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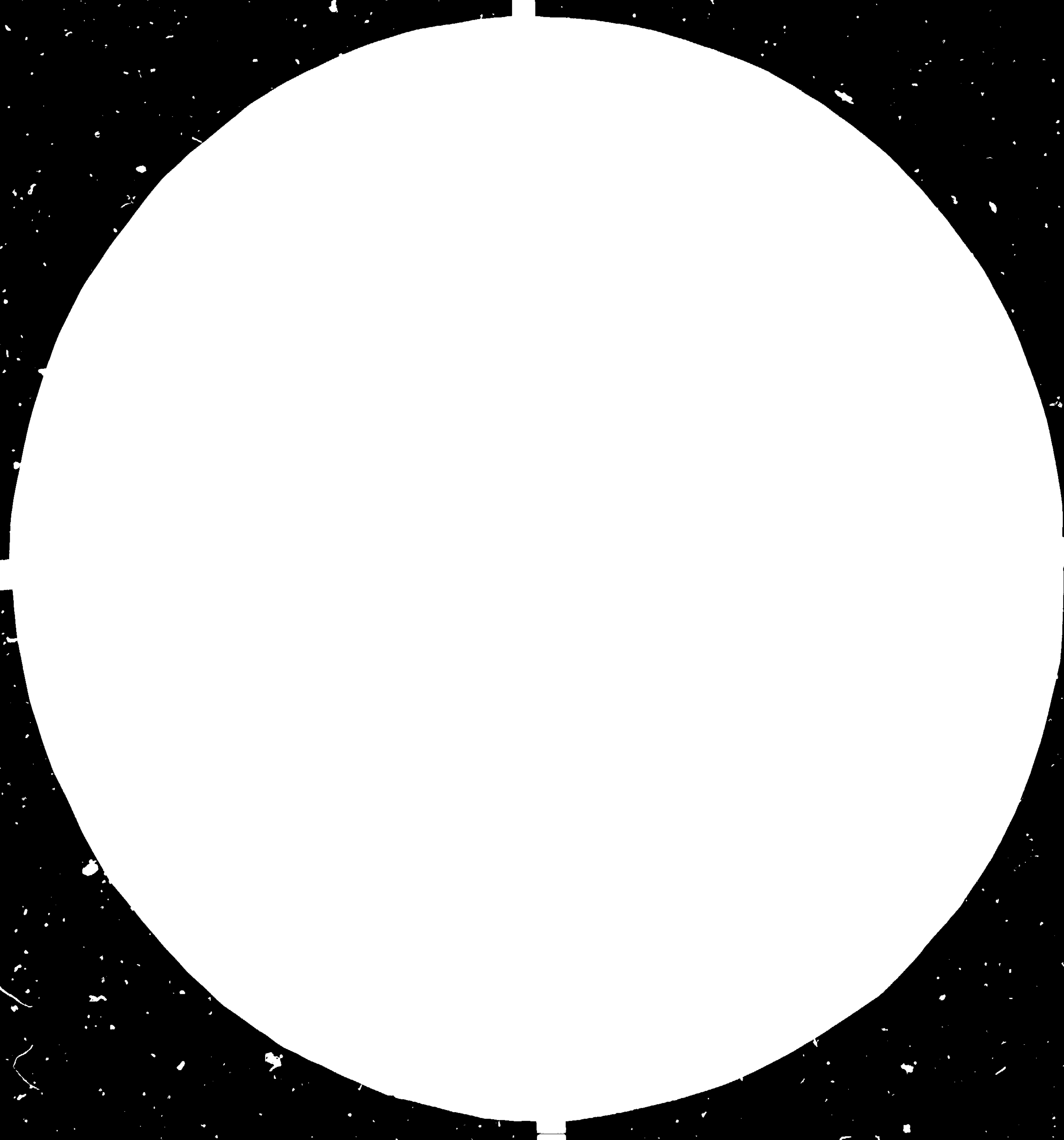

