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SIMULATING THE NEW ECONOMY

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Abstract

The IT, the Internet, or the Computing & Communications technology revolution has been central to the economic discussion for several decades. Before the mid-1990s the catch word was the "productivity paradox" coined by Robert Solow, who stated in 1987 that "computers are everywhere visible, except in the productivity statistics". The New Economy, suddenly became the catch word of the very late 1990s. Its luster however, faded almost as fast as it arrived with the dot.com deaths of the first years of the new millennium.

With this paper we demonstrate that the two paradoxes above are perfectly compatible within a consistent micro (firm) based macro theoretical framework of endogenous growth. Within the same model framework also a third paradox can be resolved, namely the fact that the previous major New Industry creation, the Industrial Revolution, only involved a handful of Western nations that had got their institutions in order. If the New Economy is a potential reality, one cannot take for granted that all industrial economies will participate successfully in its introduction. It all depends on the local *receiver competence* to build industry on the new technology. We, hence, also demonstrate the existence of the possibility of failing to capture the opportunities of a New Economy within the same model.

Key words: industrial simulation, innovation and growth, the New Economy, non-linear dynamics.

JEL code: C45, C63, C81, C99, L16, L63, O14, O31, O33

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1. The Problem

The New Economy was a catch word of the very late 1990s (Kelly 1998). Its luster, however, faded almost as fast as it arrived with the dot.com deaths of the first years of the new millenium. Before that, up to the mid-1990s the catch word was the "productivity paradox" (Berndt – Malone 1995, Brynjolfsen 1993) coined by Robert Solow, who stated in 1987 that "computers are everywhere visible, except in the productivity statistics". The paradoxical emergence in the midst of the academic discussion of the productivity paradox of the shift to fast productivity growth, called the New Economy apparently has something to do with IT or the Computing & Communications (C&C) technology.

We demonstrate that the two paradoxes above are perfectly compatible within a consistent, micro based macro theoretical framework of endogenous growth. The micro-to-macro model that we use to simulate the New Economy – the MOSES model of the Swedish economy (Eliasson 1977, 1991a) – approximates, on a simulation format, the theory of the *Experimentally Organized Economy* and of *Competence blocs* (Eliasson 1987, 1996a, Eliasson – Eliasson 1996). We use the new version of the model with (Ballot – Taymaz 1998) endogenous innovative activity and learning and technological diffusion represented by genetic algorithms. Within this model framework also a third paradox can be resolved, namely the fact that even if all the objective requisites, such as technology are in place no shift onto a faster growth path may follow. We note that the previous major New Industry creation, the Industrial Revolution only involved a handful of Western nations, excluding some of the world's technologically most advanced economies at the time. Only those economies that had got the institutions needed to support a dynamic market economy in order became industrial nations. The others followed the old, slow growth trends in the Figures 1A, B (North–Thomas 1973, Eliasson 1991b). A glance at Figures 1A and B reveals a history with many false starts. If the New Economy exists, and there were skeptics (Gordon 2000a) among all enthusiasts, one cannot take for granted that all industrial economies will participate successfully in its introduction. It all depends on the local *receiver competence* (Eliasson 1985, 1986, pp. 47 ff, 57 ff, 1990) or absorptive capacity (Cohen – Levinthal 1990) at the societal level. We also demonstrate within the same model the existence of the possibility of failing to capture the opportunities of a New Economy. Finally, there is also the worrisome collapse of some of the C&C industry beginning in late 2000 that has caused a discontinuation of much of the New Economy hype. We will, therefore, also discuss the sustainability of the

New Economy in terms of the simulation experiments. Hence, in this paper we demonstrate through simulations on the Swedish micro-to-macro model MOSES that three paradoxes are fully compatible within the same comprehensive modeling framework;

Paradox 1; The long gestation period, before positive circumstances generate the expected upward shift in macroeconomic performance, leads to the premature and mistaken conclusion that investment in new technology has been wasted.

Paradox 2 The dynamics of the sudden surge in macroeconomic performance, cannot be explained in terms of current or near term circumstances.

Paradox 3; A shift to a New Economy development does not occur, even though abundance of technological knowledge is in place locally.

Paradox, or hypothesis 3, means that a sustainable, new and fast growing economy will not appear if the local competence to commercialize the New Technology is lacking (see competence bloc theory in Eliasson – Eliasson 1996, 2002a) and if the requisite institutions and other supporting circumstances are not in place.

The base hypothesis is that the technology had been created in the C&C-industry, but that the growth mover will be its introduction in the old industry through the establishment of new firms, the reorganization of incumbent firms and through the exit of failing firms, or through the Schumpeterian Creative Destruction process of Table 1. The dynamics of this gestation takes decades, not years. This means that the ongoing dynamics will not be captured by standard forecasting or econometric modeling methods. We have been able to *demonstrate the existence, within our model framework, of all three paradoxes above.* The new economy simulations have been made possible with the introduction of the C&C industry in the MOSES model (The database work is presented in the supplement to this paper).

Figures 1A, B illustrate all three paradoxes as they evolved during the first industrial revolution. The new machine tool technology was developed in the UK during the 18th century and moved the UK economy onto a faster growth rate, beginning during the last decades of the 18th century. From that time and through the first half of the 19th century the new machine tool technology became increasingly known in other Western Europe countries and in the US. In fact the Swedish economist Johan Westerman discussed the new machines in England in a book published already in 1768. But not until the later part of the first half of the 19th century could the upward shift to a new growth trend in output be observed for Sweden (see Figure 1A). And it took almost one half of an additional century for a matching shift to a faster growth trend in (labor) productivity to be observed, at about the time the large westward emigration of labor started. Even though technology was internationally available, and successful introductions could be observed along the way, it took considerable time until the then New Economy had been visibly introduced at the macroeconomic level, i.e. until sufficient *receiver competence* had been accumulated for the new technology to make a visible positive cumulative impact on the Swedish growth curve (paradoxes I and II). Atkeson – Kehoe (2001) report that it took several decades before measured productivity growth increased during the second industrial revolution in the US. Even more significant today is that most of the world experienced no shift in their growth curves whatsoever. Most economies of the world never became industrialized and followed the old trend (see Figure 1A) to the right. To **them** belonged the wealthiest economies of the world in the medieval age; China and India. These countries were solidly stuck in their old institutions and traditions.

(Figures 1A, B in about here)

The thicker part of the curve 1860-1920 provides additional insight into the industrial transformation taking place. During that time two thirds of the firms that became the largest Swedish manufacturing firms during the period 1945-1998 were founded; a “Silicon Valley experience” of gigantic proportions for the small country of Sweden. To be noted is that the burst in industrial activity was distributed geographically over a large part of Sweden demonstrating that geographical proximity was not a necessary condition for the synergies of a competence bloc to become activated even during a period of (by modern standards) primitive information- and communications technology. Most of these firms were founded on the technology of the early industrial revolution developed in England, the machine tools (Woodbury 1972), and some of them (ASEA, Atlas Copco, Electrolux, SKF etc.) later became international engineering giants.

2. The Swedish Micro-to-Macro Model

The Swedish micro-to-macro model has been documented in detail in a number of publications. For a fast introduction we refer to Albrecht et al. 1989, 1992, Ballot – Taymaz 1998, Eliasson 1977, 1991a. The most salient features of the model to be emphasized in the context of the simulations are:

- A Schumpeterian creative destruction model of growth or the *Experimentally Organized Economy* (EOE), see Table 1 and Eliasson 1996, p. 45).
- The creation and selection of new technology (*Competence bloc* theory; Eliasson – Eliasson 1996, 2002a).
- The diffusion of new technology through learning from successful introductions (genetic algorithms, Ballot – Taymaz 1998).

