An Essay on the Concept of Dynamic Efficiency and its Implications for Assessments of the Benefits From Regulation and Price Control

Lewis Evans, Neil Quigley and Jie Zhang

New Zealand Institute for the Study of Competition and Regulation

http://www.iscr.org.nz

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1. Introduction

1.1 Definitions

Economists usually distinguish between three types of efficiency:

(i) Allocative efficiency refers to the allocation of scarce resources among competing uses.

(ii) Productive efficiency is determined by the efficiency of production processes within firms; in particular whether firms minimise production costs.

(iii) Dynamic efficiency refers to the efficiency of the framework for future decision-making.

Allocative and productive efficiency are static concepts, in the sense that they relate to welfare at a point in time. Allocative and productive efficiency reflect the outcome at a single point in time of resource allocation and production decisions.

The literature in economics contains a wide range of definitions of dynamic efficiency, most of which are tailored to particular contexts, but all entail consideration of the impact of intertemporal decisions[1]. We consider that dynamic efficiency refers to the outcomes from the sequence of future decision-making relating to the allocation of resources, production technologies of firms, and investment in new knowledge. Dynamic efficiency is determined by decision-making relating to investment including R and D, the purchase of new capital equipment embodying those innovations, and the adoption of new production processes. Dynamically efficient states of the world are those in which the incentives for decision-making are such as to maximise the present value of social welfare over time, subject to the overall constraints provided by the resources in the economy.

In the public sector we would expect dynamic efficiency to be influenced by all those factors that determine incentives, including the clarity of the policy objectives, the effectiveness of management and decision-making and accountability for the outcomes. Public policy will also

[1] Among the most general examples, dynamic efficiency has been defined as 'a concept of long-run efficiency of development which excludes persistent inefficiencies' Funk (1996) "changing the production function in profitable directions" Ghemawat and Ricart i Costa (1993), and as 'the result of inter-temporal cost minimisation' Urbino (1996).

effect the private sector; tax, education and tariff policies are obvious examples, but competition law and regulation also have a major impact on the dynamic efficiency of the private sector.

Dynamic efficiency is often associated with competition and the incentives that are associated with the operations of private enterprise in competitive markets, but in some important contexts (especially public sector decision-making) competition may not be feasible. An alternative way in which to think about the problem is to say that a key plank of the dynamic efficiency of competitive markets results from the fact that decision-making is decentralised. Here we use decentralisation to mean that there is competition in decision-making, so that no firm or group of individuals makes decisions as a matter of right.

By comparison, in heavily regulated industries or government-owned industries where entry is precluded, decisions are based on the views of a small group at the top of a (often politically influenced) hierarchy (be it government department or regulator).[2] This sort of decision making involves reaching a consensus view. Typically there are legitimately different assessments and expectations of factors that are material to wise investment. None of these may represent a consensus and certain of them may turn out to be incorrect. Decentralised decision making, whereby entities reach their own views, make their own judgements, and bear the consequences of their decisions, is likely to be based on a wider set of information and lead to an average outcome based on a portfolio of investment decisions that is less vulnerable to picking the wrong (potential) strategy. This is particularly the case where technological change is important (as it is to a varying extent in all our infrastructure industries). Decentralised decision making also facilitates the efficient adoption of niche market opportunities.

For decentralised decision making to function as claimed, however, requires that there be a number of firms that are not much directed by regulation, each of which is accountable for investment outcomes. In both government ownership and heavy regulation (e.g. invasive incentive regulation and rate of return regulation), investments are to various extents directed and the entities unaccountable for outcomes. In the case of heavy regulation this is illustrated by the problem of stranded assets (investment in which was sanctioned or encouraged by

[2] From this perspective a key advantage of the SOE model is its decentralisation of decision-making by comparison with a government department.

regulatory authorities) which now impose dynamic inefficiencies because of prices that are charged consumers and producers, and the effects these are having on new investment.

1.2 The trade-off between static and dynamic efficiency.

The trade-off between static and dynamic efficiency is widely recognised in the literature (for example, Ghemawat and Ricart i Costa 1993; Viscusi, Vernon and Harrington 1995: 93; Van Witteloostuijn 1992). The trade-off is based on the notion that under the conditions associated with perfect competition (free entry and exit, all firms have the same technology and information) price is driven down to the short-run marginal cost. At this price, and with instantaneous adjustment to any lower short-run marginal cost resulting from technological innovation, no firm has an incentive to innovate. This is because the perfectly competitive market rules out the innovating firm being able to recover any of the fixed costs of investment in the new technology. Ex ante, therefore, no rational entrepreneur would invest in research and development.

