ijk} that satisfies (3) and (4) and minimizes transportation costs (Tramel and Seale 1963).

To solve for flows that minimize transportation costs, total supply and demand quantities (and transportation costs) must be known. King and Ho (1972) compute the starting quantities by solving the supply and demand equations with the assumption that transportation costs are zero. In a multiperiod model, supply and demand totals from the previous period's solution can be used as initial estimates of PT_{ik} and X_{jk}.

In REACTT, starting quantities for supply and demand regions are read in as part of the data for the problem. These values may be more or less arbitrary, with the sole restriction that the sum of supplies must equal the sum of demands. An efficient starting basis for computing the market equilibrium is then found by solving:

$$\text{Minimize} \sum_i \sum_j \sum_k TC_{ijk} q_{ijk}; \tag{8}$$

subject to:

$$q_{ijk} \leq UUU_{ijk}, \tag{9}$$

$$q_{ijk} \geq LLL_{ijk}, \tag{10}$$

$$\sum_j q_{ijk} \leq PT_{ik}, \tag{11}$$

$$\sum_i q_{ijk} \geq X_{jk}, \text{ and} \tag{12}$$

$$q_{ijk} \geq 0 \text{ for all i, j, and k}; \tag{13}$$

where UUU_{ijk} is the upper limit on shipments of product k from supplier i to market j, LLL_{ik} is the lower limit on these shipments, and the other terms are as defined earlier.

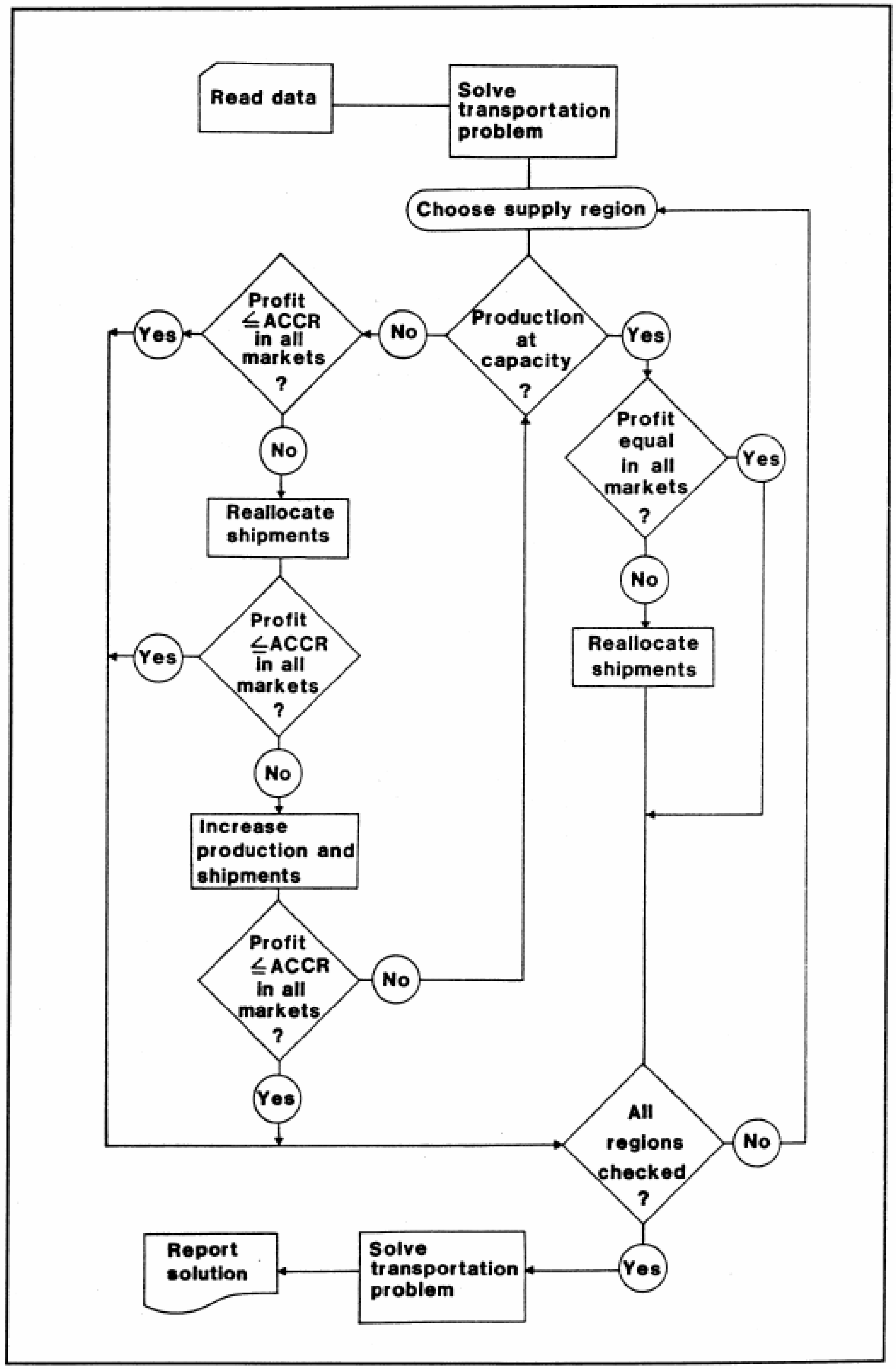

Figure 2—General structure of reactive programming.

The remainder of the reactive programming algorithm is summarized in the following steps, in this case for one supply region and one product:

1. Compute net price (excess profit) for shipments to each market and the quantity-weighted average profit for shipments to all markets (AVPN). If a region is operating at its capacity (an upper limit on production entered as data for the problem), then AVPN remains equal to the average profit in all markets. If production can be increased, A VPN is set equal to zero. Then for each market compute:

$$SKP_{jk} = P_{jk} - C_{lk} - TC_{ijk} - t_{ijk}C_{ik} - AVPN \; . \tag{14}$$

2. Using the solution tolerance (ACCR) in place of zero, check the equilibrium condition stated in equation (5) by comparing SKP_{jk} and ACCR. (Continue to the next market if flows are zero.) For any supply region operating at capacity, the comparison of SKP_{jk} from equation (14) and ACCR defines the equilibrium condition as equal excess profit in all markets. When production is not constrained, the equilibrium condition is that the absolute value of excess profits must be less than ACCR. If the equilibrium condition is not met, continue with the calculations for this supplier; if the condition is met, go to the next supply region.

3. Using the slope of the supply equation for this region (SLOPS) and the slope from the demand equation for each market (SLOPDj) compute a new shipments quantity for each market using Newton's approximation:

$$S_{jk} = q_{ijk} - SKP_{jk}/(SLOPD_j - SLOPS) \; . \tag{15}$$

4. Compute the difference' between the current supply from this region and the production capacity ($DIFF = PT_{ik} - PC_{ik}$, where PC_{ik} is the supply region capacity); compute the change in quantity demanded given a unit change in price ($Rj_k = 1 / SLOPDj_k$) for each market, and the total change for all markets (TOT). Compute a revised shipment to each market as:

$$S_{jk} = S_{jk} - (R_{jk} / TOT) \; DIFF. \tag{16}$$

5. Adjust the market total and compute the new market price for each market:

$$X_{jk} = X_{jk} - q_{ijk} + S_{jk} \text{ ; and} \tag{17}$$

$$P_{jk} = P\,(X_{jk}) \; . \tag{18}$$

6. Adjust the production total for this supplier and compute the new (marginal) cost:

$$PT_{ik} = \sum_j [PT_{ik} - q_{ijk} + S_{jk}] \text{ ; and} \tag{19}$$

$$C_{ik} = c(PT_{ik}) \; . \tag{20}$$

7. Go to the next supply region and repeat steps 1 through 6, and continue until the equilibrium condition (step 2) is satisfied for all supply regions (and products). This iterative procedure is continued until no producer can benefit from a change in the quantity produced or from a change in the pattern of shipments.

Tramel (1965) and King and Ho (1972) discuss several steps that can be used to improve the efficiency of the reactive programming algorithm. In addition to the use of linear programming to determine an efficient starting point, these steps include a series of checks to determine whether some or all the calculations are required in each iteration. These procedures are not shown in steps 1 through 7, but they have been retained in REACTT.

If supply from a region is fixed, equation (15) is simplified, and the problem is then one of allocating this (fixed) quantity to equate excess profit in all markets. When both supply and demand are fixed (in all regions) the spatial equilibrium problem is reduced to the transportation problem, equations (8) through (13). One illustration of the flexibility of reactive programming is its ability to solve a problem containing a mixture of price-responsiveness and nonprice-responsiveness (fixed quantities) in both supply and demand regions. There are also no restrictions on the functional forms of the supply and demand equations, other than the requirement that the slopes of equations (1) and (2) can be defined (for use in equation 15).

Applications of Reactive Programming

Tramel and Seale (1959) describe the reactive programming algorithm and illustrate its application with an analysis of the supply and demand for watermelons. Seale and Allen (1959) provide another example of an early use of the technique. More recent examples of reactive programming can be found in Riley and Blakely (1975) and Dahlgran (1980).

King and Ho (1972) document an "improved" version of the Tramel and Seale (1959) algorithm and provide sample problems to illustrate its use. The paper by King and Gunn (1981) is an update of King and Ho (1972) and provides additional examples of spatial problems that can be solved using reactive programming.

There are surprisingly few examples of the application of reactive programming to an analysis of trade and trade policies. Zusman and others (1969) elaborate on the algorithm described by Tramel and Seale (1959) and apply their solution procedure to an examination of the impact of alternative trade policies instituted by the European Economic Community. Gemmill (1977) conducts an analysis of world sugar markets and examines the impact of U.S. trade policies. Adams and Haynes (1980), Adams (1983), and Brooks (in press) use reactive programming to model forest products markets.

Revisions to King and Ho's Reactive Programming Code

King and Ho (1972) provide a detailed description of the reactive programming algorithm and include the "Tramel/NCSU" program written in FORTRAN. This program reflects some improvements on the algorithm described in detail by Tramel (1965), most notably the ability to solve a problem with two interdependent products and an efficient method for computing initial supply and demand quantities. The version of reactive programming described in this report is an extension of the King and Ho (1972) algorithm.[2] Technical differences between this and the King and Ho (1972) code will not be discussed in any detail because these changes will be of interest only to users of the original code and should be readily apparent to them.

Major revisions to the King and Ho (1972) algorithm will be described in some detail, however. The REACTT code contains the following, additional features:

1. Separate supply and demand regions are defined for all products.
2. Price interaction (in supply or demand) for up to five products can be examined.
3. Fixed demand regions can be included in the problem.
4. Ad valorem (import) tariffs can be specified for each product and every pair of supply and demand regions.
5. Upper and lower bounds can be specified for shipments along any route.

Regional definitions—In REACTT the spatial equilibrium for each product is computed separately, but the interaction between products in both supply and demand functions is still accounted for. In earlier versions of the algorithm (such as King and Ho 1972), supply and demand regions are defined as "product-regions," and flows of one product to another product's "region" are prevented by setting transportation costs very high. In REACTT, there is a single list of supply (demand) regions that includes producers (markets) for all products. If a region does not produce (consume) a particular product, the coefficients of its supply (demand) function are set to zero. The dimension of variable arrays in REACTT allows for the specification of as many as 20 producing regions and 20 markets[3]

Price interaction—The supply and demand function coefficients specify the price (or cost) of each product as a function of an intercept, of its own quantity, and of the quantity of all other products. This relationship is stated in general terms in equations (1) and (2). As many as five products may be included in REACTT; previous versions of the algorithm were restricted to two products. If there is no interaction between products in supply or demand, in any region, a zero must be entered for the appropriate (quantity) coefficient.[4]

Fixed demand—The range of spatial equilibrium problems that can be solved using REACTT includes those in which one or more supply or demand regions do not respond to price changes. Previous versions of reactive programming included fixed supply regions; the treatment of fixed demand regions here is analogous. Supply and

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[2] King and Gunn (1981) also document a revised version of the program described by King and Ho (1972).

