# SIMULATING THE PERFORMANCE OF A MULTIPLE EXCHANGE MECHANISM MARKET

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The impact of a monopolist or monopsonist on the price and output performance in comparison with perfectly competitive markets is well documented. These markets are coordinated through spot market exchanges. However, most markets have combinations of alternative vertical exchange mechanisms (contracts, vertical integration, spot exchange, etc.). The price and output performance of a multiple exchange mechanism (M.E.M.) market when compared to a spot exchange mechanism (S.E.M.) market needs additional conceptual modeling. This paper evaluates the relative performance between markets with and without multiple exchange mechanisms, using a model derived with an explicit set of production functions.

A decline of spot markets and the continual emergence of contracts and vertical integration calls for a better understanding of the economic consequences of using multiple exchange mechanisms. Most research has dealt with analysis of firm level inducements for employing alternatives to spot markets (Arrow, Buccola, Logan, Perry, Stigler, Williamson). This article models the concept of a multiple exchange mechanism market, using Cobb-Douglas-type production functions. Simulated equilibrium price and market output indexes are developed to draw implications relative to the performance of a multiple exchange mechanism (M.E.M.) market relative to a spot exchange mechanism (S.E.M.) market. The alternative mechanisms for exchange are illustrated in Figure 1.

The transfer of x from node k to k+1 through a spot transaction does not provide a mechanism for direct control of the production and transfer functions by the buyer or seller. Such product characteristics are quality, time of delivery, and quantity are left virtually uncontrolled, except by the spot price negotiated. In contrast, contracting can provide direct control over the production and transfer functions. The risk of inferior product characteristics, uncertain prices, and poor technology can be reduced. With backward integration, product characteristics and the technology used to produce x are directly controlled by the buyer (node k+1), thus potentially eliminating much of the risk of quality uncertainties. Such control benefits may be partially or totally offset by the transactions cost of maintaining the non-spot exchange mechanisms.

## MULTIPLE EXCHANGE MECHANISM MODEL

Commodity x is produced with the input w assuming a traditional type production function as expressed in equation (1),

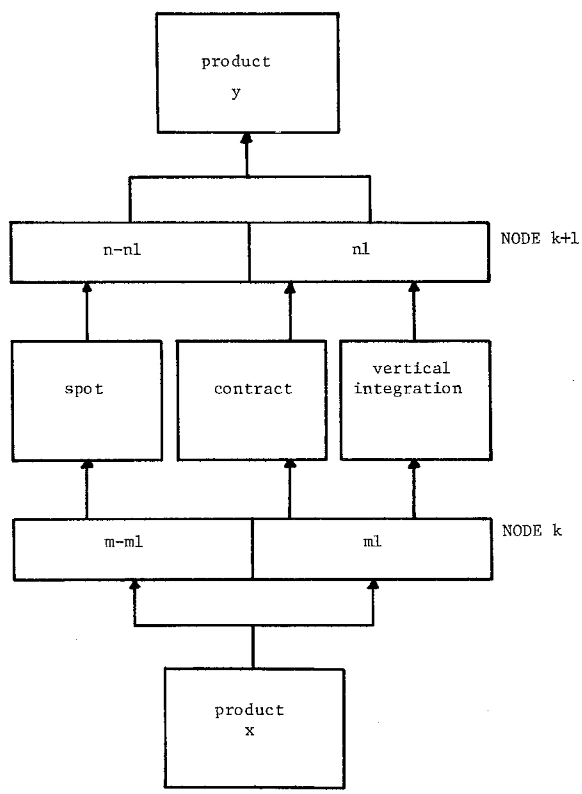


**FIGURE 1.** Alternative Exchange Arrangements for Product x

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(1) $x = a0\,[1+d][w]^{a1}$

where $0 < a1 < 1.0$ and $(1 + d) >= 0.0$. If parameter $d > 0$, then the productivity of w can be improved with non-spot exchange. For example, if, through vertical integration, n1 firms at node k+1 in Figure 1 start producing x, the firms then have greater control over the technical processes. Productivity may be improved if $d > 0$, and technical control over production may lead to the output of x having more desirable quality characteristics. However, the situation could exist in which a non-spot mechanism leads to lower productivity (e.g., non-mechanized harvesting) such that $-1 < d < 0$.

