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DISCUSSION

KENNETH J. SINGLETON*: This paper explores the relations between the prices of capital assets and the specifications of the underlying technologies of the economy. Professor Huffman deduces the equilibrium price of capital for several economies, and then examines how the behavior of this price and investments in

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capital are affected by the presence of installation costs. These comparisons across alternative technologies are interesting and will be discussed in more detail subsequently. First, I shall comment briefly on the motivation for this analysis, and discuss the structure of Huffman's model and its relation to several asset pricing models that have been studied previously in the literature.

The motivation for this analysis seems to be the fact that infinitely lived, representative agent models of asset pricing have had limited success in representing the time-series properties of asset returns. While this observation certainly seems correct, it is misleading to attribute the failings of representative agent models to misspecification of the technology of the economy. The empirical models in Hansen and Singleton [5] and Dunn and Singleton [4], e.g., place essentially no restrictions on the technology underlying the production of consumption or capital goods. In particular, these studies implicitly accommodate adjustment costs, time-to-build factors, and interrelated production technologies that are much more complicated than the "primitive" technology implicit in Equation (2) or the installation technologies in Huffman's paper. Accordingly, by themselves, the findings in previous studies of dynamic asset pricing models do not point to the omission of adjustment costs as the key misspecification underlying the poor performance of representative agent models.

A comparison across equilibrium relations for prices implied by different specifications of technology is nevertheless of interest in its own right, since it enhances our understanding of the links between these aspects of equilibrium models. That the specification of technology matters for the form of equilibrium asset prices has, of course, been observed previously by many authors. For instance, Brock [3] deduces the equilibrium price process implied by a model with production in which both capital goods and claims to shares of the profits of firms are priced. More recently, Altug [1] has derived the equilibrium prices of capital in a general equilibrium model with adjustment costs and a time-to-build production technology.

What distinguishes Huffman's analysis from most previous studies is the use of the overlapping generations framework. Agents are assumed to live two periods in his model, and there are limited mechanisms for transfering consumption goods into the future (the consumption good in this model is not storable). Therefore, it is worthwhile to discuss briefly the role of the capital good in this economy with incomplete markets and to compare its role to that of capital in many of the existing representative agent models.

Consumption goods can be transformed into capital goods using the "installation" function Ψ, but capital cannot be converted back into consumption goods in Huffman's model. Furthermore capital, which is the only asset in this economy, pays a stochastic, *exogenous* dividend each period. Since consumption goods are not storable, the capital good provides the only means in this model of shifting consumption from the first to the second period of a given generation's lifetime. Thus, in general, the capital good is valued for two reasons. First, it pays a dividend in the form of consumption goods. Second, it serves as a store of value.

Under the assumptions of logarithmic utility and the two-period lifetime of agents, the presence of a dividend does not affect the equilibrium price of capital [see Equation (14)]. Thus, in Huffman's examples, the store of value function of

capital is the only reason that capital is valued by agents in his model. Capital would have the same equilibrium price in an economy in which capital is an intrinsically worthless commodity that takes on positive value because it is the *only* store of value. In this regard, capital is the counterpart of "fiat money" or government bonds in Wallace's [7] overlapping generations models.

Also, it seems that capital can be converted into consumption goods in this model. Specifically, the fact that capital pays a dividend in terms of consumption goods seems to make his model observationally equivalent to a model in which capital can be converted by a constant returns to scale stochastic production function. Viewed this way, it is clear that the model is not capturing many of the characteristics of production that have been found to be important in modeling the U.S. economy.

Furthermore, many of the qualitative conclusions deduced for the two-period model are not robust to fairly plausible changes in the model. For instance, Huffman notes that the dividend will generally affect the price of capital in a model in which agents live for more than two periods. The price of capital will also depend on the dividend in general if agents have preferences other than the logarithmic type assumed by Huffman, even with two-period-lived agents.

