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FURTHER OBSERVATIONS, SUMMARY, AND CONCLUSIONS

IN this final chapter, we first comment on interindustry results reported in previous chapters and then compare our results with those reported in the literature. An over-all summary and conclusion is contained in section C.

A. INTERINDUSTRY DIFFERENCES

Impact effects, distributed lags, and long-run coefficients show substantial variation among industries, reflecting corresponding variation in industrial structure. Many of the systematic patterns among the results were noted above and need not be repeated. Instead, we concentrate on the three salient features of the results: (i) Response patterns for nondurable industries are slower and displaced one or two quarters behind those in durables; (ii) long-run sales responses tend to be much greater in durables, in contrast to long-run price effects, which are similar and small among all industries; (iii) distributed lag patterns do not converge in several nondurable industries.

An explanation for these divergences must be sought in the underlying characteristics of the two types of industry. Sales and price variability as measured by the coefficient of variation is much higher in durables than in nondurables. Furthermore, as measured by wage rates, workers in the durables industries tend to be more skilled and, also, more highly unionized (Lewis [1963]). The fraction of woman workers is much greater in nondurables than in durables, and turnover rates tend to be slightly higher in these industries. Finally, as indicated in Appendix B, Tables B.1 to B.5, utilization rates are significantly higher in nondurables over the sample period, in part because of the lower variation in output and the manner in which utilization is measured. All these factors suggest that input responses should be *slower* in durables than in nondurables. Yet the reverse behavior is observed.

One clue toward resolution of the issue is provided by the large differential impact effect of sales on inventories between industries. The immediate inventory response is strong and positive for most durable industries, but strongly negative for most nondurables. This difference might be due to differences in the composition of total inventories (Y_5) between groups. Finished goods constitute about 50 per cent of total inventory in nondurable manufacturing, but only about 33 per cent in durables (*Survey of Current Business*). Purchased materials constitute about 30 to 35 per cent of total inventories in both. However, the main difference is in the relative proportions of goods in process. For example, in total durables it is about 40 per cent of the total, while in total non-durables it is about 13–15 per cent of the total. These breakdowns suggest that in durables the initial impact of a change in sales is mainly borne by finished goods inventories, but in durables, by all types of inventory, and especially goods in process. Finished goods evidently serve as a better buffer against sales fluctuations in nondurables, which exhibit smaller relative sales variations. Finished goods inventories are likely to be relatively interchangeable with "inventories" of productive inputs, whereas goods in process are more likely to be complementary to other factors of production. Inventories of finished goods provide a wedge between sales variations and input decisions. In contrast, goods in process do not serve this function. Hence, input decisions can be delayed in industries where the proportion of finished goods inventories is higher, that is, in nondurable industries. These relationships imply relatively stronger and direct linkages between inventories and productive inputs in the case of durables, forcing more rapid adjustments of inputs to changes in sales in those industries.[1]

Some further evidence is provided by the relative behavior of unfilled orders and new orders in the two types of industry. Both mean and relative

1. It can be argued that if the inventory-sales ratio is high, the buffer function of inventories should be greater, independently of composition. This ratio is higher for durables than nondurables in our data and seemingly goes against the argument in the text. However, note that this ratio is not an exogenous variable in our model and may merely reflect the same kinds of forces underlying the delayed adjustment as those already mentioned.

variance of unfilled orders is much higher in durables than in nondurables (see Tables B.1 and B.4 in Appendix B). Large backlogs reflected by unfilled orders in durables are in fact a type of inventory "held" by *buyers* rather than sellers. These "inventories" arise because a large fraction of durables manufacture is made to order, to the technical specifications of the buyer. These goods are "thinly" traded, because of their technical specificity. On the other hand, backlog "inventories" in nondurable industries are extremely small, because these goods are homogeneous and easily marketed. These technological differences link sales and production decisions and hence input decisions more closely in durables than in nondurables.

We conclude that this relation between inventory and sales variability is stronger than and outweighs higher "adjustment costs" in durables in linking input decisions over time. Therefore, input lags to sales shocks are shorter in durable goods. These same factors also contribute to lack of convergence of estimated responses in some nondurable industries. Note that production function restrictions have not been imposed a priori on the estimates. In most cases the smallest characteristic root is near zero, implying that the restrictions come close to being fulfilled. It still remains true that the production function is overidentified. If the restrictions held identically, and the scale parameters were exactly identified, the result—that returns to scale are much higher in durable goods industries than in nondurables—would reinforce our interpretation of the response patterns described above, namely, if returns to scale are sharply diminishing, firms will not find it optimal to adjust output very rapidly. As it stands, the estimated long-run sales elasticities can only be suggestive in this regard.