The input x used in producing y is assumed to be usable within a narrow band of product characteristics—timing, quantity, quality, location. For the vertically integrated firm, x would be produced with those product characteristics needed for the production of y. Under contracting, the producer of y can specify the desired product characteristics for x and improve productivity. Purchasing x in the spot market may lead to variation in product characteristics, which reduces the productivity of x. Product characteristics can also exchange as x is distributed from node k to k+1. Both contracting and vertical integration may provide more direct control relative to spot transactions as x is distributed to k+1.[1]

Let f represent the adjustments in y from using input x where the product characteristics of x vary within the narrow band discussed above. The production process assumed is

(2) $y = b0\,[1 + f]\,[x]^{b1}$

where $(1 + f) >= 0.0$ and $0 < b1 < 1.0$; y = final firm output; and x = input with a band of variation in product characteristics. Assuming that x is employed up to where the marginal value product equals the input price (Px) and using equation (2), the derived individual firm demand for x follows in equation (3):

(3) $xd = D0\,[Px],^{-(1/(1-b1))}$

where $D0 = [\,b0\,b1\,Py\,[1 + f]\,]^{(1/(1-b1))}$ and Py = price of output y.

The demand for x should differ among exchange mechanisms because f likely differs across exchange arrangements. If $f > 0$, then the demand through non-spot mechanisms exceeds that from spot demand because

$[1+f]^{(1/(1-b1))} > 1.0.$

The firm's supply of x is generated where the marginal cost of x is equated to the price of x. This cost includes fixed and variable production cost and the relative difference in transactions cost among coordinating mechanisms. The cost of producing x with specific production characteristics is defined in equation (4), where Pw includes the spot market transactions cost associated with transferring product x from node k to k+1 plus the price of the input w.

(4) $c = w\,Pw\,[1+q] + \text{fixed costs}$

The component q represents the net difference in transactions cost for supplying x through one of the non-spot exchange mechanisms instead of the spot mechanism. Note that the $1 + q > 0$ implies a positive cost, but does not preclude $q < 0$. Non-spot exchange could lead to greater efficiencies, in which case $-1 < q < 0$.

Using equations (1) and (4), the supply curve for x follows, assuming marginal cost equals Px:

(5) $xs = S0\,[Px]^{(a1/(1-a1))}$

where $S0 = [a0\,(1+d)[Pw\,a1/(1+q)]^{a1}].^{(1/1-a1))}$ Spot demand (xds) and supply (xss) are defined when $d = q = f = 0$, and from this base, both non-spot supply and demand are expressed as $xdv = [h][xdx]$ and $xsv = [r][xss]$, letting $h=[1+f]^{(1/1-b1))}$ and $r=[1+q]^{(-a1/(1-a1))}[1+d].^{(1/1-a1))}$ Given that n firms demand and m supply x of which n1 and m1 use a nonspot exchange, then the market demand and supply are readily calculated for the M.E.M. market.[2]

(6) $xD = \Sigma xds + \Sigma h\,xds = [n-n1+n1h]xds$

(7) $xS = \Sigma xss + \Sigma r\,xss = [m-m1+m1r]xss$

Define $Ed = 1/(1-b1)$ and $Es = (a1/(1-a1))$, and equating equations (6) and (7), then an equilibrium price is:

(8) $$Px = \left|\frac{Ds\;\;n(1 - n^* + n^*h)}{Ss\;\;m(1 - m^* + m^*r)}\right|^{(1/(Ed+Es))}$$

where $n^*=n1/n$ and $m^*=m1/m$. Note in (8) that the equilibrium price depends on both spot and non-spot activities.

## RELATIVE PRICE PERFORMANCE

The equilibrium price in equation (8) is based on a M.E.M. market. Comparing this price to a S.E.M. market gives an index of relative prices (RP) as in equation (9).

(9) $$RP = \left|\frac{1-n^*+n^*h}{1-m^*+m^*r}\right|^{(1/(Ed+Es))}$$

[1] For example, time delays, excess handling, transportation and shipping facilities, storage practices, and quantity delivered may be better controlled via the non-spot arrangements.

[2] It is assumed that the market demand curve of the input factor x is the horizontal summation of the individual firm's derived demand functions. This requires that the product being produced y does not vary in price as the quantity of factor input x increases.