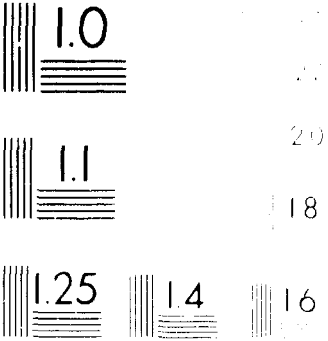
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A SIMULATION MODEL OF INNOVATION IN DEVELOPING AND DEVELOPED COUNTRIES FOR INDUSTRIALIZATION STRATEGIES

by

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I. Introduction

The purpose of this paper is to highlight methods of evaluating alternative government economic policies for stimulating technological change under various industrial development strategies. Technology and its diffusion is critical in the overall global strategy of accelerating international industrial restructuring because such transfers are required for the developing country to contribute to the international division of labor. Moreover, the transfer of standarized technology from the developed to the developing countries will be enhanced by the adoption of a research and development policy in the developed countries that speeds technological advance there. The paper develops a model that focuses upon the firm's decisions in both private and state-owned firms. The objective of government policy in each instance is to provide incentives to the managment to introduce the "best available world practice" so that the firm and industry is operating with the highest feasible technology.

Since the main focus of the paper is upon the role of science and technology in economic development the model is applicable to those developing countries that have some industrial base, no matter how modest. The main criterion for use of the model is that the firm or industry in question have research and development capabilities, even though those abilities may derive from a governmental unit, rather than residing in the firm itself. In the developing world, the probability of success for research and development policies perhaps is greatest in the newly-industrialized countries (NIC's). Therefore, it is recommended that the model be applied first to industries in such countries. To the extent that an overall global strategy of accelerating international industrial restructuring is feasible, the model also can be applied to development countries.

This paper is related to several issues regarding the effect upon industrial development of public and private decision-making regarding science and technology, but especially to the effects of government policies and market conditions upon the level and productivity of research and development (R & D). In particular, the paper focuses upon the impact of public taxes and subsidies under alternative industry and environmental conditions. The specific policies considered are detailed below.

II. The Advantages of an Evolutionary Model of the Firm and Industry

An evolutionary simulation model of technology adoption and diffusion is suggested as a means to quantify the probable direct and indirect impacts of various policies upon the rate of innovation and its diffusion in selected types of industries. In such a model the determinants of technology adoption and diffusion in selected industry types can be identified with a view to understanding better the impact of various policies upon that process as well as considering new methods for stimulating technological change.

We suggest a simulation technique because simulation models do not require a complete set of real-world data and because simulation is a good tool for evaluating alternative policies. The firm and industry simulation model described in this paper can be used to provide quantitative estimates of the direct and indirect effects of alternative policies upon the rate of innovation and its diffusion in selected types of firms and industries.

We know, for example, that tax policy influences innovation both through its contribution to the general macroeconomic climate and through direct effects on specific kinds of innovation (Mansfield, Nadiri), and that tax incentives can have a positive effect on the level of innovation, but the size of the effect is unknown. We also lack quantitative evidence about these same effects on different kinds of firms in different countries be they small, large, R & D intensive, capital intensive, etc.

These issues can be dramatized in several specific questions. (a) In the development or imitation of new processes, does the general economic environment entirely overwhelm in its quantitative impacts any in-place tax incentives, be they aimed specifically at R & D or at capital investment in general? (b) Do the differential impacts mentioned in (a) have substantially different values in the R & D-intensive firms relative to others, or in large firms compared to small or in capital-intensive firms compared with others? (c) Do the internal dynamics of the firm dominate in the adoption of productivity improvements or do the exogenous elements dominate? (d) Are the determinants of capital investment in general the same or similar to those deciding R & D expenditures? In answering the first and the last questions we believe that the investment funding constraint of the firm is a key element. For this reason careful attention is paid to sales revenue growth relative to current production costs in the simulation model.