[3] The parameter MAXREG sets the maximum number of regions (either supply or demand); computer memory requirements can be minimized by adjusting this parameter to the size of the problem.

[4] See appendix 3 for a description of the structure of the data file for REACTT.

demand function data are entered in price-dependent form; functions are fixed when the coefficients for all quantity terms are zero and, in this case, the starting demand quantity is taken as the fixed requirement for that region (and product).[5] Flows to fixed demand regions are determined in initial solution of the transportation problem. Because the market price is undefined, or arbitrary (at least initially), fixed-demand regions are skipped during reactive programming computations that reallocate shipments. After an equilibrium has been computed, the price reported for a fixed demand region is the quantity-weighted average cost (including any tariffs) for shipments to that region.

Import tariffs—All computations of excess profit (per unit) in REACTT take into consideration any ad valorem tariffs imposed by the market. Tariff data for each product is entered as a proportion, as part of the definition of the problem. A unique tariff rate can be specified for shipments from each possible supplier to each market. Tariffs can be computed on producer cost (customs basis) or be based on delivered cost (producer cost plus transportation cost). An integer variable (zero or one) is used to indicate the type of tariff computation appropriate for each market.

Flow bounds—In REACTT, the network allocation routine NETFLO, described by Kennington and Helgason (1980), is used in place of the linear programming subroutine described by King and Ho {1972).[6] An important feature added by NETFLO is the ability to specify upper and lower bounds on shipments. In principle, shipments from any supplier to any market can be specified exactly by setting the upper and lower bounds equal. Caution must be exercised when imposing flow constraints, however; difficulties may arise because of the structure of REACTT or because of the nature of the problem.

The structure of the solution in REACTT is shown in figure 2. The transportation problem is solved first (by using NETFLO) to establish a starting basis for the reactive programming computations. Supply and demand totals are revised in the reactive programming computations, afterwhich NETFLO is used to compute the final shipments pattern. If no constraints are placed on shipments, the second solution of the transportation problem is redundant because the equilibrium solution (for competitive markets) will minimize transportation costs (Samuelson 1952, Seale and Tramel 1963). An infeasible problem is created when producer (or market) adjustments result in quantities that conflict with the flow constraints. An example of such a conflict is total market demand that is less than a minimum flow from a single producer.

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[5] The intercept term is taken as the initial value for market price and is displayed in any intermediate reports.

[6] The expansion of the reactive programming code to five products and the inclusion of NETFLO are described in J. L. Arthur and B. A. McCarl, "Extensions and modifications of the reactive programming algorithm of King and Ho," unpublished manuscript on file at the Pacific Northwest Research Station, Macroeconomics of U.S. and International Trade Project, Portland, Oregon.

Infeasible flow constraints will cause a program error (see table 3, appendix); the only possible correction is to relax the constraint(s) until the problem becomes feasible.[7] Kennington and Helgason (1980) provide a more detailed description of NETFLO and include a listing of the program.

Some other changes to King and Ho's (1972) code should be noted as well. Only one functional form (linear) has been included for supply and demand functions in REACTT; the code (in appendix 6) is annotated to indicate where changes must be made in order to use different functional forms. Any differentiable functional form can be used for either supply or demand functions; functional forms can differ between regions for supply or demand. These modifications require only that slopes, prices, and costs be (re)defined appropriately, and for mixed functional forms, that careful attention be paid to the indexes that refer to particular supply and demand regions.

The code for REACTT is divided into five subroutines (plus one program segment) that facilitate incorporation into a larger market simulation model, if desired. The general structure of a multiperiod simulation model using REACTT is illustrated in figure 3. The Timber Assessment Market Model (Adams and Haynes 1980) provides one example of how the reactive programming routines can be incorporated into such a model system.[8] Program segment REACTT provides the structure for the solution process and would be replaced (or expanded) in any multiperiod market simulation model. Subroutine DATAIN is used to enter the data for this single solution of the spatial equilibrium problem. Subroutine REACT contains the core of the reactive programming calculations; subroutine REPORT provides reports on intermediate results and reports the equilibrium solution. Subroutines SETUP and NETFLO are used to solve the network allocation problem.

The source code for REACTT is written in the American National Standards Institute (ANSI) FORTRAN 77 language. This code has been compiled and tested on a Control Data Corporation[9] (CDC) Cyber 170/720-2 computer at Oregon State University, Corvallis. With the possible exception of the function calls for the date and time, all statements should compile on any system supporting ANSI-standard FORTRAN.

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[7] The equilibrium solution computed in subroutine REACT is "lost" when an infeasible linear programming problem is encountered because all flows (q_{ijk}) are set to zero before the attempt to solve the transportation problem.

[8] For more detail on the structure of TAMM, see D. Adams, J. Gourley, and R. Haynes, "Timber Assessment Market Model: user's guide," unpublished manuscript on file at the Pacific Northwest Research Station, Macroeconomics of U.S. and International Trade Project, Portland, Oregon.

[9] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the Department of Agriculture of any product or service to the exclusion of others that may be suitable.

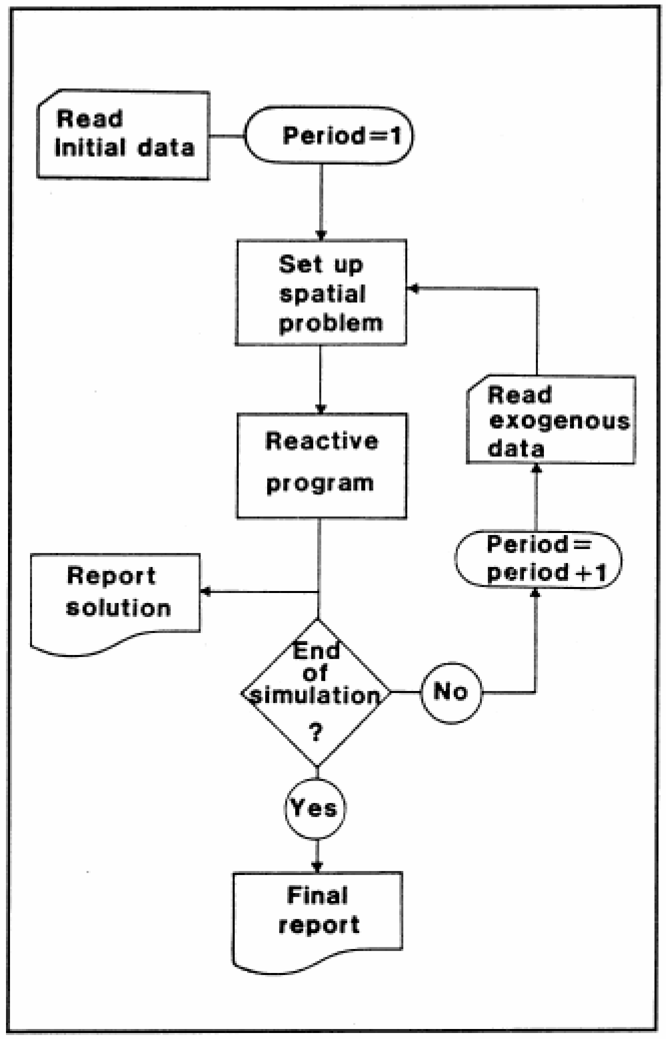

Figure 3—An example of multiperiod market simulation using reactive programming.

Source code and sample data sets can be supplied (at cost) on IBM-compatible diskettes or on magnetic tape. Those interested in obtaining a copy should contact the authors.

This code has also been compiled and executed on IBM-compatible microcomputers. In general, although with exceptions, microcomputer results are comparable to mainframe computer results; supply prices and market prices will differ by an amount less than the solution tolerance. The microcomputer solution will require more iterations than does the mainframe version of REACTT. Some problems arise with the microcomputer version of REACTT; most can be traced to internal precision. Scaling factors must be reduced (to 1.0) to solve the network allocation problem; other, minor modifications to the code may be required as well.

Extensions to REACTT

The modifications to Tramel and Seale's (1959) reactive programming algorithm shown here do not exhaust the possibilities for revisions or enhancements to this computational procedure. The algorithm can be used to compute spatial equilibria using both a variety of functional forms and a mixture of functional forms for supply and demand equations. The REACTT code can be easily modified to accommodate this. Another extension to this code would be the addition of export tariffs or subsidies. This is analogous to the import tariffs included here. Where supply and demand equations (costs and prices) are denominated in different currencies, the rate of exchange can be added to the calculation of excess profit in equation (14).

Adams (1983) describes a spatial equilibrium problem that involves two market levels (trade in raw materials and processed products) and interdependent prices (costs). He solves each market level problem using reactive programming and an iterative procedure to link the two solutions. That is, one market equilibrium is solved using a guess at prices in the other market; the resulting prices are used in the solution of the remaining market problem. Successive substitution of prices between markets leads to convergence to an overall equilibrium. In principle, this procedure can be used to link any number of market levels in either a recursive or a cascading structure. Brooks (in press) uses the reactive programming code reported here and this iterative procedure to solve for spatial equilibrium in two linked markets.

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Appendix 1: A Comparison of Reactive and Quadratic programming

A data set similar to that shown in appendix 4 was used to compare the reactive programming algorithm REACTT, and the quadratic programming algorithm SEBEND (McCarl and others 1984). The sample problem has seven supply regions, six demand regions, and two products; the slope coefficients of both supply and demand equations are symmetric (as required by quadratic programming). Both algorithms were compiled and run using a CDC Cyber 170/720-2 computer, and in both cases the output option chosen was to echo the problem data and report only the final solution.

The reactive programming solution required 3.036 CP seconds; the quadratic programming solution required 3.347 CP seconds. Table 1 compares price and quantity data reported by both models, for one product (lumber). The solution tolerance in REACTT was set at 2000; no price reported by REACTT differs from the SEBEND price by more than this amount. Supply region and market quantities are also substantially the same. Data for the second product are similar.

Table 1—A comparison of REACTT and SEBEND

Supply region prices			Market prices		
Region	REACTT	SEBEND	Market	REACTT	SEBEND
WW	160200.9	159920.8	NW	164828.9	164510.8
WE	163507.4	162030.8	SW	178574.8	176740.8
SW	166746.4	165020.8	RK	174267.2	175260.8
RM	165087.1	166150.8	NC	189720.6	189580.8
SC	177983.2	179830.8	NE	190893.9	191980.8
SE	177373.9	178460.8	SO	188755.1	189390.8
CA	158104.3	158113.4			

Supply region quantities			Market quantities		
Region	REACTT	SEBEND	Market	REACTT	SEBEND
WW	6313.5	6311.7	NW	2551.0	2552.2
WE	2659.1	2643.1	SW	9294.1	9320.2
SW	6338.8	6325.5	RK	2483.5	2478.7
RM	3624.9	3633.2	NC	9948.3	9951.1
SC	8578.9	8592.9	NE	3123.0	3114.8
SE	7393.0	7401.5	SO	12970.2	12954.1
CA	5462.1	5463.1			
TOTAL	40370.2	40371.1		40370.2	40371.1

Appendix 2: REACTT Variable Definitions

This appendix provides definitions of variables used in Program REACTT, and subroutines REACT, REPORT, and DATAIN. The reader is directed to Kennington and Helgason (1980) and Helgason and Kennington (1979) for more information on NETFLO.