The Swedish micro-to-macro model when seen "from above" appears as a Leontief – Keynesian 11 sector model, with complete macro demand feed back from a non-linear Stone type consumption expenditure system and a combination of neoclassical and financial flow based investment functions, defined and quantified at the micro (firm, division) level on real firm data.

Five manufacturing sectors have been carved out of the input/output matrix and been redefined to correspond to the OECD end use of products classification: raw materials, intermediate goods, non-durable consumption goods, investment goods (consumer and producer) and computing and communications goods and services (Albrecht et al., 1992). The latter market has been added to the model recently (see Johansson, 2001, pp. 145 ff, also see supplement). For each initial year (see Supplement) a consistent micro (firm) to macro (National Accounts) data base has been constructed in the financial production (output) and input (labor, purchasing etc.) dimensions. In that context the entire micro-to-macro initial data base was updated to the year 1997 using the firm planning survey of the Federation of Swedish Industries and a special survey on the same format of the largest 100 firms in the C&C industry (Albrecht et al., 1992, pp. 181 ff). The C&C industry to a great extent covers the private service industry and significant redefinitions of national accounts data have been needed to obtain a consistent micro-to-macro data set.

The macro data of the five market defined segments have been replaced by five sets of firm/division data from the above planning survey and the special survey of the C&C industry. The difference between the national accounts macro data and the five aggregates (in all dimensions; financial, profits, value added etc.) of individual firms have been computed and regarded as “synthetic” firms.[1]

The initial state of the model consists of a complete and consistent set of Salter curves (of all performance variables of firms. See Figures S1 and S2 in Appendix) for each micro defined industry (see Salter 1960, Albrecht et al 1992). The endogenous micro behavior of firms during a simulation updates the firms and the Salter curves *each quarter* and growth occurs through the Schumpeterian creative destruction process of Table 1.

(Table 1 in about here)

The firm is defined as a profit oriented production organization with its outer klimits as a controlled hierarchy, defined by its internal statistical accounts. Each incumbent firm makes up investment, production and employment plans under the assumption of reaching a satisfactory ex ante rate of return each period, and attempts to realize the plans in competition with other firms, each having its own particular expectations of the market situation. In doing so they climb *ex ante profit hills* and halt search temporarily (for that quarter) when a satisfactory profit level has been reached (for more detail see Eliasson 1977, 1991a). In the process product and factor prices and the interest rate are endogenously determined. The dynamics of this highly non-linear model of the Swedish economy means that the profit hills constantly change as a result of individual firm search. Firms constantly make business mistakes and the nature of the “business error correction” process is an important part of the dynamics of economic growth in the MOSES model. This is a typical Austrian – Wicksellian – Old Stockholm school feature of the MOSES model and of the EOE (Eliasson 1991a, 1992). The ex ante, ex post correction behavior updates the position of incumbent firms on the Salter curves. If they fail to meet their profit targets for many periods the firms eventually exit (see item 4 in Table 1).

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[1] Each “residual aggregate” has been ”chopped up” into a number of synthetic firms. We have tried, when constructing the ”synthetic firms” to preserve known distributional pattern of the industry/market. See Taymaz 1992.

Firm *entry* and turnover feature importantly[2] in the MOSES model (item 1 in Table 1). Simply expressed, a new firm enters into a market if it is expected to be able to profitably do so. In the simulation experiments discussed in this paper, the number of new firms in each year is modeled as a random function of sectoral profitability. Key characteristics of new firms (entry size, technological level, etc.) are also determined randomly in such a way that a new firm is about 15% of incumbent firms in terms of (initial) employment. On average, the technological level of new firms is lower than that of the incumbents, but there are some new firms that are significantly more productive than the best incumbent firms (see Eliasson 1991b).

Innovations are embodied in investment. Furthermore, disembodied learning-by-doing occurs. There are two types of innovation. An incremental innovation yields an improvement in the capital and labor productivity (INVEFF and MTEC) variables in the model, within the limits of an optimal technology, which we label the "global technology". The essential point is that firms do not know the global technology and therefore cannot jump to it. Incremental innovation is obtained by discoveries within the firm or by imitation and improvement of another firm's technology. Radical innovation determines a change in the global technology. Global technologies are also ranked by their productivity, and all the technologies that have the same limiting global technology belong to the same technological paradigm. Such a paradigm, also called techno-economic paradigm by Freeman and Perez (1988), corresponds to a cluster of inter-related innovations that affect most of the sectors. We have also introduced user-producer learning that stimulates the diffusion of innovations between sectors.

The "technological level" variable in the model refers to the average of technology codes. Technologies are ranked from 1 to 100 and the rank of the technology defines its potential limit. For example, technology 10's potential limit is higher than technology 4's, etc. A firm gets closer to that technological limit by incremental innovation and the closer it gets the more difficult it becomes to improve productivity. Then the firm will try to switch to another technology that is more likely to have a higher potential limit. Therefore, the average technological level in the model (the technology index) is an abstraction. The number of

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[2] See further Eliasson – Johansson – Taymaz 2001.

patents issued can be used as an indicator, but in the model the technological level refers to qualitative differences in technologies.

The move of the economy towards a new paradigm is favored by the decreasing returns to incremental innovations, but its success depends on the willingness of many firms to follow the first firms that have ventured into the new paradigm. There are increasing returns to adoption (Arthur, 1988). This means that better paradigms might not develop if the returns to the current paradigm are satisfactory. Several paradigms may then be represented in the manufacturing industry for a long time, involving lock-in effects (Ballot – Taymaz, 1998). One not so good paradigm may also block the development of a better paradigm.

New technology is introduced through new entering firms and through new investment in incumbent firms. Radically new technology tends to enter more frequently through new firm entry. If through new investment in incumbent firms the impact is reduced because it has to be integrated in old vintages of capital. On the other hand, the new technology, if successfully introduced applies to a much larger capital base, with a much larger (than with the small firm) leverage on total firm productivity growth. One could look at the introduction of new technology in a MOSES firm (through investment) as a strategic acquisition of a new technology firm the capital structure of which is then integrated with the existing capital structure (see Eliasson 1985, pp. 156f, Eliasson – Eliasson 2002b).

As far as the treatment of human capital is concerned, the focus in the model currently is on the training expenditures of firms, since no initial education module has yet been included. A usual and useful distinction is made between general human capital and specific human capital. Standard human capital theory models specify human capital as non-transferable to other firms, whereas general human capital can be carried totally by the worker from one firm to another. The two types of human capital have a hierarchical relation in our model. Specific human capital simply improves the efficiency of production. Moreover in the present paper, it is partly specific to the technology, and partly specific to the firm. General human capital has three effects on productivity, all of them indirect. *First* it favors the discovery of new technologies for a given level of R&D. *Second*, it enables the firm to imitate the technologies of the other firms to improve its performance. *Third*, it creates a higher platform of receiver competence that increases the productivity of the training investment necessary to acquire specific human capital. Hence, and contrary to Becker's argument it becomes profitable for the firm to invest in general training (Ballot – Fakhfakh – Taymaz 2001).