An evolutionary approach is used so that individual firm decisions are altered as the industry evolves and vice versa. The firms are presumed to establish long-term policies with respect to the funds allocated to efforts of obtaining new processes of production. The history of each firm and each industry is known. This history provides a "baseline" for the study of innovation in each industry. That is, the historical pattern of actual policies are "givens" that have influenced firms' decisions in each industry. If the modeling is successful, the "hypothetical" decisions made by the firms would result in an approximation of the firms' historical allocations of funds to investment and R & D activity and the observed net sales growth from such outlays. The proposed policy simulation would introduce a new policy set. Among other things we then can judge how each group of firms fares under the new policy set and the impact of their behavior on output and competition levels of the industry. Several alternative policy simulations, including one related solely to plant and equipment credits and depreciation rules, will be conducted.

This approach embodies the spirit of the behavioral theorists such as Simon, Cyert, Chandler, and March. This literature shows that the goal of capital acquisition permeates the organizational structure of most firms (see, e.g., Chandler). More particularly the modeling itself will imitate to a considerable degree the pioneering simulation work of Nelson and Winter. They have provided a breakthrough procedure that is expanded conceptually and shaped for policy-simulation purposes in this paper. Professors Nelson and Winter hoped to stimulate new empirical research on technological advance, productivity growth and market structure through their demonstration that formal models could be constructed. The Nelson-Winter model and its extension in this paper focuses upon the place of innovation in the growth strategy of the firm.

In this behaviorialist view the individual firm is governed by its current decision rules, criteria which link its actions to environmental stimuli. Nonetheless there are significant departures from the published Nelson-Winter modeling. These departures derive from the policy-oriented goals of the research as well as new developments in post-Keynesian economic literature, especially with regard to the relation of the firm's capital accumulation goal to its pricing strategy. The relevant contributions include those of Eichner, Levine, Marris, Penrose, Ong, Shapiro, and Wood. This literature and that of the behavioralists is complementary. Other important influences include those of Binswanger, Browr, Ruttan, David, Gold, Sylos-Labini, and Williamson.

The following summary statements comprise the main departures from or modifications in the Nelson-Winter (N-W) simulations:

1. A variety of possible pricing behaviors of firms and industries can be studied, such as price-taking vs. price-"making" firms. Wherever. for example, the firm is state-owned, it is by definition a price-maker.
2. Policy variables such as alternative depreciation allowance rates and R & D tax credits can be utilized in the simulations.
3. The evolution of industry productivity changes can be simulated at various rates of capacity utilization as the industry follows the contours of the actual economic cycles. The purpose here is to isolate the impacts of the general economic environment (from macro-policies) upon the industry from the specific targeted tax or other policies.
4. A strategy mark-up on prime costs (whether or not the "strategy" is the state's or a private firms's) is based upon the growth objectives of the firm whose success is determined in part by the number of (evolving) firms in the industry and historical price elasticities. A mark-up pricing rule now has been widely used in econometric modeling, though the models thus far have been of developed market economies. Examples from well-known economists include Eckstein (The Econometrics of Price Determination, 1972), Okun (Prices and Quantities: A Macroeconomic Analysis, 1981) and

Nordhaus ("The Falling Share of Profits", 1974). In N-W market price elasticity is constrained to unitary and the number of firms play a different role. In N-W and in this paper, however, the number of firms is determined by the evolutionary process which in turn has an impact on intermediate decisions.

5. Rather than a putty-putty assumption about the relationship between capital and techniques, we recommend a putty-clay version. In this way the prices of inputs matter prior to switches in technique but not after. This is consistent with our modeling of the role of the economic cycle. This also means--unlike the N-W modeling--latent or potential productivity in the industry does not grow necessarily at a constant rate.
6. The futuristic nature of the firm's decisions is modeled further by incorporating future expected capital, labor and other costs rather than current input prices.

III. A Simulation Model

The measurement of the impact of direct and indirect R & D policies presently is in an undeveloped stage. The proper model must be sufficiently general to be applicable to the selected industries and selected countries and adequately specific to be used as an evaluative tool for R & D policy. The following are among the specific hypotheses to be considered: (a) The general economic environment has a substantial and quantifiable impact upon innovation in the selected industries. (b) The relative importance of general economic conditions on innovation is greater for small than for the large firms in selected industries. (c) The treatment of R & D (or, for that matter, of any investment outlay) benefits differentially firms whose R & D is relatively capital-intensive and whose investment is rising rapidly. (d) Accelerated tax credits or depreciation allowances benefit differentially capital-intensive firms without adding to their share of R & D outlay. (e) Policies that provide new (external to firms) processes to the selected industries (without industry start-up cost) have a higher benefit-cost ratio than specific tax incentives for R & D.