Variable	Definition
ACCR	Solution tolerance, defined as the amount by which excess profits (for any supplier in any market) may differ from zero (must be scaled to supply and demand equations)
AVPN	The average net price (profit) for the current supply region in the current iteration AVPN = SUM/CNT; AVPN is set=0 if the supply region production total (PT(I,K)) is less than capacity (PC(I,K))
BIG	Sufficiently large number, used to indicate no flow in NETFLO
C(I,K)	Cost, supply region I, product K
CNT	The total quantity shipped to all markets by the current supply region in the current iteration
CPAY	Consumer outlay in each market
CPT	Total consumer outlay, all markets
DEMAND(N,J,K)	Price-dependent demand equation coefficients; N=1 is the intercept, N=2 to N=NPROD + 1 are the coefficients for the quantity of the first through the NPROD th products (for each I and K)
DIFF	The difference between PACT and capacity for the supply region (PC(I,K))
DUMP	Integer variable that determines the quantity of output (see table 2)
EPS	Parameter sufficiently close to zero
FINIS	Integer flag that defines when the RP iteration is completed; when FINIS =5, the iteration continues; FINIS=0 indicates an equilibrium solution; FINIS is set=0 at the start of each iteration, and set=5 if net price is greater than ACCR (in absolute value) in any market, for any supply region
FLWSCL	Scaling parameter for flows in NETFLO
IFAS(I)	Integer flag used to indicate whether to skip supply region I in the current iteration; IFAS is set equal to 1 (skip this region) when the equilibrium conditions are met; IFAS is reset to 0 on a cycle determined by ITEST
INDIC	Integer flag used to indicate the need for a recalculation within an RP iteration; INOIC is set=0 to start, then set=5 if S(J,K) has been set arbitrarily because the initial S(J,K) was less than or equal to zero; when INDIC=5 a new total supply and residual supply is computed, and a new S(J,K) is computed for each market
ISP(I,K)	Implicit supply price: for each supply region (and product) this is computed as the greatest difference between price (in any market) and transportation cost (plus tariffs); for supply regions operating below capacity ISP(I,K)=C(I,K)+ ACCR; otherwise ISP indicates the "profit potential" in the absence of the capacity (or flow) constraint

Variable	Definition
ITEST	Integer counter that defines the cycle for setting the flag IFAS(I,K) = 0; every ITEST RP iterations the flag is set to 0 and all supply regions are examined for possible improvements to the supply total or shipments pattern (regions are skipped when there is no change from the previous iteration)
IX(I,K}	Integer flag used to indicate a fixed supply region for this product (IX(I,K) = 0) or marginal cost varying with quantity (IX(I,K) = 1)
JX(J,K}	Integer flag used to indicate a fixed demand region for this product (JX(J,K) = 0) or price varying with quantity demanded (JX(J,K) = 1)
LINMAX	Maximum number of lines per page (output file)
LLL(I,J,K}	Lower bound on shipments of product K from I to J
MAXIT	Maximum number of reactive programming iterations
NDEM	Number of product demand regions (markets)
NLIN	Number of lines printed, current page (output file)
NLPIT	The number of NETFLO iterations
NOLO	The total number of RP iterations
NPAGE	Page number (output file)
NPROD	Number of products
NRPIT	The number of the current RP iteration
NSUP	Number of product supply regions
OBJSCL	Scaling parameter for the objective function in NETFLO
P(J,K)	Price, demand region J, product K
PA(I,K)	Production allocation for supply region I, in the current RP iteration
PAT	Total quantity supplied, all producers
PC(I,K)	Production capacity, supply region I, product K
PREV(I)	Producer revenue, supply region I
PRINTS	Integer counter used to determine the cycle for intermediate reports
PROD(K)	3-character identifier of products (K=1, NPROD)
PROT	The total supply for the current supply region in the current iteration (the sum of flows to all markets)
PRT	Total producer revenue, all producers
PT(I,K)	Production total, supply region 1,- product K
Q(I,J,K)	Quantity of product K shipped from I to J
QST	The total quantity shipped, all producers, all markets
R(J,K)	The inverse of the slope of the demand function; that is, (1/DEMAND(K+ 1 J,K))

Variable	Definition
R DATE	Date of the current run (system-defined)
REGDEM(J)	2-character identifier of demand regions (J=1, NDEM)
REGSUP(I)	2-character identifier of supply regions (1=1, NSUP)
RTIME	TIme of the current run (system-defined)
RUNERR	Integer variable used to indicate that an error has occurred (when greater than 0) and its location (see table 3)
S(J,K)	Trial quantity for shipments of K from the current supply region to market J
SC	The shipping cost for flows Q(I,J,K)TC(I,J,K)
SCT	Total shipping cost, all producers, all markets
SKP	The deviation of net price in a market from the average net price in all markets (AVPN), for the current supply region in the current iteration; SKP is compared to ACCR (for each supply region, all markets) to determine if an equlibrium has been reached for this supplier
SUM	The total profit (net price times quantity) in all markets for the current supply region in the current iteration
SUPPL V(N,I,K)	Cost-dependent supply equation coefficients; N=1 is the intercept, N=2 to N=NPROD+ 1 are the coefficients for the quantity of the first through the NPRODth products (for each I and K)
TAR	The tariff collected on flows Q(I,J,K)
TARIF	The total tariff collected in each market
TARIFF(I,J,K)	Ad valorem tariff (expressed as a proportion) imposed by market J on shipments of product K from supply region I
TC(I,J,K)	Transportation cost for shipments of product K from I to J
TFLAG(J)	Integer flag indicating the type of tariff computation for market J; TFLAG=0 indicates tariff assessed on the "customs price" (producer cost only); TFLAG= 1 indicates tariff assessed on producer cost plus transportation cost
TITLE	80-character description of ,the data set, used as a heading on each page of output
UUU(I,J,K)	Upper bound on shipments of product K from I to J
X(J,K)	Total quantity demanded, market J, product K
XJT	Total quantity demanded, all markets

Table 2—REACTT documentation options[1]

DUMP	Output
0	None[2]
1	Final report
2	+ data echo
3	+ intermediate reports
4	+ SETUP reports[3]
5	+ NETFLO reports[3]

1 Reports are cumulative.

2 For use when REACTT is included as a set of subroutines in a larger simulation model.

3. See Helgason and Kennington (1979) for more information.

Table 3—REACTT error messages[1]

NSTOP	Subroutine	Problem
10	SETUP	Infeasible problem: net requirements are negative
20	SETUP	Too many arcs
30	SETUP	Too many arcs
40	SETUP	Too many arcs
50	NETFLO	Too many arcs
60	NETFLO	Infeasible problem: net requirements are negative (induced by lower bounds on arcs flows)
70	NETFLO	Infeasible: artificial variables in basis

[1] These errors originate in the network allocation subroutines. The value of RUNERR is reported when abnormal termination occurs, where RUNERR = NSTOP + NPROD (the number of the current product at the time of the error). Two additional error messages can occur in REACTT: an "illegal end of file encountered" while reading input; and "illegal data encountered" (too many regions or too many products).

Appendix 3: REACTT Data File Structure

Data for REACTT is read from file DATA by subroutine DATAIN called .by program REACTT. File DATA contains three sections: (1) parameter information; (2) alpha-numeric data identifying regions and products; and (3) blocks containing the supply and demand functions, transportation costs, tariffs, flow bounds, capacities, and starting values (one block for each product). The sequence of data entry is shown below; a sample data set is included as appendix 4.

1. Parameter information
   TITLE (80-character title of the data set)
   DESC (80-character description)
   NSUP, NDEM, NPROD, DUMP, ACCR
   DESC (80-character description)
   FLWSCL, OBJSCL, BIG, MAXIT

2. Alphanumeric data identifying regions and products
   (REGSUP(I), I=1,NSUP)
   (REGDEM(J), J=1,NDEM)
   (PROD(K), K=1,NPROD)

3. Product data blocks (K=1 ,NPROD)
   DESC (BO-character description)
   ((SUPPLY(N,I,K), N=1,NPROD+ 1), 1=1,NSUP) (1 line for each region)
   DESC
   ((DEMAND(N,J,K), N=1,NPROD+1), J=1,NDEM) (1 line for each region)
   DESC
   (TFLAG(J), J=1 ,NDEM)
   DESC
   ((TC(I,J,K), 1=1,NSUP), J=1,NDEM) (1 line for each demand region)
   DESC
   ((TARIFF(I,J,K), 1=1 ,NSUP), J=1,NDEM) (1 line for each market)
   DESC
   ((LLL(I,J,K), 1=1,NSUP), J=1,NDEM) (1 line for each market)
   DESC
   ((UUU(I,J,K), 1=1,NSUP), J=1,NDEM) (1 line for each market)
   DESC

   (PT(I,K), I=1,NSUP)
   DESC
   (PC(I,K), 1=1,NSUP)
   DESC

Appendix 4: REACTT Example Data Set

```
LR 28   1977 85/01/10. 21.07.34. 2ND SOUTHERN TIMBER SUPPLY STUDY RUN
NUMBER OF SUPPLY AND DEMAND REGIONS AND PRODUCTS, DUMP FLAG AND ACCURACY
7 6 2   2 2000.
SCALING FACTORS FLWSCL, OBJSCL, BIG, MAXIT
1000.0 1000.0 1000000000. 20
WW     WE     SW     RM     SC     SE     CA
NW     SW     RK     NC     NE     SO
LUM    PLY
LUMBER SUPPLY EQUATIONS
-339669.3370            56.7995            2.1130
-133615.0350           105.8041           10.0439
-470226.3518           128.3077           13.0189
-520796.5081           139.7448            9.9400
-481186.5530           124.9247            6.1589
-314040.1351           130.0521            7.3081
    3877.0887            8.6149              .0000
LUMBER DEMAND EQUATIONS
483616.4233           -124.7632             .0000
531053.5767            -55.1405             .0000
484494.0686           -180.8876             .0000
488194.6525            -31.4651             .0000
448538.7166            -80.9404             .0000
493826.8126            -31.6092             .0000
LUMBER TARIFF COMPUTATION FLAGS
0.0      0.0      0.0      0.0      0.0      0.0
LUMBER TRANSPORTATION COSTS
 4590     5370    10490    14590    29610    31920    10120
16820    16520    11720    18050    29400    31920    19720
16160    14430    17090     9110    26180    28710    18810
29660    27550    28330    23430    15160    17470    27250
34870    32550    33310    31770    20060    13520    31250
29470    27520    28150    24100     9560    10930    30050
LUMBER TARIFF RATES
0.000    0.000    0.000    0.000    0.000    0.000    0.000
0.000    0.000    0.000    0.000    0.000    0.000    0.000
0.000    0.000    0.000    0.000    0.000    0.000    0.000
0.000    0.000    0.000    0.000    0.000    0.000    0.000
0.000    0.000    0.000    0.000    0.000    0.000    0.000
0.000    0.000    0.000    0.000    0.000    0.000    0.000
LUMBER LOWER BOUND ON FLOWS
0        0        0        0        0        0        0
0        0        0        0        0        0        0
0        0        0        0        0        0        0
0        0        0        0        0        0        0
0        0        0        0        0        0        0
0        0        0        0        0        0        0
LUMBER UPPER BOUND ON FLOWS
1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6
1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6
1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6
1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6
1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6
1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6    1.0E6
LUMBER SUPPLY STARTING VALUES
7665.00    2426.552   4961.484   4579.00    4633.00    3358.024   10429.00
LUMBER SUPPLY MAXIMA
8116.188   2427.552   4962.484   4669.720   4782.032   3359.0240  10924.00
LUMBER DEMAND STARTING VALUES
2869.8563   7075.6464   1999.4901  11204.0053   3749.0439  11154.0181
```

PLYWOOD SUPPLY EQUATIONS

-118164.4792	1.9885	20.9886
-151974.4715	10.7045	217.9148
-58534.5107	11.2239	218.1315
-225886.7596	11.1675	208.6711
-306655.9183	8.0967	65.7917
-521450.4822	9.6075	306.3367
.0000	.0000	.0000

PLYWOOD DEMAND EQUATIONS

340038.8474	.0000	-112.9010
231640.6753	.0000	-56.3961
543402.9341	.0000	-421.4998
218041.3847	.0000	-27.8647
222725.4516	.0000	-51.2988
271838.7707	.0000	-29.7372

TARIFF COMPUTATION FLAG

0.0	0.0	0.0	0.0	0.0	0.0

PLYWOOD TRANSPORTATION COSTS

2410	2550	4990	6930	15660	16880	1000000
8820	7850	5570	8580	15540	16880	1000000
8890	6860	8120	4330	13840	15180	1000000
15550	13100	13470	11130	7990	9250	1000000
18280	15470	15840	15100	10650	7250	1000000
15450	13030	13380	11450	5550	6440	1000000

PLYWOOD TARIFF RATES

0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000

PLYWOOD LOWER BOUND ON FLOWS

0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

PLYWOOD UPPER BOUND ON FLOWS

1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6
1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6
1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6
1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6
1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6
1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6	1.0E6

PLYWOOD SUPPLY STARTING VALUES

9509.00	1115.00	915.00	1327.00	5115.00	1705.00	0.00

PLYWOOD SUPPLY MAXIMA

.10E+06	.10E+06	.10E+06	.10E+06	.10E+06	.10E+06

PLYWOOD DEMAND STARTING VALUES

2271.0000	2628.0000	1082.0000	4803.0000	2673.0000	6229.0000

Appendix 5: REACTT Example Output

This appendix is the output from two runs of REACTT. In both cases, the output option chosen echos the problem data and reports only the final equilibrium solution.