Business mistakes occur frequently in the EOE and in the MOSES model. They should be looked at as a normal cost for economic development and learning. Because no investment venture can be perfectly planned and enacted, as assumed in the general equilibrium setting of the mainstream model, the dominant transactions cost in the EOE and in the MOSES model is made up of business mistakes (Eliasson 1992). All other measured costs are regarded as production costs geared to measured output. Hence, to experience any successes at all – and growth – the economy has to absorb a large number of mistaken business experiments. In fact, we have demonstrated elsewhere on the model (Eliasson 1984, Eliasson – Johansson – Taymaz 2001) that a certain balancing of firm turnover between entry and exit is necessary for stable macroeconomic growth. Under such "dynamic" circumstances it becomes important that both project creation and selection and the learning process be efficient in the sense that the economic consequences of two types of errors are minimized, i.e. of keeping losers on for too long and of losing winners. Competence bloc theory (Eliasson – Eliasson 1996, 2002a, Eliasson 2001) attends to that within the theoretical environment of the EOE.

Competence bloc theory is an organizational design, featuring the minimum number of actors with categorized functional competences that are needed to create and select projects and to carry winners on to industrial scale production and distribution. The MOSES model incorporates a very crude version of the competence bloc that has been significantly improved upon by the addition of the genetic innovation and learning mechanisms in Ballot – Taymaz (1998) and the more sophisticated financial services markets in Eliasson – Taymaz (2002). We mention this here only because the efficiency of selection helps us to define Schumpeterian efficiency in a dynamic model where growth is generated through competitive selection and a maximum, exogenously determined, sustainable (or "equilibrium") growth rate cannot be defined as a reference or a bench mark because it requires that the lost winners be identified. For our purposes we only conclude here that Schumpeterian efficiency requires significant exit but that only a minimum of potential winners should belong to the exit flow (Eliasson 2001).

One important feature of the competence bloc, clearly manifest in the MOSES model, is that it breaks the direct technology – growth drive so typical of postwar growth models in the neoclassical and linear Schumpeterian (1942) traditions. The competence bloc is defined from the demand (customer) side and screens all innovative technological "suggestions" for profitability (the *entrepreneural* and *venture* capital functions). If the economic circumstances, including institutions and industrially competent actors, are not the right ones, however advanced, technology residing in the economy does not lead to growth. If so we have the case of lacking receiver competence that is explicitly represented in the model.

The MOSES model simulates the complete Swedish economy as defined at the national accounts level. It has been estimated ("calibrated") on macro (national accounts) data for the Swedish economy (Taymaz 1991b). The simulations to follow should therefore be regarded as "empirical forecasts" on a "Swedish like" economy that are based on facts (data and estimated relationships) and the prior assumptions embodied in the model specifications.

3. The New Economy Scenario

The New Economy has been generally associated with computing and communications (C&C) technology and its ultimate manifestation, the *Internet*. The C&C-technology has three industrial dimensions (Eliasson 1998). In its modern form it is (1) a "new" generic *technology* that diffuses through the economy being carried by (2) the *industry* producing C&C equipment, software and services to be (3) *used* practically everywhere in products and in production. The interesting industrial dimension of C&C-industry is not C&C-industry itself but the quality increases achieved in products based on C&C technology and the productivity effects generated when its products are integrated with other forms of production, for instance in the financial service industry to create very large positive systemic effects (see Eliasson 1995, 1998 and 1999, Eliasson – Wihlborg 1998, Eliasson – Taymaz 2000).

This is the sequence of events that we envision in reality and have explicitly represented in the model. *First*, new generic C&C technology is developed within the C&C industry and forms the base for rapid expansion of the C&C industry. The same technology is carried to the incumbent firms in existing industry through their investments in hardware and software produced in the C&C industry. The successful introduction and realization of productivity gains from those investments in user firms, however, require a particular *local receiver competence* (Eliasson 1990) that is rarely present. *Second*, the early successful introductions

are, therefore, preceded by sequences of failed introductions. *Third*, once a success has been registered learning sets in among other firms as modeled through genetic algorithms in the model. The diffusion of successful new technology introductions, however, take a very long time before the opportunities to learn become plentiful. We register a strongly non-linear introduction process, beginning with the productivity paradox and culminating with a surge in productivity advance as the new technology takes hold of the entire production system, forcing firms that have not been able to accommodate the new opportunities to exit.
The fast movers/introducers are the new entrants. *Fourth*, once the new technology has established itself in the form of several successful technology introductions (the technology index, or the tech level in figures 3, 4 and 5) other firms will find it easier to learn, and the more firms that have learned the faster other firms learn and technology diffuses at an accelerating rate. Eventually, the entire economy should have assimilated the new technology and shifted to a higher growth path. This takes care of the first two paradoxes.

The third paradox involves failure on the part of the entire economy to introduce the new technology. Receiver competence from an economy wide perspective has an economic or industrial dimension that is captured by competence bloc theory but also an institutional dimension, including the institutions that support the actors in the competence bloc. If the political spirits of a nation are against the formation of private wealth policies will be enacted that discourage the development of a competent venture capital in industry. This will effectively short-circuit the competence bloc. Among the many possible institutional explanations to a deficient receiver competence could also be mentioned fundamentalist cultural or ethical ad hoc resistance to particular novelties, for instance the cultural resistance that has prevented nuclear power from becoming an economic energy source for a long time and the ethical opposition to bio technology that may prevent Europe from developing a viable bio tech industry (Å. Eliasson (2002). Our analysis will however only demonstrate that simple economic, or economic policy circumstances associated with the institutions of a national economy may be sufficient to prevent the successful transformation of an old economy to a New Economy. From Eliasson –Taymaz (2000), Eliasson – Johansson – Taymaz (2001) and Johansson (2002) we know that a balanced entry and exit process and a mobile labor market are required for new technology introductions through new entry of firms to be successful. If a viable exit process and a mobile labor market do not facilitate the transfer of resources, notably labor resources to the entering and growing firms the whole growth process might stall. There may not be any New Economy experience.

4. The Design of Simulation Experiments

Experiments have been designed to show the successful and innovative introduction of C&C technology (reflected by the technological level curve in the graphs, see above) to be learned by other firms at fast, medium fast and slow rates. These introductions occur through firm investments, in which we vary the share of C&C investments exogenously. Two things now occur. *First,* C&C industry investment increases the probability of successfully innovating and initiating new technology in the C&C industry firms. *Second*, productivity of new investments in the firms using C&C industry products increase strongly.[3]

The experiments also distinguish between fast and slow innovative entry, and fast and slow exit. In this model setting, a (a) low level of, and a slow rate of growth in the technology level and (b) a slow introduction of C&C technology are taken to reflect a low receiver competence on the part of the firm population of the economy. A slow increase in successful new and innovative C&C technology introductions can also be caused by a badly functioning competence bloc in the sense that radically new and innovative technologies or products are not identified and supported commercially, e.g., because of lack of sophisticated customers or competent venture capitalists. The genetic learning mechanisms of the model capture some of that in a stylized way. Similarly, the whole economic system can be more or less adopted for facilitating the introduction of new technology through new entry etc. In our simulation experiments this is crudely represented by the speed of entry that can be varied by setting the parameters that determine how new firms react differently to profit opportunities in the market. The other side of the receiver competence of the economy at large is a more or less speedy exit process that releases resources more or less early for fast growing new entrants and incumbents. In the slow case, firms exit when they have used up their equity. In the fast case they exit after so and so many years of below market interest rates of return. One problem should, however, be mentioned right away. The successful introduction of new C&C technology (the technology level curve) is all endogenous. We cannot keep that factor constant, and vary other parameters to see how fast technology diffusion occurs.

[3] That is labor and capital productivity (MTEC and INVEF respectively) in new investment vintages increases, and the more the larger the share of C&C investment in total firm investments.