B. COMPARISONS WITH THE LITERATURE: EMPIRICAL RESULTS

As mentioned in Chapter 2, the model underlying this study is a generalization of existing employment investment functions. It presents new evidence on the interpretation of short-term employment and investment functions obtained by less general methods.

It was noted in Chapter 1 that previous short-run employment functions yielded implausibly high short-run returns to scale to labor inputs and exceedingly long lags of adjustment (Brechling [1965], Jorgenson [1963]). There are two possible explanations for these results in the context of the present model.

First, if one takes the fixed output constraint of the production function seriously, there is a good possibility that observed long adjustment lags of labor may really be only "sympathetic" reflections of long lags elsewhere in the system. In model (4.1) this possibility is allowed for by specifying the interdependence of adjustment lags among all inputs. Thus, if capital stock or nonproduction employment or both are the real sources of adjustment delays in the system, all other inputs will reflect the long lags of these two factors as a matter of course, because the output or sales constraint must be maintained during the adjustment period. Indeed, that is one of the major empirical findings of the present study. Most of the lag distributions on capital stock are of the familiar "bell" pattern and imply exceedingly long response lags. On the other hand, most of the responses of production employment and utilization rates tend to overshoot their long-run equilibrium values fairly soon after the shock, so that the sales-production function constraints are maintained while capital changes. Use of the Koyck or stock adjustment formulation in the absence of interaction terms simply precludes the possibility of ever estimating response patterns of the sort we found above, and such restrictions are clearly unwarranted. Thus, the small stock adjustment coefficients estimated in most time-series employment models really do not reflect costly labor adjustment alone, but also adjustment costs elsewhere in the system, and therefore have no ready interpretation. It must be noted, however, that in those studies using disaggregated data for the United States, adjustment delays in nondurable industries tend to be longer than those in durables (Dhrymes [1969]), a finding also derived in the present study.

Secondly, model (4.1) allows us to perform certain conceptual experiments that are capable of generating all possible short-run input demand functions, depending on what factors are considered to be "fixed" in the short run. Since our initial four-equation model (Nadiri and Rosen [1969]) using labor and capital stocks and utilization rates and real output rather than sales is more comparable with models in the literature than with our expanded model, these experiments were first performed with the former estimates.

i. The labor stock adjustment model considered in the literature can be approximated arbitrarily in our larger model by conceptually fixing Y_3 (capital stock) and Y_4 (general utilization) in the short run and treating them as parameters and ignoring inventories and nonproduction labor.

This reduces the model to a two-equation interrelated model in labor stock and labor utilization. On the basis of our earlier results, estimated short-run output elasticities under this procedure are 1.36 for employment stock (Y_1) and 0.12 for hours per man (Y_2). Hence, estimated returns to scale for employment equal $1/1.36 = 0.735$, suggesting decreasing returns, as is indicated in the theory; and these values are far below most of the usual ones estimated, which typically range above unity. To approximate returns to "scale" for total man-hours, output coefficients of Y_1 and Y_2 may be added, resulting in estimated short-run returns to scale for total labor input of 0.68.

ii. If capital services are allowed to vary by fixing capital stock only (Y_3), the conceptual experiment is performed by working with a three-equation interrelated model in Y_1, Y_2, and Y_4. These three equations are used to solve for the stationary values of Y_1, Y_2, and Y_4 in terms of output (Q), w/c, T, and Y_3. Now output elasticities are estimated as 0.77 for Y_1, 0.14 for Y_2, and 0.81 for Y_4. Estimated returns to scale are 1.30 for Y_1, and 1.10 for man-hours of production workers.

Taken at face value, these experiments suggest the following conclusion. The reason for large returns to scale, for labor estimated from short-run employment functions is that the rate of utilization of capital is omitted. These high estimates should not be considered as returns to labor alone, but are interpreted more properly as short-run returns to both labor and capital utilization. We note that similar conclusions have been reached in a more recent discussion of the issue, though from a rather different approach (Ireland and Smyth [1967]).

Similar experiments were performed with the full model aggregate estimates for total manufacturing (Table 4.1) and are presented in Table 7.1. The equations corresponding to the inputs considered "variable" for experimental purposes were solved for steady state values in terms of sales, w/c, T, and the inputs considered "fixed," as in the experiment above. Thus, the first line gives the results for a two-equation subsystem; the second line, for a three-equation subsystem; and so on. The results from the first two lines are very similar to the results reported above for the simpler four-equation full-model estimates: decreasing returns to production labor if capital utilization is considered to be "fixed," and increasing returns if it is considered to be "variable." There are still "increasing returns" to labor as inventories (line 3) and finally nonproduction labor are allowed to "vary"; these too must be considered as factors accounting for estimated short-run increasing returns to labor in previous short-run employment studies.