Values of RP > 1.0 imply a greater equilibrium price under a M.E.M. market relative to a S.E.M. market, and this condition will be true so long as $1 + n^*[h-1] > 1 + m^*[r-1]$. Furthermore, the supply and demand must be equal for that proportion of x which is exchanged through each mechanism. Hence, in equilibrium, a weighting of the demand shifter (h) must equal a weighting of the supply shifter (r), such that $[n^*/(1-n^*)]h = [m^*/(1-m^*)]r$, or equally $r = [(1-m^*)/m^*][n^*/(1-n^*)]h$. Using these two conditions, the determining factor for establishing the direction of RP reduces to that derived in (10).

$$h[m^*-n^*] > [(1-n^*)/n^*][n^*-m^*] \tag{10}$$

Using (10) and given that $h > 0.0$, $n^* < 1.0$, and $m^* < 1.0$, then if $m^* > n^*$, the M.E.M. market is expected to have inflationary effects on the input price Px. Whereas, if $m^* < n^*$, price will fall in the M.E.M. market relative to a market with all spot transactions. This conclusion shows the direction of change, while all parameters must be known if the absolute level of RP is to be calculated. Referring to the relative price index (equation (9)) and using the condition where $m^* > n^*$, then the relative price will be greater than one so long as $[n^*][h] > [m^*][r]$. This inequality has a more intuitive interpretation in that so long as the shift in the demand resulting from the use of a non-spot mechanism exceeds the supply shift, the resulting equilibrium price will rise above that with spot transactions only.

## RELATIVE OUTPUT PERFORMANCE

Supplies forthcoming from M.E.M. and S.E.M. markets are readily shown, using the supply function in (7) and the equilibrium price of (8). The ratio of these supplies then gives a direct measurement of the performance of the M.E.M. market to the S.E.M. markets, as derived in equation (11).[3]

$$RS = [1-m^*+m^*r]^{(Ed/(Ed+Es))}[1-n^*+n^*h]^{(Es/(Ed+Es))} \tag{11}$$

When RS is greater than one, the M.E.M. supplies exceed S.E.M. market output. Equation (11) does not provide an immediate set of conditions on the parameters for determining when RS > 1.0 because both values in the brackets are raised to a power of the elasticities. If RS > 1.0 then $[1-m^*+m^*r]^{ED} > [1-n^*+n^*h]^{-Es}$. Each function can be expanded around 1.0, using a Taylor series approximation to the function. Using the expansion up to the first derivative, the remaining components of (11) are approximated as:[4]

$$[1-m^*+m^*r]^{Ed} \cong 1+Ed[r-1]m^* \tag{12}$$

$$[1-n^*+n^*h]^{-Es} \cong 1-Es[h-1]n^* \tag{13}$$

Then M.E.M. supplies exceed S.E.M. supplies if

$$1-Es[h-1]n^* < 1+Ed[r-1]m^* \tag{14}$$

Equation (14) can be used to explore the conditions in which output from a M.E.M. market would exceed that from a spot mechanism market. Using the equilibrium condition shown earlier, where $r = [(1-m^*)/m^*][n^*/(1-n^*)]h$ and substituting into (14) for r, the constraints on the product characteristics parameter (f) follow.

$$h > \left|\frac{Es\ n^* + Ed\ m^*}{Es(1-n^*)+Ed(1-m^*)}\right|\left|\frac{1-n^*}{n^*}\right| \tag{15}$$

$$f > \left\|\frac{Es\ n^* + Ed\ m^*}{Es(1-n^*)+Ed(1-m^*)}\right\|\left\|\frac{1-n^*}{n^*}\right\|^{(1/Ed)} - 1 \tag{16}$$

Thus, from (16) one can evaluate the output changes that might be expected, given alternative levels of non-spot coordination ($n^*,m^*$). Simulations of these limits are illustrated in Figures 2 and 3. Before discussing (16) in detail, one general coordinate of interest occurs when $n^*=m^*$. In this restrictive case, total output will always be greater in a M.E.M. market so long as $f > 0$ [see equation (2)].