There is no bias in favor of the hypotheses as stated. Moreover, these hypotheses are not exhaustive. Other testable hypotheses could emerge in the course of the implementation of the recommended simulations. The complete model for utilization in empirical estimations and simulations follow.

Initial state conditions for the firm and the industry. At t_0 each firm in the selected industries has a given production technique characterized by technical labor, capital and other technical coefficients (a_L, a_K, a_S). Throughout this analysis of the model it is understood that input requirements and productivities are expressed in terms of an "appropriate" time unit or production period. (It is understood that the amount of an output per unit of capital stock is different for one year than it is for one week.) The firm's scale relative to the industry is defined by its level of essential physical capital stock. This specification differs from N-W inasmuch as they consider only capital and labor as inputs. We recommend that at least three "necessary" inputs and their productivities be considered. The inputs, of course, are viewed as necessary only with the current production technology. That is, we presume that an essential raw material (such as petroleum in airlines) has a productivity that might in a new process swamp the effect of a change in productivity attributable solely to labor (such as number of pilots). Since productivity always can be defined in terms of capital, the main impact of considering a "set" of input requirements (a's) is to take into account changes in input requirements and their variable costs.

Following N-W, the probability distribution for latent or potential productivity at $t_0 + 1$ depends only on the value of latent productivity at t_0 and is independent of other industry variables. However, the distribution of the next-period state for a given firm in the industry depends directly on the levels of variables of that firm, and other firms in the industry that influence it through several intervening variables, including the market price of the product or service produced. In a departure from N-W, price changes from period to period vary not only with output but also with the price mark-up strategy of the individual firm or the state in the case of the state-owned firm.

As in N-W's use of U.S. productivity growth data, the initial distribution of techniques (the a's) will be decided for each industry by the historical state of production processes in firms at t_0 (which is taken as 20 years ago). These values of the a's will be compared with estimated values of a's in selected firms over time. A probability distribution will be estimated for the values of a's. This entire range will comprise the set of techniques from which the firms in the industry can "draw" during the 20 years of production history. The allocation of the productivity draws is decided by various decision rules that will be applied over the history of each industry. The 20-year history of each firm will include its primary physical capital stock, labor force size, number of research personnel, R & D expenditures, total investment expenditures, debt-equity ratio, (where applicable) dividend pay-out ratio, (where applicable) sales revenue, and real output of dominant product or service. Historical industry data will include number of firms in the industry and estimates of the price elasticity of demand for the dominant product or service of the industry. (The decision rules are specified below.) During that history, of course, the determinants of such decisions as prices, dividend pay-out ratios, wage rates, prices of inputs, etc. will be changing.

For any particular industry the state of firm j in time t can be characterized by:

K_{jt}, or its primary physical capital stock. For example, in the airline industry the primary physical capital might be defined as carrier capacity or available horsepower. Productivity or $1/a_k$ might be defined as passenger miles and cargo weight per carrier capacity or horsepower. Unlike N-W depreciation and tax credit allowances are variable and capital is not fully utilized in every simulation.

L_{jt}, or the firm's full-employment labor force. With fixed factor coefficients (at a point in time) it is possible to move back and forth between capital, labor and other requirements. In a departure from N-W, R & D expenditures in some cases will be related to labor rather than capital. Again, a firm and industry can operate at less than full-employment of capital and (after a time lag) less than full-employment of labor. For example, under-utilization of capital has characterized global industry since 1979.

Innovation and Imitation Policies

The adoption of a new technique of production requires new capital acquisition. A putty-clay concept of the relation between capital and labor in the production process is adopted. The original putty-clay hypothesis is that factor proportions can be varied while capital is being designed but not after it has been built. Capital is putty *ex ante*, but *ex post* it is hard-based clay. Any new capital vintage, once installed, can be utilized only in fixed proportion with labor. Our use of this idea runs as follows. Prior to the selection of a new technique the wage rate or price of the new equipment influences the choice of technique. Once the innovation or imitation is adopted and installed, factor coefficients (the a's) are fixed so that capital to labor to other requirements' ratios are immutable until still another chance occurs and another technique is adopted.