The first run uses data as shown in appendix 4. The second run uses the same data, except that a 3D-percent tariff is imposed by all markets on shipments of lumber (product 1) from Canada (supply region CA).

Run 1 (No Tariffs)

```
LR     28  --  1977  85/01/10.  21.07.34.  2ND  SOUTHERN  TIMBER  SUPPLY  STUDY  RUN      86/04/21.  13.21.45.  PAGE  1     REACTT
NUMBER  OF  SUPPLY  AND  DEMAND  REGIONS  AND  PRODUCTS,  DUMP  FLAG  AND  ACCURACY
                  7  SUPPLY  REGIONS
                  6  DEMAND  REGIONS
                  2  PRODUCTS
                  DIAGNOSTIC  OUTPUT  LEVEL     2
                  REACTIVE  PROGRAMMING  ACCURACY  =        2000.000
                  FLWSCL=                   1000.
                  OBJSCL=                   1000.
                  BIG     =          1000000000.

                   PRODUCT     1       LUM      LUMBER  SUPPLY  EQUATIONS
                                     INTERCEPT        LUM  COEFFICIENT       PLY  COEFFICIENT
     WW                              -339669.337                  56.800                 2.113
     WE                              -133615.035                 105.804                10.044
     SW                              -470226.352                 128.308                13.019
     RM                              -520796.508                 139.745                 9.940
     SC                              -481186.553                 124.925                 6.159
     SE                              -314040.135                 130.052                 7.308
     CA                                 3877.089                   8.615                  .000
                   PRODUCT     1       LUM      LUMBER  DEMAND  EQUATIONS
                                     INTERCEPT        LUM  COEFFICIENT       PLY  COEFFICIENT
     NW                               483616.423                -124.763                  .000
     SW                               531053.577                 -55.141                  .000
     RK                               484494.069                -180.888                  .000
     NC                               488194.653                 -31.465                  .000
     NE                               448538.719                 -80.940                  .000
     SO                               493826.813                 -31.609                  .000
                   PRODUCT     1       LUM      LUMBER  TARIFF  COMPUTATION  FLAGS
                               NW               SW               RK               NC               NE               SO
     FLAG                      0                0                0                0                0                0
                   PRODUCT     1       LUM      LUMBER  TRANSPORTATION  COSTS
                           WW          WE          SW          RM          SC          SE          CA
     NW                 4590.       5370.      10490.      14590.      29610.      31920.      10120.
     SW                16820.      16520.      11720.      18050.      29400.      31920.      19720.
     RK                16160.      14430.      17090.       9110.      26180.      28710.      18810.
     NC                29660.      27550.      28330.      23430.      15160.      17470.      27250.
     NE                34870.      32550.      33310.      31770.      20060.      13520.      31250.
     SO                29470.      27520.      28150.      24100.       9560.      10930.      30050.
                   PRODUCT     1       LUM      LUMBER  TARIFF  RATES
                           WW          WE          SW          RM          SC          SE          CA
     NW                 .0000       .0000       .0000       .0000       .0000       .0000       .0000
     SW                 .0000       .0000       .0000       .0000       .0000       .0000       .0000
     RK                 .0000       .0000       .0000       .0000       .0000       .0000       .0000
     NC                 .0000       .0000       .0000       .0000       .0000       .0000       .0000
     NE                 .0000       .0000       .0000       .0000       .0000       .0000       .0000
     SO                 .0000       .0000       .0000       .0000       .0000       .0000       .0000
                   PRODUCT     1       LUM      LUMBER  LOWER  BOUND  ON  FLOWS
                           WW          WE          SW          RM          SC          SE          CA
     NW                    0.          0.          0.          0.          0.          0.          0.
     SW                    0.          0.          0.          0.          0.          0.          0.
     RK                    0.          0.          0.          0.          0.          0.          0.
     NC                    0.          0.          0.          0.          0.          0.          0.
     NE                    0.          0.          0.          0.          0.          0.          0.
     SO                    0.          0.          0.          0.          0.          0.          0.
                   PRODUCT     1       LUM      LUMBER  UPPER  BOUND  ON  FLOWS
                           WW          WE          SW          RM          SC          SE          CA
     NW             .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07
     SW             .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07
     RK             .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07
     NC             .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07
     NE             .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07
     SO             .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07   .1000E+07
                   PRODUCT     1       LUM      LUMBER  SUPPLY  STARTING  VALUES
                   WW          WE          SW          RM          SC          SE          CA
                   7665.       2427.       4961.       4579.       4633.       3358.       10429.
                   PRODUCT     1       LUM      LUMBER  SUPPLY  MAXIMA
                   WW          WE          SW          RM          SC          SE          CA
                   8116.       2428.       4962.       4670.       4782.       3359.       10924.
                   PRODUCT     1       LUM      LUMBER  DEMAND  STARTING  VALUES
                   NW          SW          RK          NC          NE          SO
                   2870.       7076.       1999.       11204.      3749.       11154.
```

LR 28 – 1977 85/01/10. 21.07.34. 2ND SOUTHERN TIMBER SUPPLY STUDY RUN 86/04/21 13.21.45. PAGE 2 REACTT

PRODUCT 2 PLY PLYWOOD SUPPLY EQUATIONS

	INTERCEPT	LUM COEFFICIENT	PLY COEFFICIENT
WW	-118164.479	1.989	20.989
WE	-151974.472	10.705	217.915
SW	-58534.511	11.224	218.132
RM	-225886.760	11.168	208.671
SC	-308655.918	8.097	65.792
SE	-521450.482	9.608	306.337
CA	.000	.000	.000

PRODUCT 2 PLY PLYWOOD DEMAND EQUATIONS

	INTERCEPT	LUM COEFFICIENT	PLY COEFFICIENT
NW	340038.847	.000	-112.901
SW	231640.675	.000	-56.396
RK	543402.934	.000	-421.500
NC	218041.385	.000	-27.865
NE	222725.452	.000	-51.299
SO	271838.771	.000	-29.737

PRODUCT 2 PLY TARIFF COMPUTATION FLAG

	NW	SW	RK	NC	NE	SO
FLAG	0	0	0	0	0	0

PRODUCT 2 PLY PLYWOOD TRANSPORTATION COSTS

	WW	WE	SW	RM	SC	SE	CA
NW	2410.	2550.	4990.	6930.	15660.	16880.	1000000.
SW	8820.	7850.	5570.	8580.	15540.	16880.	1000000.
RK	8890.	6860.	8120.	4330.	13840.	15180.	1000000.
NC	15550.	13100.	13470.	11130.	7990.	9250.	1000000.
NE	18280.	15470.	15840.	15100.	10650.	7250.	1000000.
SO	15450.	13030.	13380.	11450.	5550.	6440.	1000000.

PRODUCT 2 PLY PLYWOOD TARIFF RATES

	WW	WE	SW	RM	SC	SE	CA
NW	.0000	.0000	.0000	.0000	.0000	.0000	.0000
SW	.0000	.0000	.0000	.0000	.0000	.0000	.0000
RK	.0000	.0000	.0000	.0000	.0000	.0000	.0000
NC	.0000	.0000	.0000	.0000	.0000	.0000	.0000
NE	.0000	.0000	.0000	.0000	.0000	.0000	.0000
SO	.0000	.0000	.0000	.0000	.0000	.0000	.0000

PRODUCT 2 PLY PLYWOOD LOWER BOUND ON FLOWS

	WW	WE	SW	RM	SC	SE	CA
NW	0.	0.	0.	0.	0.	0.	0.
SW	0.	0.	0.	0.	0.	0.	0.
RK	0.	0.	0.	0.	0.	0.	0.
NC	0.	0.	0.	0.	0.	0.	0.
NE	0.	0.	0.	0.	0.	0.	0.
SO	0.	0.	0.	0.	0.	0.	0.

PRODUCT 2 PLY PLYWOOD UPPER BOUND ON FLOWS

	WW	WE	SW	RM	SC	SE	CA
NW	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
SW	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
RK	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
NC	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
NE	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
SO	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07

PRODUCT 2 PLY PLYWOOD SUPPLY STARTING VALUES

WW	WE	SW	RM	SC	SE	CA
9509.	1115.	915.	1327.	5115.	1705.	0.

PRODUCT 2 PLY PLYWOOD SUPPLY MAXIMA

WW	WE	SW	RM	SC	SE	CA
100000.	100000.	100000.	100000.	100000.	100000.	100000.

PRODUCT 2 PLY PLYWOOD DEMAND STARTING VALUES

NW	SW	RK	NC	NE	SO
2271.	2628.	1082.	4803.	2673.	6229.