If the proportion of non-spot coordination is weighted to the demand side (i.e., $n^*>m^*$), the M.E.M. market output will be larger so long as the product characteristics (f) differential between spot and non-spot commodities is greater than the negative f-min in Figure 2. Assuming that a non-spot exchange mechanism improves productivity (i.e., $f>0$), then a M.E.M. market leads to greater output when $n^* > m^*$. But when the proportion of sellers using a non-spot mechanism is greater than those buying ($m^* > n^*$), then in order for M.E.M. markets to be larger than spot markets, the characteristics of the product exchanged through a non-spot mechanism must be significantly greater than zero or f > f-min. The value of f must be above the surface shown in Figure 2.

The relative magnitude of output in a M.E.M. market varies also with the uniqueness of each industry, as measured with the elasticities of

[3] Indexes RS and RP were derived from specific production functions. The results following from these specifications are limited to the extent that (a) the functional form is reasonable; (b) output cannot be negative (i.e., $1+d > 0$, $1+f > 0$, and $1+g > 0$); and (c) production is in the second stage. The general solutions are not preconditioned on more restrictive values for d,f, or g. However, some of the subsequent discussions will be centered around the circumstances in which the M.E.M. leads to some productivity gains (i.e., $d > 0$ and/or $f > 0$).

[4] Equations (12) and (13) have been expressed as a power series in (h−t) and (r−t). Note that letting t=1 is equivalent to assuming that the Taylor series is expanded from values corresponding initially to the spot market or where d=f=0. Furthermore, if equation (12) is expanded for both variables in each power function (i.e., [m*,h] and [n*,r]), the results will be identical to those in (12) and (13), assuming t=1. Equations (12) and (13) show the minimum conditions that must exist for f in order for output to have increased, given a particular degree of coordination.

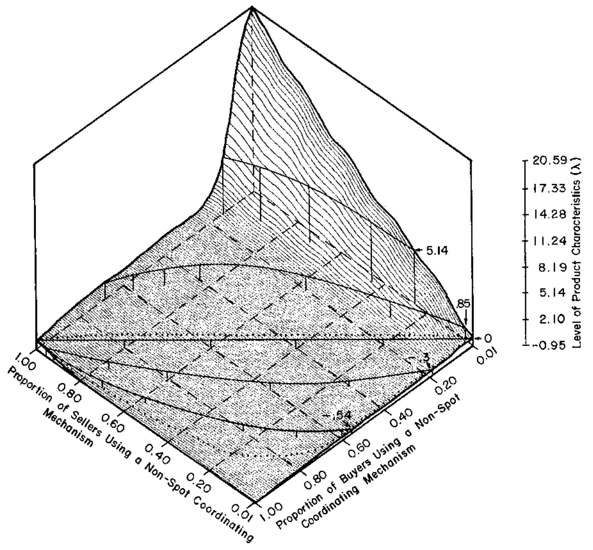


**FIGURE 2.** The Minimum Level of Product Characteristics Required for a MEM Market Output to be Greater than SEM Market

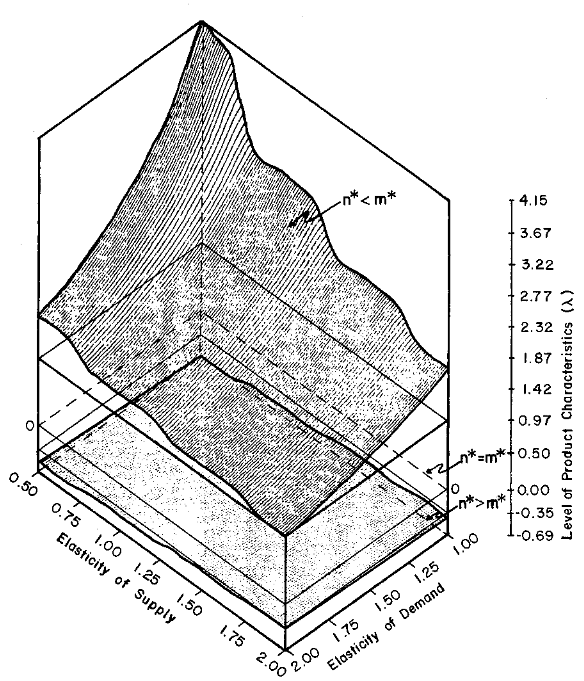


**FIGURE 3.** The Minimum Level of Product Characteristics Required for MEM Market Output to be Greater than a SEM Market for Different Elasticities