This approach enables negative quasi-rents to appear for capital of older vintage. As an example, older vintages may be highly labor intensive: even though the wage rate is rising rapidly, the firm cannot reduce the number of workers allocated to each "older" machine and losses may occur. To avoid losses the firm scraps the capital earning non-positive quasi-rents. This scrapping may involve an entire plant. Since the present value of capital depends upon future interest rates (even though such rates may be administered) and labor costs are to be incurred after the installation of the new technique, the price of capital and the wage rate are expected future values.

$\underline{R_{jt}}$, or j's research policy. A research policy is a commitment to a certain level of research expenditures that is decided by the growth objectives of the firm. This commitment is expressed in terms of R & D expenditures and in terms of the number of research personnel. Thus, in a variation of N-W the research policy dimensions can be expressed in some cases as expenditure per period per research employee and (where applicable) in terms of research personnel costs. For computational convenience, R & D expenditures can always be expressed in terms of shares of total investment.

For the industralizing country, the potential technology is the world-standard technology. Especially the technology of basic industry is standardized and potentially transferable to any country in the world. However, all technologies are transferable: the ease of transfer is a matter of degree and of workable policies in the "receiving" country.

The first possible research result may be to facilitate the acquisition of an innovation, a process heretofor unavailable to the industry. The research policy increases productivity of capital, labor, or other key input through innovation if it results in the "drawing" of a new technique or technical coefficients combination that has productivities higher than the firm's current technique. The a's are based upon productivities that have yet to be adopted at time t by <u>any</u> firm in the particular industry being studied. The firm's research expenditure (R_{jt}) buys in a given period a probability of sampling the latent a's. $P(R_{jt})$ or the probability of a research draw from the distribution of a's is positively related to the firm's investment expenditures devoted to R & D and to the size of the firm's research staff. That is,

$$P(R_{jt}) = f(RD_{jt}, RL_{jt}),$$

where RD is the level of R & D expenditures and RL is the size of the research staff. Where R & D expenditure is purely a government function for any particular industry, RD and RL represent the government's committment to research and development. (In N-W the probability is proportional to the level of research expenditure.) When a successful research draw occurs and results in a higher productivity level, the firm moves to this new technique in a subsequent period (the value of t + i would be determined by additional empirical research.)

The second possible research result would be the acquisition of the best available or world standard technology already in use in the firm's industry.

In other words, there also are favorable impacts upon production processes from the acquisition of extant "more advanced" equipment and tools. Normal replacement investment would tend to follow a historical trend line for a particular firm. However, the aggressive acquisition of new equipment and tools would be reflected in a more rapid than "normal" growth in total investment (adjusted for the effects of the economic cycle). The indirect impacts upon process innovation from accelerated depreciation on non-R & D investment, from increased investment tax credits or increased state subsidies are most likely to be reflected in an "above-norm" growth rate in total investment. This acquisition of new processes by purchasing the latest vintage of capital perhaps is best described as "imitation policy".

Let IM_{jt} represent the firm's imitation policy, a policy with similarities to R_{jt}. However, the distribution of a's from which the drawings are made is comprised only of actual a's of firms in the industry at t. In this case R & D expenditures buy a probability of drawing the current "best available would practice" technique, in which the highest productivity technique in use would be selected. $P(IM_{jt})$ or the probability of a successful imitation draw is positively related to the firm's total investment growth rate above the "norm" (defined above) and to the size of the firm's (or government's) research staff, but is a decreasing linear function of the quantitative difference between the existing and adopted technique (the time period over which the investment growth rate is computed would have to be determined empirically). The values of the linear coefficients (or weights) in this case depend upon the expected prices of the physical capital, labor and third primary input. Unlike other models this one takes into account the effect of expected changes in the relative prices of inputs in the selection of techniques. That is, let I be the above-Norm investment growth rate, RL be size of research staff, h be most productive firm in the industry, and we can write:

$$P(IM_{jt}) = F(\dot{I}_{jt}, RL_{jt}) - WTK^*(a_{k,jt} - a_{k,ht}) - WTL^*(a_{l,jt} - a_{l,ht}),$$

where, for example, the weights WTK* and WTL* depend upon the expected prices of the primary physical inputs and WTK* + WTL* = 1. Only when WTL* = WTK*, for example, would the choice of techniques be unbiased. The weighted averages of the input coefficients means that the probability of adopting the "best available practise" would decreases as firms become more "dissimilar".