Generally speaking, according to the Le Chatelier principle, when some of the inputs are assumed to be fixed, the estimated "stationary" responses, shown in Table 7.1, of the "variable" inputs should be greater than the "fixed" variables when all factors are free to vary (given the sales constraint). The long-run elasticities of the full model based on Table 4.1 were 0.73 for Y_1, $-$ 0.130 for Y_2, 1.20 for Y_4, 0.177 for Y_5, and 0.156 for Y_6. Comparing these figures with those of Table 7.1, it is seen that the expectation is usually borne out for Y_2, Y_4, Y_5, and Y_6. On the other hand, it is true for Y_1 only in the first experiment.

Some qualifications to these results should be kept in mind:

i. These experiments are truly conjectural in nature, since model (4.1) stresses the dynamic interrelationships of all factors. In our model, all inputs are specified as "quasi-fixed," and none of them are really entirely fixed in the "short run." Thus, arbitrarily fixing some inputs for the purpose of the exercise is, strictly speaking, outside the framework of the model. Yet the procedure is suggested for purposes of comparison with existing models and to highlight the fact that most of the short-run employment functions are implicitly based on such assumptions.

ii. Also, there is some arbitrariness in the experiment because the restrictions on the β_{ij} adjustment terms are not met exactly and the production

TABLE 7.1

"SHORT-RUN" SCALE EFFECTS, PRODUCTION WORKER EMPLOYMENT, AND HOURS OF WORK IN TOTAL MANUFACTURING, FULL MODEL[a]

Line	Inputs Considered Variable	Inputs Considered Fixed	Estimated Scale Effects				
			Y_1	Y_2	Y_4	Y_5	Y_6
1	Y_1, Y_2	Y_3, Y_4, Y_5, Y_6	1.08	.33	—	—	—
2	Y_1, Y_2, Y_4	Y_3, Y_5, Y_6	0.68	$-$.09	1.24	—	—
3	Y_1, Y_2, Y_4, Y_5	Y_3, Y_6	0.74	$-$.04	0.91	.33	—
4	$Y_1, Y_2, Y_4,$ Y_5, Y_6	Y_3	0.47	$-$.22	2.00	.05	.53

a. Derived from estimates in Table 4.1.

function is overidentified. This means that more than one estimate of the production function parameters is possible. For example, in experiment (i) above in the four-equation model any two equations can be deleted to solve for Y_1 and Y_2 in terms of output, and so on at stationary values. That is, choose any two equations, set $Y_{it} = Y_i$ for all i, and solve the two equations simultaneously for Y_1 and Y_2 in terms of Y_3, Y_4, and so on. If the constraints hold and the production function is identified exactly, any pair will produce the same estimate of short-run returns to scale. We chose the first two as being more in the "spirit" of the employment function literature, but some other result would be obtained by using some other pair. Similar remarks hold for experiment (ii) and for those in Table 7.1.

iii. We have already noted the difficulty of estimating long-run coefficients in models of this sort in the face of the nearly nonstationary response of the dynamic system and the relatively short period (20 years) spanned by available data. That discussion applies equally to other studies.

The main import of investment functions in the literature can be summarized as follows: (a) Distributed lag patterns display long lags of adjustment and tend to be "bell" shaped; (b) estimated long-run relative price elasticity has considerable range, depending on the a-priori restrictions used in estimation (Jorgenson and Siebert [1968], Jorgenson and Stephenson [1967]); and (c) the output elasticity is also subject to great variation, depending on specification. Our model throws new light on all these issues.

We could have performed conceptual experiments similar to those above. Our capital stock structural equation contains the previous period's utilization, employment, and inventory variables, in contrast to the neoclassical investment functions, which usually do not include such variables. Had we ignored these feedbacks, geometric distributed lag investment functions would have been obtained. However, when the full set of feedbacks is included, bell-shaped patterns emerge. This result was obtained for all industries without the a-priori restriction of imposing second-order lag terms on the structure. In contrast to the results reported by Jorgenson and Stephenson [1967], who constrain initial responses of investment to changes in output and prices to be zero immediately following the shocks, we find immediate nonzero responses in most industries. The result is that the mode of the lag distributions is about four quarters shorter than that obtained by Jorgenson and Stephenson. As in their results for some industries, we find oscillatory behavior far out in the tail of the investment-sales distribution. However, the industries where the oscillations occur are not the same in the two studies.