5. Simulation Experiments

The figures 2A, 3A and 5 show cumulative developments of (1) the C&C technology level, (2) C&C industry output, (3) manufacturing output and (4) (labor) productivity. In the first round of experiments exit is fast, releasing resources fast (fast exit).

The reader should, however, note one particular thing. Towards the end of the simulations productivity growth is quite fast and total demand does not keep pace with growth in potential output. Unemployment reaches fairly high levels in most experiments. This means that the experimental design is not that of a full employment economy. Unemployment is all endogenous in the model and a growing unemployment will eventually be self-correcting through endogenous downward adjustments in wage growth, if not prevented by policy determined stickiness of wages (not in these experiments). This has consequences for the interpretation of the simulation results that were not anticipated when designing the experiments (see below).

(Table 2 and Figures 2A, B, 3A, B, 4 and 5 in here)

Table 2 gives key “end of 60 years” data for three of the 16 simulation runs. For each of the 16 simulation experiments five Monte Carlo variations[4] have been run to test for robustness (see Figures 2B and 3B). Table 2 and Figures 2A, 3A give average outcomes. The Worst Growth case experiment features (a) no entry, slow diffusion of C&C technology and a high exit rate. The Best Sustainable Growth case experiment (b) features significant entry, fast diffusion of C&C technology and fast exit of low performing firms. If we vary the parameters of the entry function in the model we find that the maximum growth scenario (the best sustainable growth case) is obtained when rates of entry and exits are balanced (se Eliasson – Johansson – Taymaz 2001).

With sustainability we mean that the circumstances are such that fast growth most probably will continue beyond the simulated long run horizon (see below). Figures 2A and 3A show the evolution of over time of C&C industry output, total manufacturing output, the level of

[4] by varying the seed number of four pseudo-random number generators in the model that affect (a) the sequencing of firms sending hiring signals in the labor market, (b) the timing of entry, conditional on objective incentives, (c) the degree of success of R&D outcomes and (d) new firm characteristics.(see Eliasson – Taymaz 2000).

technology and labor productivity in the best sustainable and the worst growth scenarios respectively. The B figures show Monte Carlo variations in manufacturing output for the same scenarios. The technology level is an index of the productivity levels achieved in the most successful new technology introductions from which all other firms can now learn.

The worst growth case experiment has been designed to show the absence of a successful new economy introduction. The negative institutional circumstances that prevent the introduction of a New Economy are very crudely represented by the absence of new entry (vs fast and very fast entry) and the slow diffusion of C&C technology. But this is sufficient to generate a remarkable difference in long term industrial development, best shown in the B figures. The Best Growth case shows (Figure 2B) a rapid phase shift onto a faster growth pattern after some 30 " productivity paradox" years. The Monte Carlo experiments show a significant spread of the new economy introductions, but the whole "fan" points strongly upward. Nothing of the kind can be registered in the 3B figure. The economy "misses the fan", or the New Economy entirely. The A figures and Figure 4 tell why. Figure 4 compares the four indexes in the two runs using the Worst Case as a benchmark (i.e. as index 1).

The technology level rushes away dramatically in the Best Sustainable Growth scenario. There are plenty of successful new technology introductions for firms across industry to learn from (learning is modeled by genetic algorithms, see Ballot – Taymaz 1998). Labor productivity in all manufacturing firms surges ahead, but only after some 25 years of "productivity paradox" have passed. With a delay of several years manufacturing output surges ahead.

We should also observe (see Eliasson – Johansson –Taymaz 2001) that the Best Growth successful New Economy introduction scenario features a balanced entry and exit process (see Table 1). None of the other experiments did that.

The only peculiar circumstance to observe is that C&C industry output in the best Best Successful New Economy introduction case grows much more slowly than in the worst growth case. The reason appears to be the productivity of C&C equipment. The larger the share of C&C equipment in total investment the higher the probability of radical innovation and successful imitation raising productivity levels in the investing firms. Since C&C equipment is very productive, demand for C&C equipment expressed in volume terms decreases.

Finally we have (Figure 5) the Best 60 year growth case. It differs from the Best Sustainable growth case only in one way. Exits have been slowed down. Fast exits mean that rational firms shut down after some years of below market average rates of return, and release their resources (physical capital and labor) in the market. Slow exit means that firms do not exit until their net worth is turning negative ("bankruptcy"). This means that badly performing firms on the average stay on longer in production in the low exit than in the fast exit simulations, locking in resources and raising factor prices for the fast growing successful firms, thus, lowering growth. Such was the common sense hypothesis based on earlier model experience (Carlsson 1983, Eliasson – Taymaz 2000). But here the model comes up with a surprise.[5] Capacity utilization and employment are completely endogenous in the model and the new economy experiments all turned out to be significantly less than full employment scenarios.[6] We have encountered something of a "Keynesian situation". Keeping the low performing firms alive longer meant significantly reduced labor productivity across manufacturing (cf. Figure 2A with Figure 5) but much less unemployment (Table 2). Apparently, the lowered supply of factors was not sufficient to raise factor prices significantly and the "Keynesian" effect dominates over the factor reallocation effect. Manufacturing output becomes higher than in the best sustainable growth scenario.[7] On the macro surface we can observe the emergence of a strong upward shift in growth. Also the C&C industry grows rapidly. But new technology introductions are negatively affected (the technology index) and there will not be much in the form of successful new technology introductions to learn from. Compared to the fast entry, fast C&C diffusion and fast exit case (Figure 2A) this faster growth case is not positioned for sustained faster growth beyond the 60 year simulation horizon. Could the sudden unexpected emergence of fast growth after many "productivity

[5] Which it frequently does because of its extreme complexity.

[6] Because the new database and the calibration took much longer than expected we have not had the time needed to design an entirely new set of experiments where a higher level of capacity utilization is maintained.

[7] One should of course not overdo the interpretation of the simulation experiments, but it is tempting to make one comment here. During the real industrial revolution in Sweden during the 19th century expansion began first in output and growth in productivity took more than a quarter of a century to catch up. The difference might have a Keynesian explanation in the sense that strong export demand supported output growth, but not sufficient to keep labor fully employed. Measured productivity caught up with output when a surge in emigration to the US began. This interpretation is perfectly testable on the MOSES model but was not anticipated when the experiments were designed and would be a new project to reenact through simulations.

paradox years" in the U.S. economy and then the sudden collapse of parts of the C&C industry have anything to do with this "sustainability" issue. More slack in the economy (cf. Figure 2A) caused by a faster exit process would have paved the way for a better very long term sustainable future than the slow exit case (cf. Figure 5).

Supplement: MOSES 1997 Database – including the C&C industry

Creating an initial database for the Swedish micro-to-macro model MOSES (see Eliasson 1977, 1978, 1985, 1991a) is a major research undertaking. Not only has data for a consistent micro firm to macro GNP (National Accounts) level database to be collected (see Albrecht *et al*. 1992) and adjusted for complete consistency. The model also has to be dynamically calibrated/estimated (see Taymaz 1991b). The same initial databases, therefore, have to be used for years. The previous initial databases were compiled for the years 1968, 1974, 1976 and 1982. They increasingly meant the creation of a complete and consistent micro-to-macro national accounts system.[8] 1976 was the first year planning survey data on firms and divisions of firms specifically designed for the MOSES model were used (see Albrecht *et al*. 1992). A "synthetic" (deidentified) database for outside use was put together for 1990. Only for 1976 was it possible to get a complete input output table for the OECD end use industrial classification that we use (see Ahlström 1978).