In each period there are three possibilities regarding productivities. Potentially, the firm may have the options of a new "exogeneous" world set of a's, a country inter-industry set, or its current set. The independent variables determining $P(R_{jt})$ and $P(IM_{jt})$ provide the estimated probabilities for an innovation or imitation of best available practice. At equal probabilities where $P(R_{jt}) = P(IM_{jt})$, the results from each set of a's are compared by the firm with its current set. Wherever a draw only from $P(R_{jt})$ or $P(IM_{jt})$ is made, that set of a's is compared only with the current set. Then the firm is presumed to select the highest productivity set. If one selected industry is airlines, for example, the new potential outputs of the world aerospace industry will be considered potentially available to the innovative firm in the airline industry. The best available carriers in use by the lowest-cost world airline would be considered the "best available world practice" and currently available for imitation. Once a net set of a's is acquired, input coefficients are fixed at the lower levels until the next innovation draw.

The Financing Constraint on Investment

Firm costs, economic profits and net income. Costs include variable costs (from noncapital inputs), depreciation of capital, and costs of financial capital (interest and any dividends payed out). If R & D is fully expensed for tax or other purposes, such expenditures are included in variable costs. (Except for tax credits, that would be a reasonable assumption, but such expensing can be varied to simulate tax policy changes.) In a modification of N-W the depreciation rate and the interest rate are variables. The firm's net income (y_{jt}) is current economic profits or:

$$y_{jt} = (P_{jt} \cdot a_{k,jt}^{-1} - r_j - D_{jt} - VCP_{jt}) \cdot K_{jt} \cdot (1 - T) + c_0 I_{jt}$$

where P is the product price, a_k^{-1} is productivity (measured via primary capital), r is the rate of interest, D is the rate of depreciation, VCP is variable costs (mostly current labor costs) as a percent of capital stock, T is the corporate income tax rate and c_0 is the percentage tax credit on total investment. Let c_1 be a tax credit percentage on R & D expenses and VCP can be adjusted (for policy simulation purposes) by VCP - c_1RD. By the same token, let SRD be a state R & D subsidy or stipend and VCP can be adjusted by VCP - SRD. In full-employment simulations the capital stock only changes if the quantity of primary physical capital changes. For example, in the airline firm or industry net additions to the airplane fleet would add carrying and horsepower capacity. When this happens, a variable depreciation rate can be applied to the "old" capital vintage and the "new" capital vintage. The different vintages of capital that emerge in the historical simulations have different depreciation rates. (N-W assume a constant D throughout and no tax credits).

It is assumed that a mark-up pricing rule is followed so that:

$$P_{jt} = VC_{jt} (1 + M_{jt}),$$

where VC is variable costs and M is the percentage mark-up. These costs are expressed in terms of the same time units as the productivities (see below). In turn, the mark-up is determined as:

$$M_{jt} = -1/n_t \cdot E(N_{jt}),$$

where n_t is the current number of firms in the industry and $E(N_{jt})$ is the perceived or expected price elasticity of demand to firm j at time t. The perceived deviation of the firm's price elasticity of demand from the industry elasticity (N_t) is assumed to be based upon expectations of a market share gain from firm j's lower relative production costs. Of course, for a state monopoly, $n_t = 1$ and $E(N_{jt}) = E(N_t)$: no distinction need be made between the firm's and the industry's price elasticity. That is, if N_{jt} is greater than N_t, it is because a market share gain is expected. The perceived or expected firm price elasticity is:

$$E(N_{jt}) = N_t + INN_{jt}, \text{ where } INN_{jt} = C(VC_{mt} - VC_{jt}) + e,$$

which says that firm j's expected price elasticity equals the industry market price elasticity plus an incremental elasticity (INN) which is a linear function of the difference between the variable costs of the highest cost firm (firm m) and firm j's variable costs plus an error term (e). That is, an expected market share gain is based upon a cost differential between firm j and the other firms in the industry.