LR 28 -- 1977 85/01/10. 21.07.34. 2ND SOUTHERN TIMBER SUPPLY STUDY RUN 86/04/21. 13.21.45. PAGE 3 REACTT
FINAL REPORT DUMP 2 LP ITERATIONS 2 TOTAL RP ITERATIONS 11
ACCURACY 2000.000 SCALE FACTORS FLWSCL, OBJSCL, AND BIG 1000. 1000. 1000000000.
COMMODITY LUM

PRODUCING REGION SUMMARY

IDENT.	MAX. Q. SUPPLIED	QUANTITY SUPPLIED	SUPPLY PRICE	IMPLICIT SUPPLY PRICE	PRODUCER REVENUE
WW	8116.1880	7684.8730	115179.7144	116554.6112	885141477.54
WE	2427.5520	2274.4730	116686.9547	117129.3365	265401327.91
SW	4962.4840	4578.9150	122735.3291	121654.6112	561994639.50
RM	4669.7200	4487.4520	118769.6386	120549.3365	532973052.36
SC	4782.0320	4667.6500	135603.9633	135089.3365	632951839.11
SE	3359.0240	3325.4530	132206.7506	130339.2226	439647335.32
CA	10924.0000	10923.9990	97986.2477	113755.7185	1070401671.73
ALL		37942.8150			4388511343.47

MARKET SUMMARY

IDENT.	QUANTITY DEMANDED	MARKET PRICE	CONSUMER OUTLAY	TARIFF COLLECTED
NW	2914.1980	120031.7554	349796301.48	.00
SW	7212.1030	133374.6112	961911433.76	.00
RK	1971.4690	127879.7727	252111007.64	.00
NC	11034.0960	141005.7185	1555870633.93	.00
NE	3764.2450	143859.2226	541521359.38	.00
SO	11046.7040	144649.3365	1597898404.37	.00
ALL	37942.8150		5259109140.57	

TRADE FLOWS AND OPPORTUNITY COSTS

SOURCE	DESTINATION	QUANTITY SHIPPED	OPPORTUNITY COST	TRANSFER COST	SHIPPING COST	TARIFF COST
WW	NW	2914.1980	262.0410	4590.00	13376168.82	.00
WW	SW	2633.1880	1374.8968	16820.00	44290222.16	.00
WW	RK	.0000	-3459.9417	16160.00	.00	.00
WW	NC	.0000	-3833.9960	29660.00	.00	.00
WW	NE	.0000	-6190.4918	34870.00	.00	.00
WW	SO	2137.4870	-.3779	29470.00	62991741.89	.00
WE	NW	.0000	-2025.1993	5370.00	.00	.00
WE	SW	.0000	167.6565	16520.00	.00	.00
WE	RK	.0000	-3237.1820	14430.00	.00	.00
WE	NC	.0000	-3231.2362	27550.00	.00	.00
WE	NE	.0000	-5377.7321	32550.00	.00	.00
WE	SO	2274.4730	442.3818	27520.00	62593496.96	.00
SW	NW	.0000	-13193.5737	10490.00	.00	.00
SW	SW	4578.9150	-1080.7179	11720.00	53664883.80	.00
SW	RK	.0000	-11945.5564	17090.00	.00	.00
SW	NC	.0000	-10059.6107	28330.00	.00	.00
SW	NE	.0000	-12186.1065	33310.00	.00	.00
SW	SO	.0000	-6235.9926	28150.00	.00	.00
RM	NW	.0000	-13327.8832	14590.00	.00	.00
RM	SW	.0000	-3445.0274	18050.00	.00	.00
RM	RK	1971.4690	.1341	9110.00	17960082.59	.00
RM	NC	548.8890	-1193.9202	23430.00	12860469.27	.00
RM	NE	.0000	-6680.4160	31770.00	.00	.00
RM	SO	1967.0940	1779.6979	24100.00	47406965.40	.00
SC	NW	.0000	-45182.2079	29610.00	.00	.00
SC	SW	.0000	-31629.3520	29400.00	.00	.00
SC	RK	.0000	-33904.1905	26180.00	.00	.00
SC	NC	.0000	-9758.2448	15160.00	.00	.00
SC	NE	.0000	-11804.7407	20060.00	.00	.00
SC	SO	4667.6500	-514.6267	9560.00	44622734.00	.00
SE	NW	.0000	-44094.9952	31920.00	.00	.00
SE	SW	.0000	-30752.1393	31920.00	.00	.00
SE	RK	.0000	-33036.9779	28710.00	.00	.00
SE	NC	.0000	-8671.0321	17470.00	.00	.00
SE	NE	3325.4530	-1867.5280	13520.00	44960124.56	.00
SE	SO	.0000	1512.5859	10930.00	.00	.00
CA	NW	.0000	11925.5077	10120.00	.00	.00
CA	SW	.0000	15668.3635	19720.00	.00	.00
CA	RK	.0000	11083.5250	18810.00	.00	.00
CA	NC	10485.2070	15769.4708	27250.00	285721890.75	.00
CA	NE	438.7920	14622.9749	31250.00	13712250.00	.00
CA	SO	.0000	16613.0888	30050.00	.00	.00
ALL		37942.8150			704161030.20	

LR 28 -- 1977 85/01/10. 21.07.34. 2ND SOUTHERN TIMBER SUPPLY STUDY RUN 86/04/21. 13.21.45. PAGE 4 REACTT
FINAL REPORT DUMP 2 LP ITERATIONS 2 TOTAL RP ITERATIONS 11
ACCURACY 2000.000 SCALE FACTORS FLWSCL, OBJSCL, AND BIG 1000. 1000. 1000000000.
COMMODITY PLY

PRODUCING REGION SUMMARY

IDENT.	MAX. Q. SUPPLIED	QUANTITY SUPPLIED	SUPPLY PRICE	IMPLICIT SUPPLY PRICE	PRODUCER REVENUE
WW	100000.0000	8685.1540	79406.2436	81042.2817	689655453.97
WE	100000.0000	961.1330	81817.6711	83492.2817	78637663.71
SW	100000.0000	418.7490	84200.9794	84097.7233	35259075.91
RM	100000.0000	1254.3380	85970.7724	85872.9771	107836406.70
SC	100000.0000	5469.4440	88980.6358	89018.5712	486674604.64
SE	100000.0000	1883.4950	87482.4324	88304.7517	164772723.97
CA	100000.0000	.0000	.0000	.0000	.00
ALL		18672.3130			1562835928.89

MARKET SUMMARY

IDENT.	QUANTITY DEMANDED	MARKET PRICE	CONSUMER OUTLAY	TARIFF COLLECTED
NW	2280.9050	82522.3920	188225736.51	.00
SW	2517.4250	89667.7233	225731768.22	.00
RK	1075.2080	90202.9771	96986962.65	.00
NC	4358.5290	96592.2817	421000260.85	.00
NE	2479.0190	95554.7517	236882045.06	.00
SO	5961.2270	94568.5712	563744719.72	.00
ALL	18672.3130		1732571493.02	

TRADE FLOWS AND OPPORTUNITY COSTS

SOURCE	DESTINATION	QUANTITY SHIPPED	OPPORTUNITY COST	TRANSFER COST	SHIPPING COST	TARIFF COST
WW	NW	2280.9050	706.1484	2410.00	5496981.05	.00
WW	SW	2098.6760	1441.4797	8820.00	18510322.32	.00
WW	RK	.0000	1906.7336	8890.00	.00	.00
WW	NC	3813.7900	1636.0381	15550.00	59304434.50	.00
WW	NE	.0000	-2131.4918	18280.00	.00	.00
WW	SO	491.7830	-287.6724	15450.00	7598047.35	.00
WE	NW	.0000	-1845.2791	2550.00	.00	.00
WE	SW	.0000	.0521	7850.00	.00	.00
WE	RK	.0000	1525.3060	6860.00	.00	.00
WE	NC	365.6090	1674.6105	13100.00	4789477.90	.00
WE	NE	595.5240	-1732.9194	15470.00	9212756.28	.00
WE	SO	.0000	-279.1000	13030.00	.00	.00
SW	NW	.0000	-6668.5874	4990.00	.00	.00
SW	SW	418.7490	-103.2561	5570.00	2332431.93	.00
SW	RK	.0000	-2118.0022	8120.00	.00	.00
SW	NC	.0000	-1078.6977	13470.00	.00	.00
SW	NE	.0000	-4486.2277	15840.00	.00	.00
SW	SO	.0000	-3012.4082	13380.00	.00	.00
RM	NW	.0000	-10378.3804	6930.00	.00	.00
RM	SW	.0000	-4883.0491	8580.00	.00	.00
RM	RK	1075.2080	-97.7952	4330.00	4655650.64	.00
RM	NC	179.1300	-508.4907	11130.00	1993716.90	.00
RM	NE	.0000	-5516.0207	15100.00	.00	.00
RM	SO	.0000	-2852.2012	11450.00	.00	.00
SC	NW	.0000	-22118.2438	15660.00	.00	.00
SC	SW	.0000	-14852.9126	15540.00	.00	.00
SC	RK	.0000	-12617.6587	13840.00	.00	.00
SC	NC	.0000	-378.3541	7990.00	.00	.00
SC	NE	.0000	-4075.8841	10650.00	.00	.00
SC	SO	5469.4440	37.9353	5550.00	30355414.20	.00
SE	NW	.0000	-21840.0404	16880.00	.00	.00
SE	SW	.0000	-14694.7091	16880.00	.00	.00
SE	RK	.0000	-12459.4552	15180.00	.00	.00
SE	NC	.0000	-140.1507	9250.00	.00	.00
SE	NE	1883.4950	822.3193	7250.00	13655338.75	.00
SE	SO	.0000	646.1388	6440.00	.00	.00
CA	NW	.0000	-917477.6080	1000000.00	.00	.00
CA	SW	.0000	-910332.2767	1000000.00	.00	.00
CA	RK	.0000	-909797.0229	1000000.00	.00	.00
CA	NC	.0000	-903407.7183	1000000.00	.00	.00
CA	NE	.0000	-904445.2483	1000000.00	.00	.00
CA	SO	.0000	-905431.4288	1000000.00	.00	.00
ALL		18672.3130			157904571.82	

Run 2 (30 Percent Tariff on Shipments From Canada)

LR 28 – 1977 85/01/10. 21.07.34. 30% TARIFF ON SHIPMENTS FROM CANADA 86/04/21. 13.32.21. PAGE 1 REACTT

NUMBER OF SUPPLY AND DEMAND REGIONS AND PRODUCTS, DUMP FLAG AND ACCURACY

7 SUPPLY REGIONS
6 DEMAND REGIONS
2 PRODUCTS
DIAGNOSTIC OUTPUT LEVEL 2
REACTIVE PROGRAMMING ACCURACY = 2000.000
FLWSCL= 1000.
OBJSCL= 1000.
BIG = 1000000000.

PRODUCT 1 LUM LUMBER SUPPLY EQUATIONS

	INTERCEPT	LUM COEFFICIENT	PLY COEFFICIENT
WW	-339669.337	56.800	2.113
WE	-133615.035	105.804	10.044
SW	-470226.352	128.308	13.019
RM	-520796.508	139.745	9.940
SC	-481186.553	124.925	6.159
SE	-314040.135	130.052	7.308
CA	3877.089	8.615	.000

PRODUCT 1 LUM LUMBER DEMAND EQUATIONS

	INTERCEPT	LUM COEFFICIENT	PLY COEFFICIENT
NW	483616.423	-124.763	.000
SW	531053.577	-55.141	.000
RK	484494.069	-180.888	.000
NC	488194.653	-31.465	.000
NE	448538.719	-80.940	.000
SO	493826.813	-31.609	.000

PRODUCT 1 LUM LUMBER TARIFF COMPUTATION FLAGS

	NW	SW	RK	NC	NE	SO
FLAG	0	0	0	0	0	0

PRODUCT 1 LUM LUMBER TRANSPORTATION COSTS

	WW	WE	SW	RM	SC	SE	CA
NW	4590.	5370.	10490.	14590.	29610.	31920.	10120.
SW	16820.	16520.	11720.	18050.	29400.	31920.	19720.
RK	16160.	14430.	17090.	9110.	26180.	28710.	18810.
NC	29660.	27550.	28330.	23430.	15160.	17470.	27250.
NE	34870.	32550.	33310.	31770.	20060.	13520.	31250.
SO	29470.	27520.	28150.	24100.	9560.	10930.	30050.

PRODUCT 1 LUM LUMBER TARIFF RATES

	WW	WE	SW	RM	SC	SE	CA
NW	.0000	.0000	.0000	.0000	.0000	.0000	.3000
SW	.0000	.0000	.0000	.0000	.0000	.0000	.3000
RK	.0000	.0000	.0000	.0000	.0000	.0000	.3000
NC	.0000	.0000	.0000	.0000	.0000	.0000	.3000
NE	.0000	.0000	.0000	.0000	.0000	.0000	.3000
SO	.0000	.0000	.0000	.0000	.0000	.0000	.3000

PRODUCT 1 LUM LUMBER LOWER BOUND ON FLOWS

	WW	WE	SW	RM	SC	SE	CA
NW	0.	0.	0.	0.	0.	0.	0.
SW	0.	0.	0.	0.	0.	0.	0.
RK	0.	0.	0.	0.	0.	0.	0.
NC	0.	0.	0.	0.	0.	0.	0.
NE	0.	0.	0.	0.	0.	0.	0.
SO	0.	0.	0.	0.	0.	0.	0.