From 1997 a new micro firm based industry, the C&C industry has been introduced. This required the creation of a completely new database for 1997. The initial database has, therefore, been shifted from 1982 to 1997 and the model has been completely recalibrated.

This supplement briefly explains the nature of the micro-to-macro data base and the new C&C industry. For more detail the reader is referred to Albrecht et al. (1992). To begin with, value added and employment shares are presented for the industries with micro data used in the 1997 version of the model. This has to been done to make future comparisons possible. Value added and employment shares for the 1982 database have been included for comparisons.

[8] See Albrecht *et al.* 1992.

To our knowledge, official value added data on the C&C industry has only been published by Statistics Sweden for the year 1998. We have, therefore, used the official data for 1998 to approximate value added for the C&C industry in 1997. Assuming the same relation between value added per employee in 1997 and 1998, the ratios of employees in the different industries have been used to approximate the 1997 shares of value added with value added data for 1998.

We also include Salter curves on the rates of return and on labor productivities of the real firms included in the model. These firm data are based on firm surveys.

There is also a brief comparison of the Swedish C&C industry share with similar data for the U.S. economy published by Jorgenson (2001), even though Jorgenson uses a different method for calculating value added by industry. Since most writing on the New Economy originates in the U.S. this comparison of the size of the C&C industries in the two economies is of interest to understand the magnitudes involved.

Table S.1 gives the size of the Swedish C&C industry as almost 5 per cent of GDP in 1997 (5.3 per cent in 1998; see *Table S.3*). The corresponding employment share in 1997 (see *Table S.2*) is 3.8 per cent, or significantly smaller, telling that labor productivity is higher in the C&C industry than in the rest of the economy on average. The C&C industry employment share has also increased since 1982 (from 2.9 per cent to 3.8 per cent, an increase of about one third). Reduction in employment shares between 1982 and 1997 have been reported for raw materials and investment goods producing industries, agriculture, mining, construction and electricity. The interesting thing is the reduction in the investment goods producing industry and a corresponding, large increase in the labor share of intermediary products producing industries. Technically this means that the firms that we have classified as intermediate goods producers have grown faster on average that the firms classified as belonging to the investment goods industry.

The total share of the C&C industry of GDP is about the same in Sweden and the US, the US C&C industry being only slightly larger (see Table S3). It is interesting to note that the Swedish share of manufacturing C&C industry is much larger than the US counterpart, while the US software and services industry is much larger than the Swedish counterpart. Telecommunications industry is of about the same size. The C&C services industry is newer and expands much faster than the old manufacturing C&C industry. This indicates a lack of renewal and low industrial transformation of the Swedish industry.

The Salter curves of manufacturing industry (Figures S.1 and S.2) show strong increases for labor productivity and also in rates of return across the entire manufacturing industry. This suggests that the top of the business cycle occurred in 1997, the year of the initial database. This was not the case in 1982, the year of the previous initial database. But Figure S1 also reflects the fact that the same period has seen a return of manufacturing rates of return to more normal levels compared to the depressed level in the 1970s and early 1980s.

Table S.1. Value added distribution, per cent of GDP in 1997 and in 1982, with and without the C&C industry

Sector	1997	1997	1982
Raw	3.78	3.78	1.70
Intermediary	6.56	6.56	6.80
Micro defined Investment	3.65	5.76	9.04
Consumer	4.98	4.98	6.07
C&C	4.92	--	--
Agriculture	2.17	2.17	3.15
Mining	0.30	0.30	0.38
Oil	0.17	0.17	0.20
Construction	3.45	3.45	7.67
Macro, sector Electricity	2.51	2.51	3.59
Other Services	67.52	70.32	61.4
Total	100	100	100

Note: The sectors are defined as in Bergholm 1989. The only difference is that the C&C industry has been "broken out" from other services (telecommunications firms and data consulting and data services firms) and from investment (manufacturing C&C firms) and is presented separately. There are no value-added data available on the C&C industry in 1982.
Source: Statistics Sweden 2001, MOSES database and own calculations.

Table S.2 Labour distribution, per cent of total in 1982 and in 1997, With and whout the C&C industry

Sector	1997	1997	1982	1982
Raw	2.88	2.88	4.20	4.19
Intermediary	6.51	6.51	4.75	4.74
Investment	3.69	5.37	6.73	8.31
Consumer	5.68	5.68	5.28	5.27
C&C	3.82	-	2.88	-
Agriculture	0.99	0.99	1.43	1.42
Mining	0.28	0.28	0.37	0.37
Oil	0.05	0.05	0.05	0.05
Construction	4.96	4.96	6.55	6.54
Electricity	0.75	0.75	1.06	1.06
Other Services	70.40	72.55	66.70	68.04
Total	100	100	100	100

Note: The sectors are defined as in Bergholm 1989. The only difference is that the C&C industry has been "broken out" from other services (telecommunications firms and data consulting and data services firms) and from investment (manufacturing C&C firms) and is presented separately.

Source: Statistics Sweden and own calculations.

Table S.3. C&C industry share of GDP, Sweden and the U.S., 1982

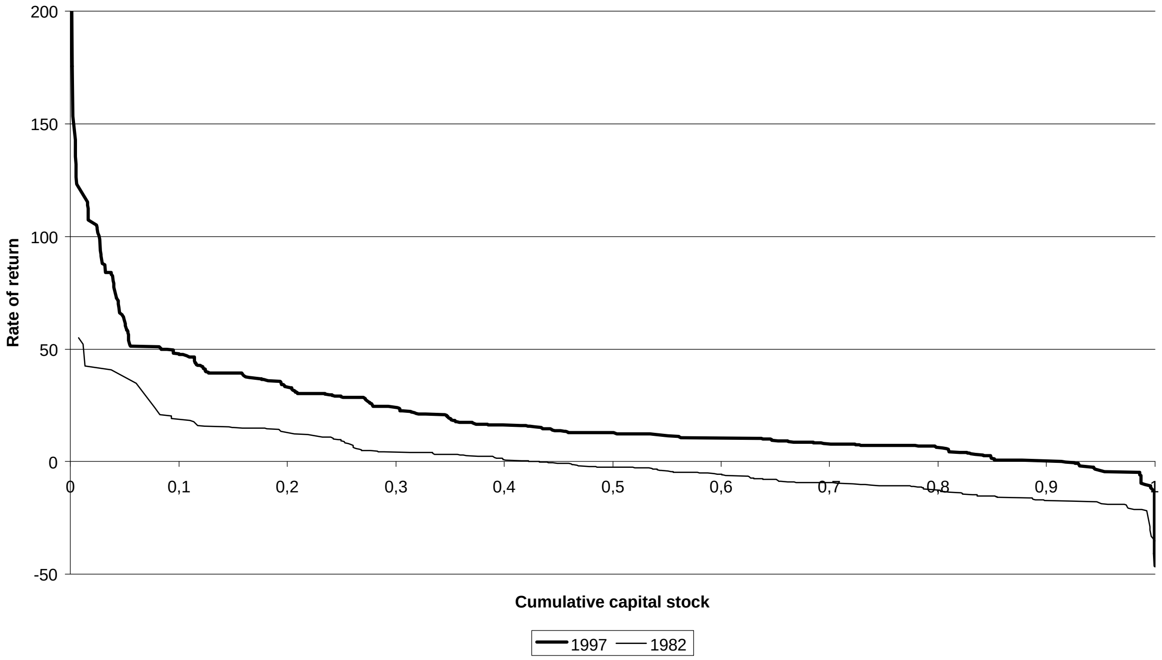
	Sweden	USA
Manufacturing C&C industry (Computer)	2.08	0.93
Telecommunications industry (Communications)	1.48	1.50
Data consulting and data services firms (Software and services)	1.77	3.49
Total	5.33	5.92

Note: Notations used by Jorgenson 2001 in parentheses. The large share of manufacturing C&C industry in Sweden is partly explained by the fact that Ericsson is classified as manufacturing C&C equipment.