The price determination simulations can be varied by industry characteristics. For example, if price leadership characterizes the industry at a particular time, a mark-up formula (that may differ from the one above) could be used for the price leader and the other n-1 firms could be assumed to behave like perfectly competitive firms.

The financial constraint of the firm. Following N-W, the amount of fundable gross investment ($I_{g,jt}$) depends upon whether the firm is making economic profits. In N-W the firm earning positive excess returns can obtain "matching funds" by borrowing. Where capital markets exist, the borrowing can happen there: otherwise, the funds would be "borrowed" from the government. In our model, rather than matching, such borrowings are decided by the firm's historical asset-debt ratio. Even state-owned enterprises relying only on subsidies have asset-debt ratios in which debt maturities depend upon the time elapsed until the firm makes positive economic profits. Thus, for the positive economic profit-maker I_g depends upon its depreciation allowances $(\dot{D}\cdot K=DEP)$, its net income (y) and its debt to asset ratio, or:

$$I_{g,jt} = DEP_{jt} + (1 + B)y_{jt},$$

where B is a function of the historical log difference of assets (A) and debt (d) over some past time (to be determined by research) or:

$$B = \beta(\log A - \log d).$$

If y is zero or less for private market firms, then:

$$I_{g,jt} = DEP_{jt} + y_{jt},$$

so that a private firm with negative economic profits contracts. Whereever shrinking firms are encountered (as defined by y = zero or less), the history of such firms could be examined to determine whether they are scraping plant and equipment over time so that appropriate adjustments can be made in levels of K. Thus, the evidence of negative quasi-rents will have feedback effects on innovation as K and perhaps the value of a_k changes.

Desired Investment of the Firm

Price is a two-edged sword. Other things held the same, the rate of growth in fundable gross investment (I_g) depends on changes in depreciation allowances and net economic profits(y). In turn, the growth of y is positively related to price(P). However, for the firms with a downward-sloping demand curve (N_{jt} greater than N_t), a price rise leads to a falling growth rate in sales. If all the other variables deciding y are held constant, there is a price that will just equate the rate of growth in sales with the rate of growth in financial funding ability. (We should bear in mind that a set of a's with higher productivity will generate this particular price at a lower level.) At a particular perceived price elasticity (N_{jt}) the two growth rates are (approximately) equal where marginal revenue equals output in capital units or:

$$P_{jt}\ (1 - 1/N_{jt}) = a_{k,jt}^{-1}K_{jt}$$

so that the equalizing price (P*) is:

$$P_{jt}* = \frac{a_{k,jt}^{-1}K_{jt}}{(1 - 1/N_{jt})}\ .$$

(We are aware that an estimated price elasticity of unitary would have to be expressed as marginally different from one.) At any time that P_{jt} (as defined above) is below the price equating the two growth rates ($P_{jt}*$), the rate of gross investment spending is increased (with R & D increased more or less proportionately, depending upon R_{jt}, IM_{jt} and R & D tax policy) until an acquisition of more productive a's enable the two growth rates to be matched at the lower product price. This gap between P_{jt} and $P_{jt}*$ leads to a surge in investment that raises the probability of a successful innovation or imitation draw.

In the absence of any descrepency between P_{jt} and $P_{jt}*$ desired gross investment, $I*_g$, is:

$$I*_g = \{ D_{jt} + F \cdot [1 - (M*_{jt} \cdot AC_{jt})/P_{jt}*]\} \cdot K_{jt},$$

where M* and P* are the values of the mark-up and price that equate the sales growth rate with the financial funding ability growth rate. The value F is an adjustment coefficient and AC is the firm's unit production cost at a higher expected productivity level. Following N-W, the unit production cost is based on the firm's future-period productivity in t+i and by the cost rate values (non-constant in our case), or:

$$AC_{jt} = (r_t + D_{jt} + VCP_{jt}) \cdot a^{-1}{}_{j(t+i)}.$$

The lower expected average costs gives $M_{jt}^* \cdot AC_{jt} < P_{jt}^*$ and raises current investment above depreciation and therefore adds to the capital stock. The future-period productivity itself may be a policy variable in an economy that has planning features.