The idea of a trade-off between static and dynamic efficiency dates at least to Schumpeter (1943), who expressed the idea as follows:

> "A system that at every point of time fully utilises its possibilities to the best advantage yet may in the long run be inferior to a system that does so at no given point of time, because the latter's failure to do so may be a condition for the level or speed of long-run performance… But in capitalist reality,… it is not that kind of price competition which counts but the competition among firms from the new technology, the new source of supply, the new type of organisation, competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits but at their foundations and their very lives….

In other words, under monopoly innovation occurs but at a slower pace than is socially optimal, whereas under perfect competition there is none at all.

Delbono and Denicolo (1990) use game theoretic analysis to compare the R&D investment under two alternative types of competition in the product market, Bertrand and Cournot. The market equilibrium resulting from price competition in a homogeneous oligopoly is, from a static viewpoint, more efficient than the market equilibrium associated with quantity competition. However, whether the same conclusion holds in a dynamic setting, for example when technological improvements are in prospect and the expected date of innovation depends on the R&D effort of the competing firms is not clear, and is the focus of this paper. Delbono and Denicolo show that social welfare (the discounted flow of consumers' and producers' surpluses, net of R&D expenses) may be greater under Cournot competition than under Bertrand competition. They also show that price-setting firms invest more than quantity-setting firms when drastic as well as non-drastic innovations are in prospect.

The nature of the static-dynamic efficiency tradeoff in differs from that of Schumpeter. According to Schumpeter, weaker competition in the product market will be associated with a faster pace of innovation. In Delbono and Denicolo, however, stronger (ie Bertrand) competition in the product market always entails an earlier expected date of innovation. However, since price-setting firms always overinvest with respect to the socially optimal level, it may happen that net social welfare is greater under Cournot than under Bertrand competition because under Bertrand competition firms employ too many resources in an attempt to win the R&D racing game. The resulting duplication of effort is detrimental to social welfare. This is more likely the greater the number of firms and the lower the productivity of the R&D expenditure.

Ross (1996) considers that the learning curve traces a fall in unit costs resulting from experience with a complex or novel production technology. Ross demonstrates that a firm can exploit a minor lead down the learning curve into a dominant market position. The result contrasts with previous work indicating that market equilibria along the learning curve will yield moderate concentration and an 'acceptable' balance between static and dynamic efficiency. The tendency toward market domination is reduced to the extent that learning is not firm specific.

Using a dynamic model based on the theory of adjustment costs, Sengupta (1999) concludes that the static production frontier gives only a limited view of productive efficiency unless it is extended to a dynamic framework. Adjustment costs allow for the role of incremental inputs such as investment along with the current inputs and various forms of adaptive behaviour on the part of firms. Sengupta argues that the dynamic production frontier which relates output growth to the incremental inputs of labour and capital displays strong empirical evidence of the dominant role played by incremental capital, as is expected in terms of adjustment cost theory.

1.3 Regulation and Dynamic Efficiency

Viscusi, Vernon and Harrington (1995) argue that regulation has an important impact on dynamic efficiency in the form of its effect on the incentives to invest in research and development (R&D) and to adopt new innovations. However they emphasise that it is quite a different matter to determine whether regulation results in a suboptimal rate of innovation, as dynamic efficiency does not necessarily imply that firms invest at the greatest rate possible, but rather that there is a particular rate of investment that is socially optimal. More innovation is not always better because resources must be used in order to discover and adopt innovations. Although a competitive equilibrium results in static efficiency, it is not at all clear as to whether it results in dynamic efficiency. Thus if regulation results in less investment in R&D relative to a competitive equilibrium, it need not imply that there are dynamic welfare losses because there might be too much R&D expenditure at a competitive equilibrium.

Viscusi, Vernon and Harrington (1995: 534 – 5) outline four effects of price regulation on innovation:

- regulation that prevents entry or keeps price so low that entry is generally unprofitable closes the door to the entrepreneurs in new firms who are thought to play a crucial role in developing and adopting technological advances,
- if regulation keeps price below cost and allows firms to suffer losses, it is possible for regulation to result in a reduced rate of innovation;
- nonprice competition may be enhanced by regulation if regulation that keeps the prices of differentiated products excessively high results in higher rates of innovation; and
- lags in the regulatory process are conducive to innovation by regulated firms. Any cost savings from adopting an innovation are retained by the firm until the regulatory agency is able to adjust price. Further, regulatory lags affect the speed at which adoption of an innovation occurs. Assuming the costs of full and gradual adoption are the same, the regulated firm earns higher profits by adopting the innovation gradually.