Perhaps a more important observation, which Huffman does not make, is that with longer lived agents the current price of capital will be a function of not only the current capital stock, but also the previous periods' stocks. Thus, different forms of adjustment costs may lead to very different time-series processes for asset prices. Unfortunately, there is no discussion of the time-series properties of asset prices implied by the various models considered in this paper. Thus, we cannot rule out the possibility that the implied processes for prices in Huffman's models are no more consistent with the observed time series of asset returns than are the price processes implied by representative agent models. In sum, this paper fails to povide many new insights into the limitations of infinitely lived representative agent models, or of the consequences of either adjustment costs or heterogeneity across agents for the time-series properties of asset prices.

The assumption that capital is the only store of value in this economy also precludes an analysis of the relative risk of investing in different types of capital or claims to the cash flows from firms. It would, for instance, be interesting to see a comparison of the implied covariances of returns and the marginal rates of transformation associated with alternative specifications of technology. For it is these covariances that are linked to the risk premia implicit in the model. Some results on these relations in the context of a representative agent model are presented in Breeden [2].

Instead of investigating these issues in dynamic and relative pricing, Huffman focuses his attention on the implications of his models for the coefficients of variation of the endogenous variables and the frequency with which agents invest. On the issue of variation, he notes that there is substantial variability in prices even if the dividend paid on the capital stock is constant each period. However, this observation does not address the issue raised in the introduction—namely, is the volatility of prices implied by this model more consistent with the data than the representative agent models studied previously? As discussed above, Huffman's specification of the technology would not, by itself, seem to be the

key factor in reconciling asset pricing models with the data, since more general specifications have been considered previously.

An important difference between his model and representative agent models, that may help in explaining asset price volatility, is the particular form of the heterogeneity of consumers associated with this overlapping generations model. Although the role of this market structure has been discussed by Huffman [6] elsewhere, a brief comment on its role in the analysis here is warranted. This model has the property that agents in the second period of their lives will supply the security to the market inelastically because they desire to consume all of their wealth. One interpretation of this setup is that large differences in portfolio holdings at different stages of the life-cycle may explain asset price variability. Alternatively, it may be interpreted more broadly as a means of modeling an environment in which a subset of the agents in the economy must supply their securities to the market inelastically. That the latter phenomenon is central to understanding asset price behavior or that it should be modeled in this way is not obviously suggested by the findings in previous empirical studies of asset pricing. Therefore, more motivation for the use of the overlapping generations framework would have been helpful. Also, my guess is that the variability of asset prices in this model would be mitigated substantially by the introduction of a bequest motive on the part of agents and possibly by extending the length of the lifetimes of the agents in each generation.

Given the specification of agents preferences and a two-period lifetime, Huffman investigates the links between installation costs, the variability of capital prices, and the optimal level of investment. An interesting feature of the overlapping generations framework is that it accommodates the possibility that in some periods zero investment in the capital good is optimal. That is, all saving will be through transactions in claims to the existing capital stock. I found Huffman's analysis of the sensitivity of investment to the form of the installation technology and the depreciation rate to be one of the more interesting aspects of the study. From the last columns of Table III and IV, it is seen that more investment is undertaken in the economy with lower installation costs and higher depreciation rates.

Also, comparing the results in Tables IV and V, one sees that both the average level and the variability of the price of capital are higher in the economy with increasing marginal installation costs relative to the economy with constant marginal adjustment costs. The higher variability emerges because, with higher marginal adjustment costs, shocks are absorbed relatively more by the price than by the quantity of capital. Neither of these findings is surprising in the context of the model considered, but they do serve as a useful reminder of the links between the moments of capital prices and the underlying technology.

Finally, it is interesting that, for the economy associated with Table IV (increasing marginal adjustment costs), the variability of the price of capital is a monotonically increasing function of the depreciation rate δ. In contrast, for the economy associated with Table V (constant marginal costs), the variability of the price of capital is inversely related to δ. Thus, there is no systematic relation between the level of the depreciation rate and price variability across the alternative economies.

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