Source: Statistics Sweden 2001, Jorgenson 2001 and own calculations.

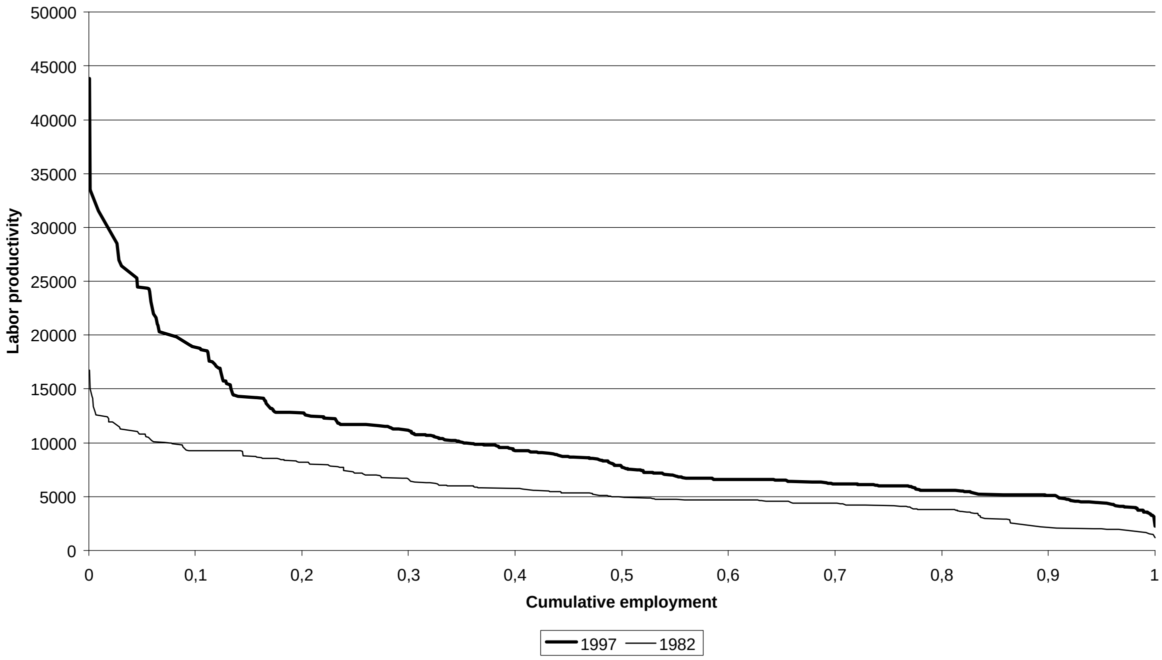
Figure S.1 Rates of return (per cent), 1982 and 1997

Note: Swedish manufacturing industry.



Source: MOSES database.

Figure S.2 Labour productivities 1982 and 1997



Note: Swedish manufacturing industry. Labour productivity is calculated as value added (1000 SEK; 1997 prices) per employee.

Source: MOSES database.

Table 1. The four mechanisms of Schumpeterian creative destruction and economic growth

1. Innovative entry enforces (through competition)
2. Reorganization
3. Rationalization

   or
4. Exit (shut down)

Source: "Företagens, institutionernas och marknadernas roll i Sverige", Appendix 6 in A. Lindbeck (ed.), *Nya villkor för ekonomi och politik* (SOU 1993:16) and G. Eliasson (1996, p. 45).

Table 2. Key end of 60 year simulated data

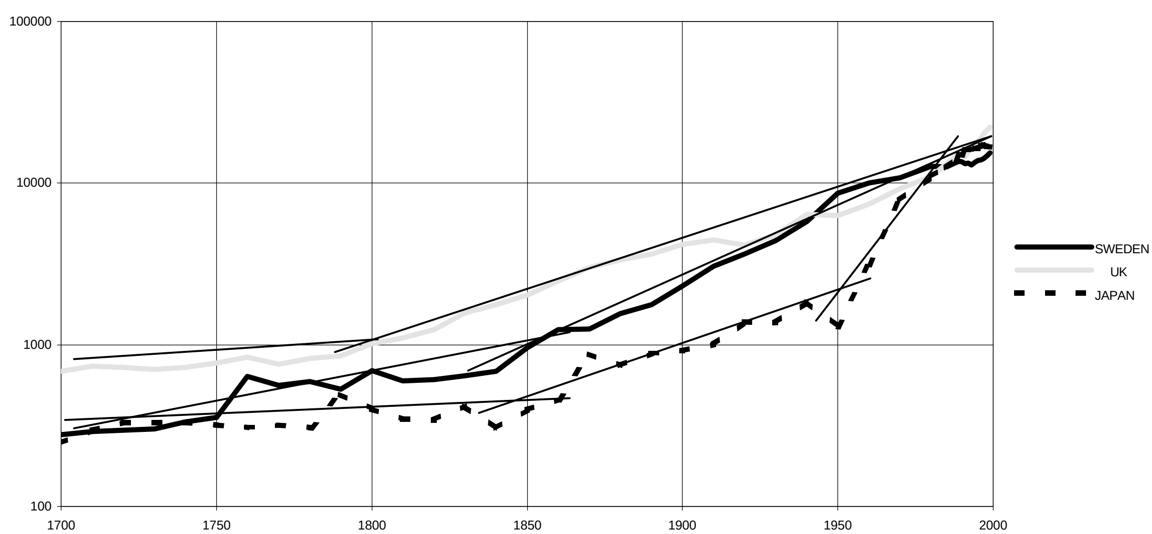
	(a) worst growth case	(b) best sustainable	c) best 60 year growth case
GNP	100	152	175
Manufacturing output	100	141	171
Entry	0	242	114
Exit	191	225	69
Technology level	100	212	160
Unemployment	100	158	89

Note: For items 1, 2 and 5 and 6 column 1 in the worst growth case has been indexed 100 for reference. Exit and entry are express in terms of number of firms. The absolute numbers do not relate to similar registered numbers for the Swedish economy because the total number of firms in the MOSES firm population is much lower than the real population of firms.

Figure 1A. Manufacturing production and productivity in Sweden 1549-2000

Source: Eliasson, Gunnar, 1988. *Schumpeterian Innovation, Market Structure, and the Stability of Industrial Development; in Hanusch (ed.),* Evolutionary Economics – Applications of Schumpeter's Ideas, s. 158. Cambridge, New York etc.: Cambridge University Press and updatings.

Figure 1B. GNP per capita in Sweden, England and Japan 1700-2000



Källa: Eliasson (1986, p. 49) and later updatings.