PRODUCT 1 LUM LUMBER UPPER BOUND ON FLOWS

	WW	WE	SW	RM	SC	SE	CA
NW	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
SW	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
RK	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
NC	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
NE	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
SO	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07

PRODUCT 1 LUM LUMBER SUPPLY STARTING VALUES

WW	WE	SW	RM	SC	SE	CA
7665.	2427.	4961.	4579.	4633.	3358.	10429.

PRODUCT 1 LUM LUMBER SUPPLY MAXIMA

WW	WE	SW	RM	SC	SE	CA
8116.	2428.	4962.	4670.	4782.	3359.	10924.

PRODUCT 1 LUM LUMBER DEMAND STARTING VALUES

NW	SW	RK	NC	NE	SO
2870.	7076.	1999.	11204.	3749.	11154.

PRODUCT 2 PLY PLYWOOD SUPPLY EQUATIONS

	INTERCEPT	LUM COEFFICIENT	PLY COEFFICIENT
WW	-118164.479	1.989	20.989
WE	-151974.472	10.705	217.915
SW	-58534.511	11.224	218.132
RM	-225886.760	11.168	208.671
SC	-308655.918	8.097	65.792
SE	-521450.482	9.608	306.337
CA	.000	.000	.000

PRODUCT 2 PLY PLYWOOD DEMAND EQUATIONS

	INTERCEPT	LUM COEFFICIENT	PLY COEFFICIENT
NW	340038.847	.000	-112.901
SW	231640.675	.000	-56.396
RK	543402.934	.000	-421.500
NC	218041.385	.000	-27.865
NE	222725.452	.000	-51.299
SO	271838.771	.000	-29.737

PRODUCT 2 PLY TARIFF COMPUTATION FLAG

	NW	SW	RK	NC	NE	SO
FLAG	0	0	0	0	0	0

PRODUCT 2 PLY PLYWOOD TRANSPORTATION COSTS

	WW	WE	SW	RM	SC	SE	CA
NW	2410.	2550.	4990.	6930.	15660.	16880.	1000000.
SW	8820.	7850.	5570.	8580.	15540.	16880.	1000000.
RK	8890.	6860.	8120.	4330.	13840.	15180.	1000000.
NC	15550.	13100.	13470.	11130.	7990.	9250.	1000000.
NE	18280.	15470.	15840.	15100.	10650.	7250.	1000000.
SO	15450.	13030.	13380.	11450.	5550.	6440.	1000000.

PRODUCT 2 PLY PLYWOOD TARIFF RATES

	WW	WE	SW	RM	SC	SE	CA
NW	.0000	.0000	.0000	.0000	.0000	.0000	.0000
SW	.0000	.0000	.0000	.0000	.0000	.0000	.0000
RK	.0000	.0000	.0000	.0000	.0000	.0000	.0000
NC	.0000	.0000	.0000	.0000	.0000	.0000	.0000
NE	.0000	.0000	.0000	.0000	.0000	.0000	.0000
SO	.0000	.0000	.0000	.0000	.0000	.0000	.0000

PRODUCT 2 PLY PLYWOOD LOWER BOUND ON FLOWS

	WW	WE	SW	RM	SC	SE	CA
NW	0.	0.	0.	0.	0.	0.	0.
SW	0.	0.	0.	0.	0.	0.	0.
RK	0.	0.	0.	0.	0.	0.	0.
NC	0.	0.	0.	0.	0.	0.	0.
NE	0.	0.	0.	0.	0.	0.	0.
SO	0.	0.	0.	0.	0.	0.	0.

PRODUCT 2 PLY PLYWOOD UPPER BOUND ON FLOWS

	WW	WE	SW	RM	SC	SE	CA
NW	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
SW	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
RK	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
NC	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
NE	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07
SO	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07	.1000E+07

PRODUCT 2 PLY PLYWOOD SUPPLY STARTING VALUES

WW	WE	SW	RM	SC	SE	CA
9509.	1115.	915.	1327.	5115.	1705.	0.

PRODUCT 2 PLY PLYWOOD SUPPLY MAXIMA

WW	WE	SW	RM	SC	SE	CA
100000.	100000.	100000.	100000.	100000.	100000.	100000.

PRODUCT 2 PLY PLYWOOD DEMAND STARTING VALUES

NW	SW	RK	NC	NE	SO
2271.	2628.	1082.	4803.	2673.	6229.

LR 28 – 1977 85/01/10. 21.07.34. 30% TARIFF ON SHIPMENTS FROM CANADA 86/04/21. 13.32.21. PAGE 3 REACTT
FINAL REPORT DUMP 2 LP ITERATIONS 2 TOTAL RP ITERATIONS 11
ACCURACY 2000.000 SCALE FACTORS FLWSCL, OBJSCL, AND BIG 1000. 1000. 1000000000.
COMMODITY LUM

PRODUCING REGION SUMMARY

IDENT.	MAX. Q. SUPPLIED	QUANTITY SUPPLIED	SUPPLY PRICE	IMPLICIT SUPPLY PRICE	PRODUCER REVENUE
WW	8116.1880	7774.9180	120356.7405	121684.6076	935763768.51
WE	2427.5520	2315.4940	120973.7536	121466.7193	280114000.65
SW	4962.4840	4622.4200	128313.2099	126784.6076	593117547.93
RM	4669.7200	4524.8890	123979.0615	124886.7193	560991491.60
SC	4782.0320	4700.8560	139754.0446	139426.7193	656963638.92
SE	3359.0240	3359.0240	136569.6356	135482.5803	458740683.49
CA	10924.0000	10109.7850	90971.8669	92132.7535	919706015.65
ALL		37407.3860			4405397166.74

MARKET SUMMARY

IDENT.	QUANTITY DEMANDED	MARKET PRICE	CONSUMER OUTLAY	TARIFF COLLECTED
NW	2881.9550	124054.4952	357519472.84	.00
SW	7119.0680	138504.6076	986023720.15	.00
RK	1942.2370	133167.4790	258642804.99	.00
NC	10853.9410	146674.3135	1591994345.39	266586933.61
NE	3700.7000	149002.5803	551413848.99	9324871.08
SO	10909.4850	148986.7193	1625368379.82	.00
ALL	37407.3860		5370962572.17	

TRADE FLOWS AND OPPORTUNITY COSTS

SOURCE	DESTINATION	QUANTITY SHIPPED	OPPORTUNITY COST	TRANSFER COST	SHIPPING COST	TARIFF COST
WW	NW	2881.9550	-892.2453	4590.00	13228173.45	.00
WW	SW	2496.6480	1327.8671	16820.00	41993619.36	.00
WW	RK	.0000	-3349.2615	16160.00	.00	.00
WW	NC	.0000	-3342.4270	29660.00	.00	.00
WW	NE	.0000	-6224.1602	34870.00	.00	.00
WW	SO	2396.3150	-840.0212	29470.00	70619403.05	.00
WE	NW	.0000	-2289.2584	5370.00	.00	.00
WE	SW	.0000	1010.8540	16520.00	.00	.00
WE	RK	.0000	-2236.2746	14430.00	.00	.00
WE	NC	.0000	-1849.4401	27550.00	.00	.00
WE	NE	.0000	-4521.1733	32550.00	.00	.00
WE	SO	2315.4940	492.9657	27520.00	63722394.88	.00
SW	NW	.0000	-14748.7147	10490.00	.00	.00
SW	SW	4622.4200	-1528.6023	11720.00	54174762.40	.00
SW	RK	.0000	-12235.7309	17090.00	.00	.00
SW	NC	.0000	-9968.8964	28330.00	.00	.00
SW	NE	.0000	-12620.6296	33310.00	.00	.00
SW	SO	.0000	-7476.4906	28150.00	.00	.00
RM	NW	.0000	-14514.5663	14590.00	.00	.00
RM	SW	.0000	-3524.4539	18050.00	.00	.00
RM	RK	1942.2370	78.4175	9110.00	17693779.07	.00
RM	NC	1085.8320	-734.7480	23430.00	25441043.76	.00
RM	NE	.0000	-6746.4812	31770.00	.00	.00
RM	SO	1496.8200	907.6578	24100.00	36073362.00	.00
SC	NW	.0000	-45309.5493	29610.00	.00	.00
SC	SW	.0000	-30649.4369	29400.00	.00	.00
SC	RK	.0000	-32766.5655	26180.00	.00	.00
SC	NC	.0000	-8239.7310	15160.00	.00	.00
SC	NE	.0000	-10811.4642	20060.00	.00	.00
SC	SO	4700.8560	-327.3252	9560.00	44940183.36	.00
SE	NW	.0000	-44435.1403	31920.00	.00	.00
SE	SW	.0000	-29965.0279	31920.00	.00	.00
SE	RK	.0000	-32112.1565	28710.00	.00	.00
SE	NC	.0000	-7365.3220	17470.00	.00	.00
SE	NE	3359.0240	-1087.0552	13520.00	45414004.48	.00
SE	SO	.0000	1487.0838	10930.00	.00	.00
CA	NW	.0000	-4328.9318	10120.00	.00	.00
CA	SW	.0000	521.1806	19720.00	.00	.00
CA	RK	.0000	-3905.9480	18810.00	.00	.00
CA	NC	9768.1090	1160.8865	27250.00	266180970.25	266586933.61
CA	NE	341.6760	-510.8467	31250.00	10677375.00	9324871.08
CA	SO	.0000	673.2923	30050.00	.00	.00
ALL		37407.3860			690159071.06	

LR 28 – 1977 85/01/10. 21.07.34. 30% TARIFF ON SHIPMENTS FROM CANADA 86/04/21. 13.32.21. PAGE 4 REACTT
FINAL REPORT DUMP 2 LP ITERATIONS 2 TOTAL RP ITERATIONS 11
ACCURACY 2000.000 SCALE FACTORS FLWSCL, OBJSCL, AND BIG 1000. 1000. 1000000000.
COMMODITY PLY

PRODUCING REGION SUMMARY

IDENT.	MAX. Q. SUPPLIED	QUANTITY SUPPLIED	SUPPLY PRICE	IMPLICIT SUPPLY PRICE	PRODUCER REVENUE
WW	100000.0000	8714.6780	80204.9623	80924.6018	698960420.12
WE	100000.0000	955.8130	81097.4929	82839.0216	77514037.93
SW	100000.0000	418.4350	84620.8761	84081.9887	35408336.29
RM	100000.0000	1252.1050	85923.0357	84809.0216	107584662.64
SC	100000.0000	5469.7510	89269.6892	88381.0948	488282971.54
SE	100000.0000	1883.0860	87679.4626	89317.7491	165107968.48
CA	100000.0000	.0000	.0000	.0000	.00
ALL		18693.8680			1572858397.00

MARKET SUMMARY

IDENT.	QUANTITY DEMANDED	MARKET PRICE	CONSUMER OUTLAY	TARIFF COLLECTED
NW	2273.7110	83334.6018	189478800.77	.00
SW	2517.7040	89651.9887	225717170.67	.00
RK	1078.5440	88796.8538	95771313.89	.00
NC	4381.9730	95939.0216	420402202.50	.00
NE	2459.2720	96567.7491	237486361.53	.00
SO	5982.6640	93931.0948	561958179.34	.00
ALL	18693.8680		1730814028.70	