Entry, Exit and Evolution

Entry and exit from each industry will be allowed. The triggering "decision" will depend upon the firm's net income costs in the case of exit and between major firms' profit rates (or returns on capital) relative to the long-term market rate of interest in the case of entry. As suggested above, negative net income implies negative quasi-rents on capital. Scraping of plants (that reduces K) as well as outright firm failure will be considered. The time lags for exit and entry will be determined by empirical tests. This will complete the evolution of each industry as it becomes more or less concentrated over time.

IV. Industry Selection and Policy Simulation

If UNIDO were to proceed with simulations, it is suggested that at least four industries be selected for study. The types of industries should include a rapid growth industry, a mature industry, an industry dominated by a few firms, a highly competitive industry, an industry with homogeneous products, and an industry with differentiated products. These criteria would apply to the global nature of the industries. Some of these criteria can, of course, be met by the same industry. Among the prime candidates would be the mainframe computers, steel, chemicals, automotive, printing, and airlines industries. Initially, each industry could be studied in each of two countries.

Balance-sheet data and data on investment spending for each firm in the selected industries are available where firms are state-owned. Data on privately-owned firms probably would have to be collected through interviews. UNIDO sources can provide much of the required information on physical characteristics of production such as employment and nature of capital equipment. Additional sources for physical data include academic studies of the selected industries and feature stories in various trade journals. Another source for some industries is their regulatory bodies over the years. After exhausting these sources two of the major firms in each industry in each country should be visited.

We emphasize again that perfect real-world data are not required for a successful simulation. Indeed, a complete simulation model could be constructed from existing estimates of price elasticities of demand, unit costs of production, and so on. However, the intent would be to replicate the real-world as closely as possible for establishing the basic parameters of the model. The policy simulations then are only limited by the imaginations of the researchers.

The results could be tested for reliability by comparing the "actual" policy simulation with the actual history of the selected industries in terms of profits, real capital, sales revenues, productivities, and number of firms in the industries at various times. A sensitivity analysis also could be connducted in order to see how responsive the simulation results are to various changes in parameter values.

At least four sets of simulations should be conducted for each industry. These can be characterized in two sets, one of which comprises simulations at assumed full employment. At full employment of the firm's labor force, all of the firm's capital stock will be utilized. Less than full employment (either in the industry or the firm) will be characterized as a smaller K. The value of K in time t will be proportional to the employment level in t + i since employment changes often lag behind output movements. The direct reduction in K will reflect the fixity of input coefficients (at a particular technology) in the economic cycle simulations. (Production technique, of course, is allowed to change as new a's are adopted.) The basic two sets are:

1. A complete historical simulation that will use the actual tax rates, subsidies and depreciation policies in place and projected through a selected future period.
2. A series of policy simulations that assume a variety of R & D tax credits, depreciation rates and subsidies over different historical periods, including simulations through the year 2000. Policies in addition to R & D tax incentives could be considered, depending upon simulation results.

From the baseline simulations, the impact of increased investment tax credits, subsidies, depreciation rates and special R & D tax credits can be made by comparing the results.

The main policy parameters have been defined above, but can be summarized easily. These are:

D = the rate of investment depreciation which in turn influences the size of DEP or depreciation allowances.

c_0 = the tax credits on investment which can influence net profits since its value is deductable from total tax liabilities.

c_1 = the percentage tax credit on R & D expenses which can reduce R & D costs

SRD = State subsidies for research and development.

Obviously, the values of each policy parameter can be varied for the simulations. Macroeconomic policy is assumed to be reflected in levels of employment below full employment. Full employment will be defined by trend lines (not necessarily continuous) through peak employment periods.

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