Figure 2a. Best sustainable growth case

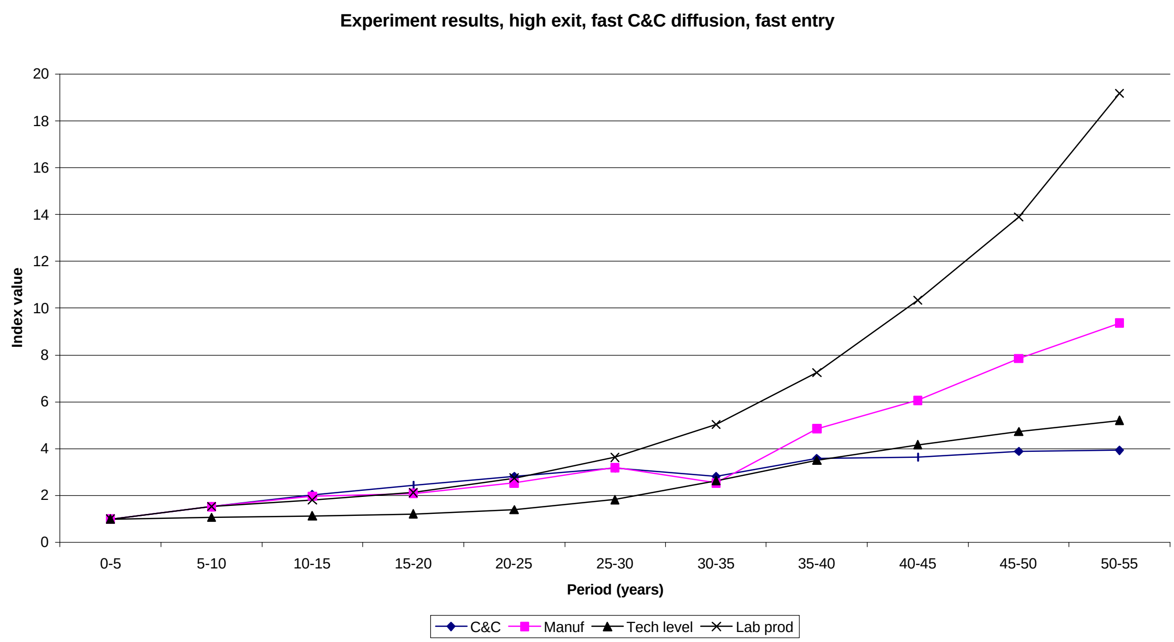


Figure 2b. Manufacturing output level in high exit, fast C&C diffusion, fast entry experiments

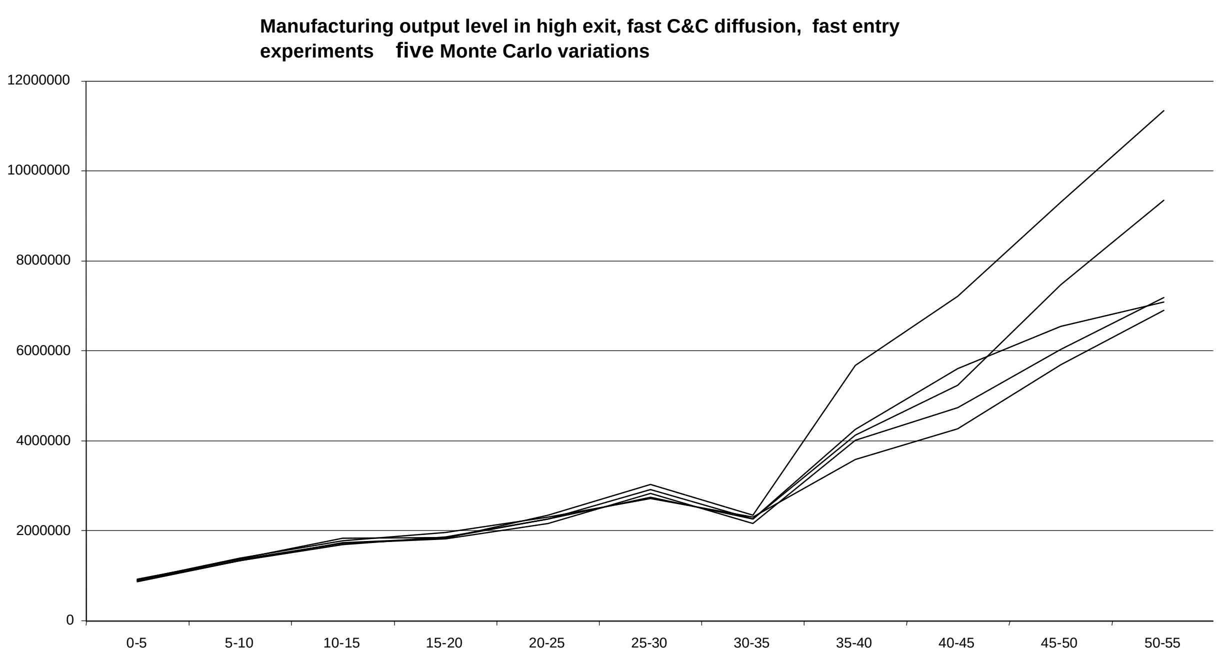


Figure 3a. Worst growth case

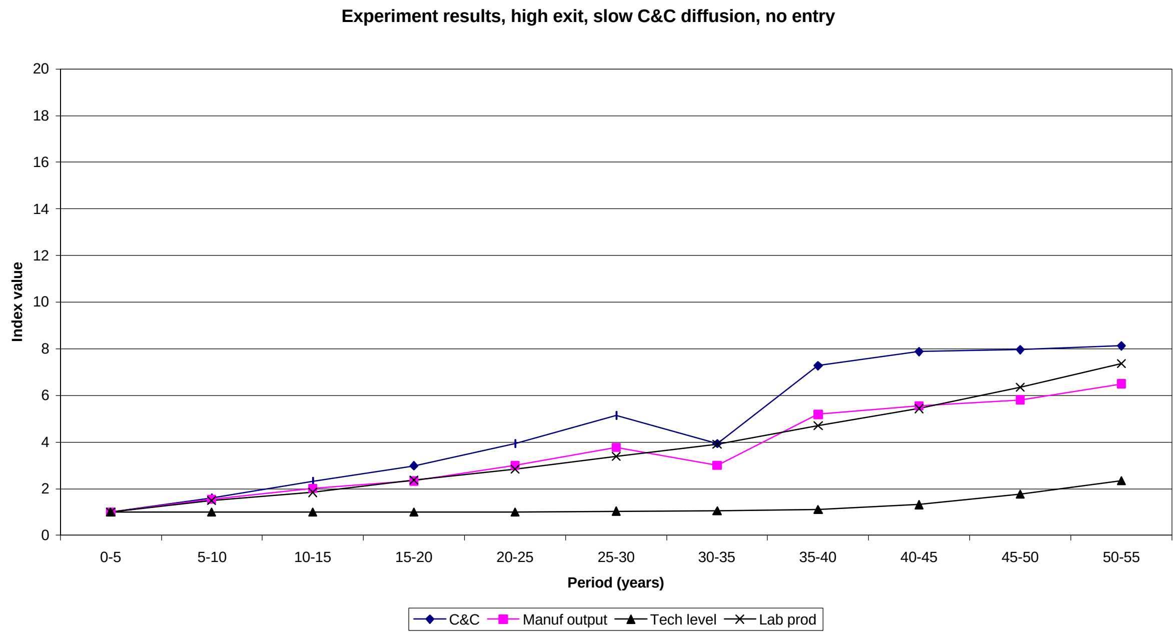


Figure 3b. Manufacturing output level, high exit, slow diffusion, no entry experiment