TRADE FLOWS AND OPPORTUNITY COSTS

SOURCE	DESTINATION	QUANTITY SHIPPED	OPPORTUNITY COST	TRANSFER COST	SHIPPING COST	TARIFF COST
WW	NW	2273.7110	719.6395	2410.00	5479643.51	.00
WW	SW	2099.2690	627.0265	8820.00	18515552.58	.00
WW	RK	.0000	-298.1085	8890.00	.00	.00
WW	NC	3828.7850	184.0594	15550.00	59537606.75	.00
WW	NE	.0000	-1917.2131	18280.00	.00	.00
WW	SO	512.9130	-1723.8675	15450.00	7924505.85	.00
WE	NW	.0000	-312.8911	2550.00	.00	.00
WE	SW	.0000	704.4959	7850.00	.00	.00
WE	RK	.0000	839.3610	6860.00	.00	.00
WE	NC	379.6270	1741.5288	13100.00	4973113.70	.00
WE	NE	576.1860	.2563	15470.00	8913597.42	.00
WE	SO	.0000	-196.3981	13030.00	.00	.00
SW	NW	.0000	-6276.2743	4990.00	.00	.00
SW	SW	418.4350	-538.8873	5570.00	2330682.95	.00
SW	RK	.0000	-3944.0223	8120.00	.00	.00
SW	NC	.0000	-2151.8544	13470.00	.00	.00
SW	NE	.0000	-3893.1270	15840.00	.00	.00
SW	SO	.0000	-4069.7813	13380.00	.00	.00
RM	NW	.0000	-9518.4339	6930.00	.00	.00
RM	SW	.0000	-4851.0470	8580.00	.00	.00
RM	RK	1078.5440	-1456.1819	4330.00	4670095.52	.00
RM	NC	173.5610	-1114.0141	11130.00	1931733.93	.00
RM	NE	.0000	-4455.2866	15100.00	.00	.00
RM	SO	.0000	-3441.9409	11450.00	.00	.00
SC	NW	.0000	-21595.0874	15660.00	.00	.00
SC	SW	.0000	-15157.7004	15540.00	.00	.00
SC	RK	.0000	-14312.8353	13840.00	.00	.00
SC	NC	.0000	-1320.6675	7990.00	.00	.00
SC	NE	.0000	-3351.9400	10650.00	.00	.00
SC	SO	5469.7510	-888.5944	5550.00	30357118.05	.00
SE	NW	.0000	-21224.8608	16880.00	.00	.00
SE	SW	.0000	-14907.4738	16880.00	.00	.00
SE	RK	.0000	-14062.6088	15180.00	.00	.00
SE	NC	.0000	-990.4409	9250.00	.00	.00
SE	NE	1883.0860	1638.2865	7250.00	13652373.50	.00
SE	SO	.0000	-188.3678	6440.00	.00	.00
CA	NW	.0000	-916665.3982	1000000.00	.00	.00
CA	SW	.0000	-910348.0113	1000000.00	.00	.00
CA	RK	.0000	-911203.1462	1000000.00	.00	.00
CA	NC	.0000	-904060.9784	1000000.00	.00	.00
CA	NE	.0000	-903432.2509	1000000.00	.00	.00
CA	SO	.0000	-906068.9052	1000000.00	.00	.00
ALL		18693.8680			158286023.76	