In the neoclassical investment models developed by Jorgenson [1963], Jorgenson and Stephenson [1967], and Bischoff [1971], there is evidence of substantial long-run price response to investment. We do not find such evidence. In the majority of cases, our price elasticities for capital as well as most other inputs are quite small. The estimates are very close to those reported by Eisner and Nadiri [1968] and Mayor [1971]. One reason for the difference is that our estimates are not tied to output responses as in the Bischoff and Jorgenson models. Another reason is that the impact price effects in our model are quite small. This, in conjunction with the slow convergence of the system, makes estimation of the long-run price effects difficult. Finally, the difference may be in using different measures of relative prices. We use wage-rental ratios whereas Jorgenson uses real rental prices. Different sample periods and data have been used in each study as well.

Finally, we do not find any evidence of constant return to scale, which is in contrast to the practice of imposing that restriction on the estimates a priori. Our result is in conformity with those obtained in time-series production function studies (Nerlove [1967b]).

C. SUMMARY AND CONCLUSIONS

In this study we have attempted to formulate and estimate a fully integrated model of demand for factors of production. The principal feature of this model lies in its disequilibrium character, corresponding to a generalized interrelated stock adjustment model. The effect of disequilibrium in one input spills over to the adjustments of all inputs, resulting in a network or feedback mechanism that traces the dynamic properties of the inputs over time. The potential of the model lies in integrating and presenting a generalized framework for time-series study of production, employment, investment, and utilization behavior. The model lends itself to certain economically meaningful conceptual experiments: (i) The passage of a unit impulse of an exogenous variable through the system generates various distributed lag patterns for all inputs, which take into account all cross adjustments and interactions among them. (ii) The stationary values of the inputs resulting from step function impulses are equivalent to conventional long-run scale and substitution effects in the theory of supply.

A specific form of the general model has been specified and estimated from quarterly time-series data for manufacturing industries in the post-World War II period. The investigation is confined to six inputs: production and nonproduction employment, hours of work, capital stock, generalized utilization, and total inventories. The coverage of the study includes total manufacturing, total durables and nondurables, and fifteen manufacturing industries for which the necessary data could be obtained. The driving forces in a dynamic system such as ours depend on the number and character of the exogenous variables in the structural estimates, sales, trend, and the wage-rental ratio. Data limitations preclude incorporating other relevant factors, such as other input prices, rental price of labor, and so forth.

Experiments with empirical estimation of the model have been confined to various specifications at the aggregate, total manufacturing level. These include (i) various "shock" specifications for both realized and anticipated sales and relative prices and (ii) examination of the stochastic structure of the model, including own- and cross-serial correlation to the extent possible. The results of these experiments indicate that current sales and current relative prices perform as well if not better than their "expected" counterparts. Furthermore, there is reason to prefer estimation techniques that account for first-order serial correlation in the disturbances. A first-order Cochran-Orcutt transformation on each equation is used for this purpose. The final model includes current sales, current relative prices, and trend in a system of first-order difference equations with a Cochran-Orcutt transformation of residuals for each equation. This model is used to estimate the structural parameters for the disaggregated industries and for forecasting beyond the sample period (1968I–1970II) for total manufacturing, total durables, and total nondurables.

Reduced form parameters of the model can be obtained by recursive methods from structural parameters. We also estimated certain reduced form parameters directly (for total manufacturing), and the results are comparable with those implied by the structural estimates.

The over-all estimates can be summarized as follows:

i. On the whole, the model fits the data exceedingly well on both aggregate and disaggregated levels. Goodness-of-fit statistics suggest its superiority in the sample period to a series of autoregressive models. Many alternative models have failed to pass this test.

ii. Forecast properties of the model were very satisfactory in the three industry aggregates—total manufacturing, total durables, and total nondurables—for which forecasts outside the sample period could be carried out. Forecasts were particularly good for levels of stock variables, as measured by size of forecast errors and turning points. The model tended to track hours per man with a one-period lag, reflecting the actual one-period lead of hours per man over other inputs. Generalized utilization rate forecast errors were large because the method of calculating the series imposed an upper limit of 100 per cent.

iii. Impact or first-period responses of sales tended to follow a systematic pattern in all industries. The effects were largest for utilization rates, but significantly smaller for stock variables. Production worker responses displayed the biggest impact effects among the stock variables and capital stock the smallest. Impact effects of relative factor prices were quite small in most cases, but were often statistically significant, especially in the labor and capital utilization equations. Estimated coefficients of trend were small in magnitude and showed no systematic patterns of statistical significance in different inputs and various industries.