supply and demand. When the non-spot intensity is concentrated among the buyers ($n^* > m^*$), then the minimum level of f lies below the zero plane in Figure 3. If the non-spot mechanism assures that $f > 0$, then net gains in output through a M.E.M. market would always be expected, regardless of the elasiticity levels. Furthermore, this increase in output would occur while the new equilibrium price is lower than would be the case with spot transactions only [see equation (9)]. In contrast, when $m^* > n^*$, the role of elasticities becomes considerably more important to the analysis, as shown with the upper plane in Figure 3. A decline in the elasticity of demand leads to increases in f-min; whereas, the more elastic the supply, the lower fmin becomes. Hence, coordination in markets that have low elasticities and a concentration of non-spot sellers ($m^* > n^*$) is less likely to yield net increases in output over that of spot exchange. Supplies would increase only if $f >$ f-min and f-min are relatively large as evidenced by the upper shaded portion of Figure 3.

Figure 3 provides a framework for evaluating the potential performance expected across markets. In general, agricultural markets are most likely depicted by the lower plane where $n^* > m^*$ or where many producers face a few buyers. The model suggests that multiple mechanisms would lead to greater output at lower equilibrium prices. The fact that $n < m$ does not assure that $n^* > m^*$; but there should be a high positive correlation between the two.

## POTENTIAL APPLICATION

The M.E.M. market model can be operationalized by using estimates of elasticities of supply (Es) and demand (Ed) and estimates of the parameters reflecting the potential cost and benefits from non-spot exchange (i.e., d,f, and g). These parameters could be estimated directly for those markets that have moved from an S.E.M. to an M.E.M. market. Alternatively, they might be approximated by using managerial judgment. Once they are known for a particular commodity market, performance can be evaluated over various levels of coordination intensity (i.e., $n^*$ and $m^*$), using equations (9) and (11).

Risk can be introduced if d,f, and g are considered to be stochastic, which will make the RP and RS indexes stochastic. Furthermore, dynamics could be entered into the model by allowing for the possibility of change in d,f, and g over time. Stability depends upon the nature of the stochastic and adjustment processes.

## SUMMARY AND CONCLUSIONS

It was assumed that the exchange performance of alternative exchange mechanisms varies depending upon its effect on product characteristics, tranactions cost, and technology. A multiple exchange mechanism (M.E.M.) market model was developed to evaluate market performance. Performance was measured by comparing prices and supplies forthcoming through M.E.M. and S.E.M. markets.

The price and output effects of a M.E.M. market when compared with a S.E.M. market depend greatly on the proportion of buyers using a non-spot exchange mechanism relative to the proportion of sellers using non-spot exchange mechanisms. As the proportion of non-spot sellers (m*) increases relative to non-spot buyers (n*), the non-spot coordination effect on product characteristics, transactions cost, and technology must be greater. Thus, the demand for use of a non-spot coordinating mechanism by sellers can offset the potential gains in output to be realized from non-spot coordination. This happens even though the price received in a M.E.M. market is greater than a price in a S.E.M. market, when the proportion of sellers using a non-spot coordination mechanism is greater than the proportion of buyers using the same mechanism.

When the relative demand for the use of a non-spot coordinating mechanism by buyers (n*) is greater than by sellers (m*), and non-spot coordinating mechanisms improve product characteristics ($f > 0$), then (1) the M.E.M. market price is less than the S.E.M. market price, and (2) the M.E.M. market output is greater than the S.E.M. market output. Whereas, the competitive market can be shown, under certain conditions to yield the largest output among economic models. The M.E.M. market addressed in this article can be shown to provide a larger output and lower price under a different set of structural conditions.

The generality of these conclusions needs further research. The analytical model in this article assumed a Cobb-Douglas-type production function, hence leading to certain restrictions on the elasticity for the derived input demand. Different approaches to entering the non-spot market characteristics into the model could be considered. Risk needs to be incorporated into the model, as well as the dynamics of adjustments. Nevertheless, this model provides the basic framework for incorporating both structural differences and degrees of coordination into one framework, from which additional variations can be built.

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