Appendix 6: Subroutine REACT

A complete listing of all subroutines in REACTT is over 2,000 lines; rather than append the entire program, we include here only subroutine REACT. This subroutine displays the detailed reactive programming computations outlined in equations (14-20). Users interested in modifying REACTT to incorporate different or mixed functional forms (for example) can examine this subroutine to get an idea of how they might proceed. A full listing of REACTT is available from the authors.

```
      SUBROUTINE REACT
C
      PARAMETER (MAXREG=20, MAXPRO=5)
      COMMON / PARAM / NSUP, NDEM, NPROD, NPAGE, NLIN, LINMAX,
     2        DUMP, RUNERR, EPS, MAXIT
      INTEGER DUMP, RUNERR
C
      COMMON / ALPHA / TITLE, RDATE, RTIME, REGSUP(MAXREG),
     2        REGDEM(MAXREG), PROD(MAXPRO)
      CHARACTER *80 TITLE
      CHARACTER *10 RDATE, RTIME
      CHARACTER *2 REGSUP, REGDEM
      CHARACTER *3 PROD
C
      COMMON / RPCOM / ACCR,SUPPLY(MAXPRO+1,MAXREG, MAXPRO),
     2        DEMAND(MAXPRO+1,MAXREG,MAXPRO), PA(MAXREG, MAXPRO),
     3        PT(MAXREG,MAXPRO), PC(MAXREG,MAXPRO), X(MAXREG, MAXPRO),
     4        TC(MAXREG,MAXREG,MAXPRO), UUU(MAXREG,MAXREG, MAXPRO),
     5        LLL(MAXREG,MAXREG,MAXPRO), Q(MAXREG,MAXREG, MAXPRO),
     6        C(MAXREG,MAXPRO), P(MAXREG,MAXPRO), FLWSCL, OBJSCL, BIG,
     7        TARIFF(MAXREG,MAXREG,MAXPRO), TFLAG(MAXREG)
      REAL LLL
      INTEGER TFLAG, BIG
C
      COMMON / REACTP / R(MAXREG,MAXPRO), S(MAXREG,MAXPRO),
     1        PREV(MAXREG), IFAS(MAXREG,MAXPRO), IX(MAXREG, MAXPRO),
     2        NOLD, NRPIT, NLPIT, JX(MAXREG,MAXPRO), ISP 9MAXREG,MAXPRO)
              REAL ISP
      INTEGER PRINTS, FINIS, SKIP
      CHARACTER *130 DESC, DTWO
C— — — — — — — — — — — — — — — — — — — — — — — — — — — — — — —
C  THE REACTIVE PROGRAMMING ALGORITHM WAS FIRST DESCRIBED BY
C  TRAMEL AND SEALE (1959), AND DESCRIBED IN MORE DETAIL BY TRAMEL
C  (1965). THIS CODE IS BASED ON THE 'TRAMEL / NCSU' PROG. PUBLISHED BY
C  KING AND HO (1972). J.  ARTHUR AND B. McCARL EXPANDED THE CODE TO
C  ACCOMMODATE PRODUCTS AND SUBSTITUTED 'NETFLO' FOR THE ORIGINAL
C  TRANSPORTATION PROBLEM SUBROUTINE. FURTHER REVISIONS TO THE
C  CODE WERE MADE  BY J. KINCAID AND D.  BROOKS.  LAST REV. FEB. 1986.
C — — — — — — — — — — — — — — — — — — — — — — — — — — — — — — —
      NOLD=0
      PRINTS=10
      ITEST=4
      FINIS=5
C
      DO 10 I=1,MAXREG
      DO 10 J=1,MAXPRO
```

```
                IX(I,J)=0
                JX(I,J)=0
                IFAS(I,J)=0
                P(I,J)=0.0
                R(I,J)=0.0
                C(I,J)=0.0
                S(I,J)=0.0
                ISP(I,J)=0.0
      10        CONTINUE
C
                DO 25 I=1,NSUP
                DO 25 K=1,NPROD
                IX(I,K)=1
                DO 20 J=2,NPROD+1
                IF(ABS(SUPPLY(J,I,K)) .GT. EPS) GO TO 25
      20        CONTINUE
                IX(I,K)=0
      25        CONTINUE
C
                DO 27 K=1,NPROD
                DO 27 J=1,NDEM
                JX(J,K)=1
                DO 26 I=2,NPROD+1
                IF(ABS(DEMAND(I,J,K)) .GT. EPS) GO TO 27
      26        CONTINUE
                JX(J,K)=0
      27        CONTINUE
C
                DO 40 K=1,NPROD
                SUPMAX=PT(1,K)
                INDEX=1
                SUPTOT=0.0
                DEMTOT=0.0
                DO 30 I=1,NSUP
                PA(I,K)=PT(I,K)
                IF(PA(I,K) .GT. SUPMAX) THEN
                        INDEX=I
                        SUPMAX=PA(I,K)
                        ENDIF
                SUPTOT=SUPTOT+PA(I,K)
      30        CONTINUE
                DO 35 J=1,NDEM
                DEMTOT=DEMTOT+X(J,K)
      35        CONTINUE
                DIF=DEMTOT-SUPTOT
                IF(ABS(DIF) .LT. .001) GO TO 0
                OLD=PA(INDEX,K)
                PA(INDEX,K)=OLD+DIF
                PT(INDEX,K)=PA(INDEX,K)
                IF(DUMP .GE. 1) WRITE(2,6010) K,PROD(K),INDEX,REGSUP(INDEX),
          2             OLD, DIF, PA(INDEX,K)
      6010      FORMAT(/' *** WARNING IN REACT'/' FOR PRODUCT',I2,1X,A3,
          2             ' REGION ',I2,1X,A2/' ALLOCATION ',F12.3,'CHANGED BY ',
          3             F12.3,' TO ',F12.3)
      40         CONTINUE
C
                NRPIT=0
                NLPIT=0
                DO 49 K=1,NPROD
```

```
            DO 48 I=1,NSUP
            IFAS(I,K)=0
   48       S(I,K)=PA(I,K)
            DO 49 J=1,NDEM
   49       R(J,K)=X(J,K)
C                   BEGIN BY SOLVING NETWORK ALLOCATION PROBLEM
            GO TO 400
   80       IF(MOD(NRPIT,ITEST).EQ.0) THEN
                DO 81 K=1,NPROD
                DO 81 I=1,NSUP
                IFAS(I,K)=0
   81       CONTINUE
                ENDIF
C                            START REACTIVE PROGRAMMING ALGORITHM
            NRPIT=NRPIT+1
            FINIS=0
            DO 225 K=1,NPROD
            DO 225 I=1,NSUP
            DO 85 J=1,NDEM
            R(J,K)=0.
   85       S(J,K)=0.
            IF(PT(I,K))88,87,88
   87       IF(IX(I,K) .EQ. 0) GO TO 225
   88       CONTINUE
            IF(IFAS(I,K))225,93,225
C           CALCULATE TOTAL NET REVENUE (SUM), TOTAL SHIPMENTS (CNT) AND
C           AVERAGE NET REVENUE
   93       COST=C(I,K)
            SUM=0.0
            CNT=0.0
            DO 100 J=1,NDEM
            IF(Q(I,J,K))98,100,98
   98       IF(TFLAG(J) .GE. 1) THEN
                  SUM=SUM+(P(J,K)-(COST+TC(I,J,K))*(1.0+TARIFF(I,J,K)))*
         2             Q(I,J,K)
                             ELSE
            SUM=SUM+(P(J,K)-COST*(1.0+TARIFF(I,J,K))-TC(I,J,K))*Q(I,J,K)
                             ENDIF
            CNT=CNT+Q(I,J,K)
  100       CONTINUE
            PROT=CNT
            IF(CNT)102,107,102
  102       AVPN=SUM/CNT
C           AVPN REMAINS > 0 ONLY WHEN PT = PC (PRODUCTION ATCAPACITY)
            IF(AVPN)107,107,104
  104       IF(IX(I,K))                    106,105,106
  105       IF(CNT-0.99999*PT(I,K))        107,108,108
  106       IF(PC(I,K)-1.001*PT(I,K))      108,108,107
  107       AVPN=0.0
  108       SKIP=0
C                   DEFINE SLOPE OF PRICE-DEPENDENT SUPPLY EQUATION (SLOPS)
            IF(IX(I,K) .EQ. 0) THEN
  114       SLOPS=0.0
            GO TO 123
            ENDIF
  116        IF(PT(I,K) .GE. PC(I,K)) THEN
                SLOPS=0.0
                GO TO 123
                ENDIF
  122       SLOPS=SUPPLY(K+1,I,K)
C           CALCULATE NET PRICE FOR SHIPMENTS TO THECURRENT MARKET (SKP)
```

```
      123  CONTINUE
           DO 160 J=1,NDEM
           IF(JX(J,K) .EQ. 0) GO TO 160
           IF(NRPIT .GE. ITEST) GO TO 125
           IF(Q(I,J,K) .EQ. 0) GO TO 159
      1251 iF(TFLAG(J) .GE. 1) THEN
                  SKP=P(J,K)-(COST+TC(I,J,K))*(1.0+TARIFF(I,J,K))-AVPN
                          ELSE
                  SKP=P(J,K)-COST*(1.0+TARIFF(I,J,K))-TC(I,J,K)-AVPN
                  ENDIF
      1251 IF(SKP) 126,159,1
C                 CHECK NET PRICE AGAINST ACCURACY (ACCR)
      126  IF(Q(I,J,K))127,159,127
      127  IF(SKP+ACCR)129,159,159
      128  IF(SKP-ACCR)159,159,129
      129  SKIP=5
           FINIS=5
C                 DEFINE SLOPE OF PRICE-DEPENDENT DEMAND EQUATION (SLOPD)
      140  SLOPD=DEMAND(K+1,J,K)
C                 COMPUTE NEW SHIPMENT S(J) USING NEWTON'S APPROXIMATION
      141  S(J,K) = Q(I,J,K)-SKP/(SLOPD-SLOPS)
C                 ADJUST PRODUCTION TOTAL (PROT)
           IF(S(J,K) .LE. 0) THEN
      145  IF(Q(I,J,K) .GE. X(J,K)) THEN
      146  S(J,K)=0.5*Q(I,J,K)
           GO TO 149
           ENDIF
      147  IF(Q(I,J,K) .GE. PROT) THEN
              S(J,K)=0.5*Q(I,J,K)
              GO TO 149
              ENDIF
      148  S(J,K)=0.0
           ENDIF
      149  PROT=PROT-Q(I,J,K)+S(J,K)
C          CALCULATE NEW COST USING SUPPLY EQUATION
           IF(IX(I,K) .EQ. 0) GO TO 160
      150         COST=SUPPLY(1,I,K)
           DO 157 IJJ=1,NPROD
           PPP=PROT
           IF(K.NE.IJJ)PPP=PT(I,IJJ)
      155  COST=COST+PPP*SUPPLY(IJJ+1,I,K)
      157  CONTINUE
           GO TO 160
      159  S(J,K)=Q(I,J,K)
      160  CONTINUE
C
           DO 161 J=1,NDEM
           IF(JX(J,K) .EQ. 0) S(J,K)=Q(I,J,K)
      161  CONTINUE
C
           IF(SKIP)167,162,167
      162  IFAS(I,K)=1
           GO TO 225
C          CALCULATE DIFFERENCE BETWEEN CURRENT SUPPLY TOTAL AND CAPACITY
      164  PROT=0.0
           DO 166 J=1,NDEM
      166  PROT=PROT+S(J,K)
      167  INDIC=0
           IF(IX(I,K))169,172,169
```

```
 169  IF(PC(I,K)-PROT)171,171,170
 170  IF(AVPN)171,200,171
 171  DIFF=PROT-PC(I,K)
      GO TO 176
 172  DIFF=PROT-PT(I,K)
      IF(DIFF)174,200,174
 174  IF(AVPN)175,175,176
 175  IF(DIFF)200,200,176
 176  TOT=0.0
C     CALCULATE CHANGE IN DEMAND QUANTITY FOR A UNIT CHANGE IN PRICE
C             FOR EACH MARKET, R(J,K) AND TOTAL FOR ALL MARKETS, TOT
      DO 191 J=1,NDEM
      R(J,K)=0.
      IF(S(J,K) .EQ. 0) GO TO 191
 188  SLOPD=DEMAND(K+1,J,K)
 189  IF(SLOPD .EQ. 0) GO TO 191
      R(J,K)=1.0/SLOPD
      TOT=TOT+R(J,K)
 191  CONTINUE
C     RECALCULATE SHIPMENTS, S(J,K) BASED ON UNUSED CAPACITY,  DIFF
      DO 198 J=1,NDEM
      IF(S(J,K) .EQ. 0) GO TO 198
 194  IF(TOT .EQ. 0.0) GO TO 195
      S(J,K)=S(J,K)-(R(J,K)/TOT)*DIFF
 195  IF(S(J,K) .GT. 0) GO TO 198
 196  S(J,K)=0.5*Q(I,J,K)
      INDIC=5
 198  CONTINUE
C     CALCULATE NEW MARKET TOTAL, X(J,K) GIVEN REVISED SHIPMENTS
 200  DO 217 J=1,NDEM
      IF(S(J,K) .EQ. Q(I,J,K)) GO TO 217
 201  X(J,K)=X(J,K)-Q(I,J,K)+S(J,K)
C             CALCULATE NEW MARKET PRICE, P(J,K) USING DEMAND EQUATIONS
      DO 213 JK = 1,NPROD
              IF(JX(J,JK) .EQ. 0) GO TO 213
 205          P(J,JK) = DEMAND(1,J,JK)
              DO 211 JKK = 1,NPROD
 207                  P(J,JK) = P(J,JK) + DEMAND(JKK+1,J,JK) * X(J,JKK)
 211  CONTINUE
 213  CONTINUE
C     CALCULATE NEW SUPPLY TOTAL, PT(I) AND STORE NEW SHIPMENTS
 214  IF(IX(I,K))215,216,215
 215  PT(I,K)=PT(I,K)-Q(I,J,K)+S(J,K)
 216  Q(I,J,K)=S(J,K)
 217  CONTINUE
C             IF S(J) HAS BEEN SET ARBITRARILY, RECOMPUTE
      IF(INDIC)164,219,164
 219  CONTINUE
C             CALCULATE NEW COST,C(I) USING NEW SUPPLY TOTAL
C             FOR FIXED SUPPLY REGION,C(I) REMAINS EQUAL TO INTERCEPT
 220  CONTINUE
      DO 224 JK = 1,NPROD
 212          C(I,JK) = SUPPLY(1,I,JK)
              IF(IX(I,JK) .EQ. 0) GO TO 224
              DO 223 JKK = 1,NPROD
 221                  C(I,JK) =C(I,JK) + SUPPLY(JKK+1,I,JK) * PT(I,JKK)
 223          CONTINUE
 224  CONTINUE
```

```
  225 CONTINUE
C                                INTERMEDIATE REPORT
      IF(MOD(NRPIT,PRINTS) .EQ. 0) THEN
         IF(DUMP .LT. 3) GO TO 350
         IF(FINIS .EQ. 0) GO TO 350
         CALL REPORT(FINIS)
      ENDIF
  350 CONTINUE
C                   END RP IF MAXIMUM ITERATIONS HAVE BEEN REACHED
      IF(NRPIT .EQ. MAXIT) THEN
           FINIS=0
           IF(DUMP .GT. 1) WRITE(2,6007) NRPIT
 6007      FORMAT(' * * * MAXIMUM RP ITERATIONS REACHED * * *',
     2               ' * * * RP ITERATIONS = ',I6,' * * *')
           ENDIF
C                                CONTINUE RP IF FINIS NOT EQUAL 0
      IF(FINIS .NE. 0) GO TO 80
C          START NETWORK ALLOCATION SUBROUTINE
  400 NLPIT=NLPIT+1
      NOLD=NOLD+NRPIT
      NRPIT=0
      DO 420 K=1,NPROD
      DO 410 J=1,NDEM
      P(J,K)=0.0
  410 CONTINUE
      DO 420I=1,NSUP
      C(I,K)=0.0
      DO 420 J=1,NDEM
      Q(I,J,K)=0.0
  420 CONTINUE
C
      CALL SETUP
C
      IF(RUNERR .NE. 0) THEN
         DUMP=3
         FINIS=0
         GO TO 600
         ENDIF
C                   NETWORK ALLOCATION COMPLETED
C     UPDATE MARKET TOTALS X(J) AND PRODUCTION ALLOCATIONS PA(I,K)
      DO 510 I=1,NSUP
      DO 510 K=1,NPROD
      IFAS(I,K)=0 327
  510 PA(I,K)=0.0
      DO 520 J=1,NDEM
      DO 520 K=1,NPROD
  520 X(J,K)=0.0
      DO 530 I=1,NSUP
      DO 530 J=1,NDEM
      DO 530 K=1,NPROD
      X(J,K)=X(J,K)+Q(I,J,K)
  530 PA(I,K)=PA(I,K)+Q(I,J,K)
      DO 550 I=1,NSUP
      IF(IX(I,K) .EQ. 0) GO TO 550
      DO 540 K=1,NPROD
  540 PT(I,K)=PA(I,K)
  550 CONTINUE
```

```
C     RECOMPUTE SUPPLY PRICES C(I) AND MARKET PRICES P(J)
C     FOR A FIXED DEMAND REGION P(J) IS THE QUANTITY-WEIGHTED COST
C     FOR DELIVERIES TO THAT REGION
C     FOR A FIXED SUPPLY REGION C(I) IS THE INTERCEPT AND ISP(I) IS
C     THE OPPORTUNITY COST FROM THE NETWORK ALLOCATION
            DO 590 K=1,NPROD
            DO 580 I=1,NSUP
            ISP(I,K)=C(I,K)
C                     COMPUTE COST FROM SUPPLY EQUATION
            C(I,K)=SUPPLY(1,I,K)
            DO 570 KK=1,NPROD
            C(I,K)=C(I,K)+PT(I,KK)*SUPPLY(KK+1,I,K)
  570       CONTINUE
  580       CONTINUE
C
            DO 589 J=1,NDEM
            P(J,K)=DEMAND(1,J,K)
            IF(X(J,K) .EQ. 0.0) GO TO 589
            IF(JX(J,K) .EQ. 0) THEN
C                                           FIXED DEMAND
            P(J,K)=0.0
            DO 587 I=1,NSUP
            IF(TFLAG(J) .EQ. 0)
     1                WP=(C(I,K)*(1+TARIFF(I,J,K))+TC(I,J,K))*Q(I,J,K)/X(J,K)
            IF(TFLAG(J) .NE. 0)
     1                 WP=((C(I,K)+TC(I,J,K))*(1+TARIFF(I,J,K)))*Q(I,J,K)/X(J,K)
            P(J,K)=P(J,K)+WP
  587       CONTINUE
                      ELSE
  C                            COMPUTE PRICE FROM DEMAND EQUATION
            DO 588 KK=1,NPROD
            P(J,K)=P(J,K)+X(J,KK)*DEMAND(KK+1,J,K)
  588       CONTINUE
            ENDIF
  589       CONTINUE
  590       CONTINUE
  600       IF(FINIS .EQ. 0) THEN
C                                           FINAL REPORT
            IF(DUMP .GT. 0)CALL REPORT(FINIS)
            RETURN
            ENDIF
C
            IF(DUMP .LT. 3) GO TO 650
C                              INTERMEDIATE REPORT AFTER NETFLO
            IF(MOD(NRPIT,PRINTS) .EQ. 0)CALL REPORT(FINIS)
  650       CONTINUE
C
            GO TO 80
C
            END
```

Brooks, David J.; Kincaid, Janna. 1987. REACTT: an algorithm for solving spatial equilibrium problems. Gen. Tech. Rep. PNW-GTR-204. Portland. OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station 37 p..

The problem of determining equilibrium prices and quantities in spatially separated markets is reviewed. Algorithms that compute spatial equilibria are discussed. A computer program using the reactive programming algorithm for solving spatial equilibrium problems that involve multiple commodities is presented, along with detailed documentation. A sample data set, program output, and a partial program listing are also provided.

Keywords: Computer programs/programing, models, supply /demand (forest products)

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