iv. Structural estimates strongly confirm the disequilibrium specification of the model, which is its major innovative feature. Strong feedback effects are indicated by highly significant regression estimates on most lagged dependent variables in each equation and in each industry. In most industries excess demand for production workers tends to increase hours of work per man and utilization of capital, but decreases the demand for inventories, nonproduction workers, and capital stock. In most cases, excess demand for hours per man has a strong negative feedback on both labor stock variables and much weaker effects on the other inputs. Excess demand for capital stock tends to decrease production and nonproduction worker employment and inventories and to increase utilization rates. Disequilibrium in capital utilization positively affects demand for capital stock and inventories and negatively affects demand for production workers; it exhibits no effect on demand for hours and nonproduction workers. On the whole, excess demand for inventories increases demand for other inputs. Finally, excess demand for nonproduction workers tends to decrease demand for production workers, hours worked, and capital stock; it has no predictable effect on level of inventories and rate of utilization. These feedback effects display some tendency toward symmetry, in that excess demand for input *i* affects the demand for input *j* in the same direction as excess demand for input *j* affects demand for input *i*. However, the tendency is weak, and many exceptions to this general statement can be found.

v. The distributed lag or the transitory response to changes in sales indicate very interesting results: (a) Utilization rates respond first and most quickly, transmitting the shock effect to the stock variables; (b) production workers follow utilization rates in terms of the speed of response; (c) nonproduction workers and inventories are rather slow in response to sales shocks; and (d) capital stock exhibits the slowest response pattern of all inputs. This pattern of response of the inputs suggests a similar rank ordering of variables in terms of ease of adjustment or an inverse rank ordering in terms of "fixity."

Most remarkably, the utilization rates and, to a lesser extent, production worker employment tend to *overshoot their equilibrium values* in almost all industries, a result that cannot be estimated in any other comparable model. Capital stock and, to a lesser extent, inventories and nonproduction workers exhibit a bell-shaped distribution often found for capital stock in other studies. The significance of these overshooting patterns for utilization rates should be emphasized, for they constitute the major justification for disequilibrium models and have significant economic meaning. To maintain sales targets, the more easily adjustable inputs, viz., utilization rates and production workers, are allowed to exceed equilibrium values to give the firm time to adjust the more fixed and costly inputs. Moreover, no evidence of zero initial response was found. All these *general* properties of the distributed lag patterns noted are extraordinarily insensitive to different specification and estimation procedures, strengthening our confidence in these findings.

vi. Systematic differences in the response patterns were found between durable and nondurable industries. The speed of response is slower in the nondurables and the convergence to equilibrium values is less rapid than in durables. In many of these cases characteristic roots of the system had imaginary parts resulting in minor damped oscillations far out in the tails of the lag distributions. The model fails to converge in some of the disaggregated industries, mainly in nondurables. Convergence in these explosive cases can be obtained by prefiltering the data through first-difference transformations. However, such transformations force very rapid convergence of the system and cause oscillations due to negative real characteristic roots. These cases need further exploration.

vii. Long-run coefficients tended to suggest significant differences in returns to scale between durables and nondurables, the latter exhibiting decreasing returns and the former increasing returns. However, the magnitudes of these estimates were highly sensitive to minor changes in specification. The reason for this lies in the convergence properties of the system. Often the lag distributions on which these estimates are based display "thick" tails, making interpretation of the results difficult. The distributed lags are nearly nonstationary. We found no systematic evidence on price and trend elasticities for the dependent variables.

viii. The model integrates empirical employment and investment functions and consequently can be used to generate estimates comparable to those found in the literature. A set of conceptual experiments was used to generate short-term employment functions. It was found that the high short-run returns to labor observed in most studies was probably due to omission of capital utilization. Long employment and hours adjustment lags, often found in such studies, are undoubtedly due to long adjustment lags elsewhere in the system, such as in capital stock. No evidence of constant returns to scale was found for capital stock, and price elasticity was always small in absolute value and often of the wrong sign. It should be noted that the bell-shaped distributed lag pattern of capital was obtained from a first-order system and not from second-order own lags in the capital stock equation. The modes of these lag distributions fell around three to four quarters after the initial impact.

Though we hope that some problems in time-series factor demand functions have been resolved by this study, other difficulties remain. Further attention needs to be given to the following problems: (i) Essentially, there exists at present no genuine market theory of supply in a dynamic setting. A complete theory is needed to resolve simultaneously the interactions between optimum expectations and reactions of individual producers in a market setting. (ii) More attention should be given to improving the quality and sources of data. Specifically, there is great need for better capital utilization and price data. (iii) Finally, better estimation techniques for dealing with serial correlation in dynamic time-series models are needed. This is especially so in view of the slow convergence of these systems.