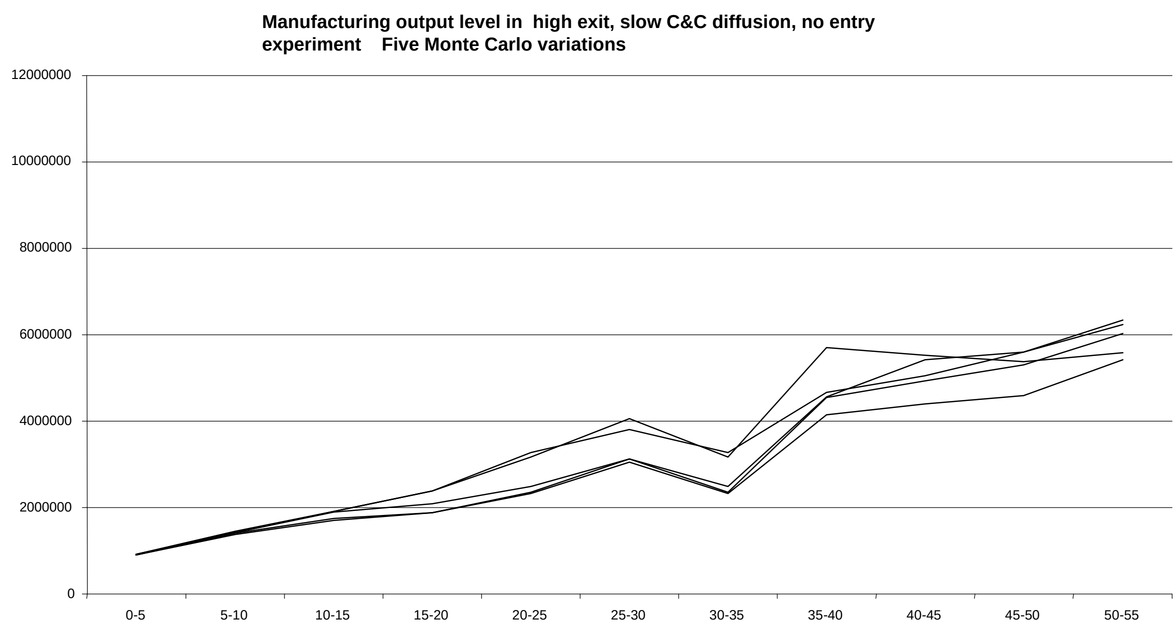


Figure 4. Relative performance of high exit/fast C&C diffusion/fast entry vs. high exit/slow C&C diffusion/no entry experiment

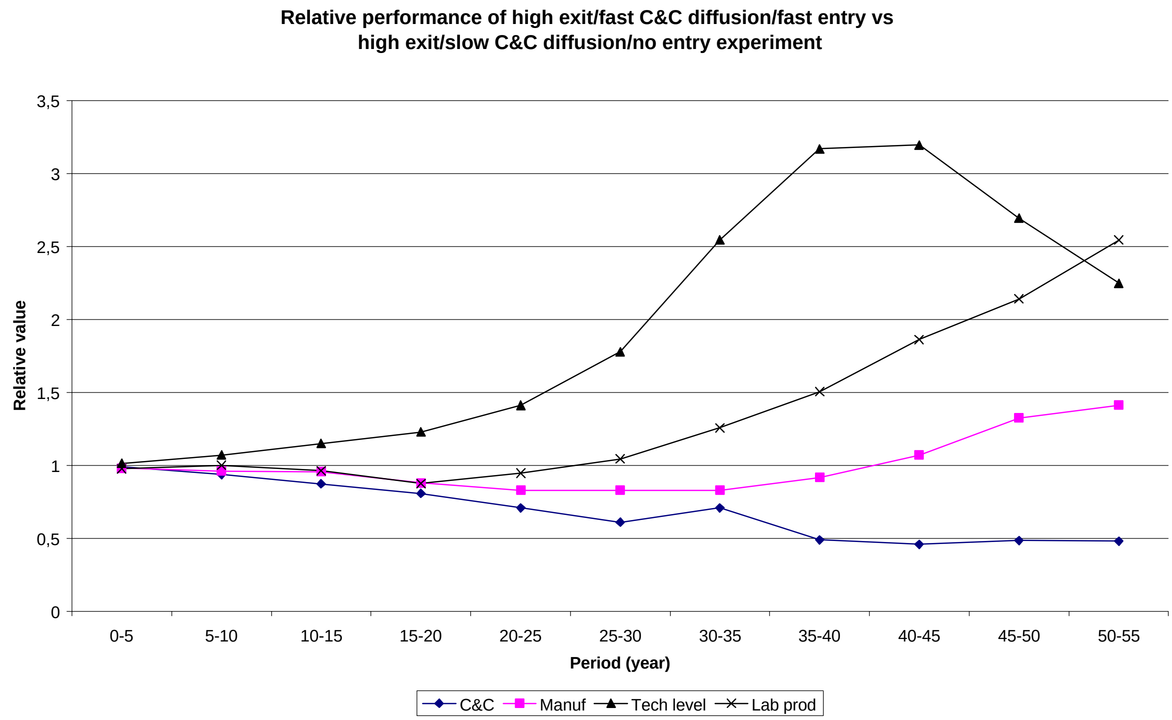
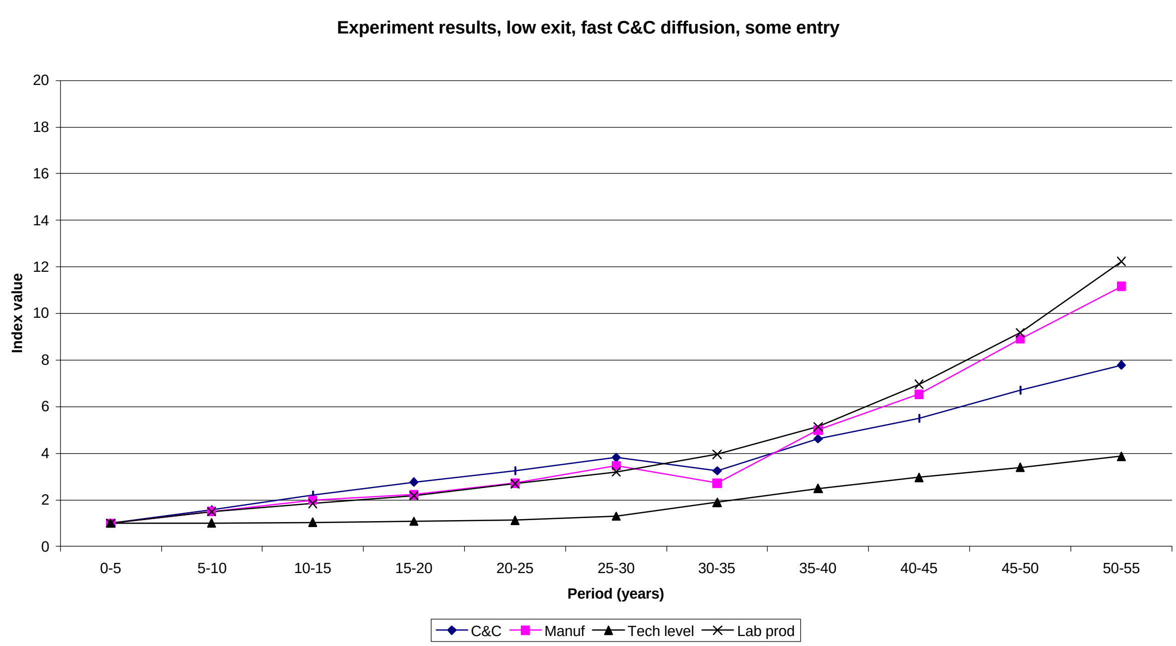


Figure 5. Best 60 Year Growth case



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