1.4 Dynamic Efficiency in Patent Races

The concept of dynamic efficiency is specifically considered within the context of patent races by O'Donoghue (1998). He investigates patent protection for a long sequence of innovations where firms repeatedly supersede each other. Incentives for R&D can be insufficient if successful firms earn market profit only until competitors achieve something better. To correct this problem, patents must provide protection against future innovators. O'Donoghue proposes use of a patentability requirement, a minimum innovation size required for patents. A patentability requirement can stimulate R&D investment and increase dynamic efficiency. Intuitively, requiring firms to pursue larger innovations prolongs market incumbency because larger innovations are harder to achieve, and long market incumbency implies an increased reward to innovation.

The impact of regulation on patent races, a subject area that incorporates both a factor in dynamic efficiency (regulation) and an area of application where dynamic efficiency may be exemplified (patent races), is explored by Riordan (1992). Two rival firms must decide if and when to adopt a new technology, knowing how adoption costs decline over time and how profit flows vary with adoption patterns. In many cases, price and entry regulation beneficially slow technology adoption by making preemption strategies less attractive. In some cases, these regulations can so discourage a firm from preemption as to change the order in which firms adopt new technologies, speeding one firm's adoption date and slowing the other's. In the context of a particular scenario for cable and telephone companies' adoption of new fibre optic technologies, the case for lifting the "cross-ownership ban" depends on the extent to which telephone companies are able to implement a superior technology.

Specifically Riordan derives a model to focus on how rent seeking and rent protection influence the pattern and timing of technology adoption, and on how price and entry regulation matter for these incentives. He argues that the cross-ownership ban is socially harmful if telephone companies are able to adopt a sufficiently superior new technology but are prevented from doing so by the ban, but not otherwise. This argument is controversial because first, it is not obvious that telephone companies are more likely to adopt an integrated broadband network (IBN), and secondly, it is not clear how much demand there is for the additional services available on an IBN. The author reports that it is apparent that residential consumers have a relatively low willingness to pay for video-on-demand. On the other hand, the range and characteristics of products deliverable on a switched IBN are difficult to anticipate in advance. He concludes that the apparent subjectivity of this rather crucial issue makes for difficult public policy.

1.5 Evolving Innovation and Competition

Declining transport and communication costs and growth in population and income worldwide have combined to materially enlarge markets, alter barriers to entry and change the vigor of competition. The very process of producing and adopting innovations has altered the competitive nature of the provision of most goods and services to the point that the trade-off between static and dynamic efficiency has been affected. Argarwal and Gort (1999) argue that the effect of these changes will generally be to reduce barriers to entry and alter the time it takes to recover investment in innovation. They draw less equivocal conclusions from their empirical work. On the basis of their study of 46 major product observations they estimate that the average time between the introduction of a new product and date of introduction of a very close substitute by imitators has declined from 33 years in the 1880s to 3.5 years in the 1980s. They conclude

> " .. competitive entry in new markets has been rising rapidly and steadily over time pointing to a weakening of entry barriers on net balance, We attribute this to increased mobility of skilled labour, b) improvements in communication and more rapid diffusion of technical information, c) an increase in the population of potential entrants and d) growth in the absolute size of markets"

If this analysis is accepted, it suggests that, rather than using patents, firms will rely more on internal mechanisms to protect secrets and rapid deployment of innovations in much larger markets to garner quasi rents from innovation. Further, it suggests that firms, whether or not they innovate, are subject to increasingly intense competitive pressures which itself will reduce the utility of centralised governance structures. It suggests that the dynamic efficiency of decentralised structures may be relatively enhanced with changing technical and economic structures worldwide.

2. Innovation, Quasi-Rents and a Calibration of the Static – Dynamic Efficiency Tradeoff

2.1 Introduction

The literature in macroeconomics has taken at least two distinct approaches to the consideration of dynamic efficiency. First, some macroeconomic growth models link dynamic efficiency to the long-term growth rate of the economy. An important example is Abel, Summers and

Zeckhauser (1989). This paper claims that if the capital sector is regularly contributing to the level of consumption (is a continual drain on the level of consumption), the economy is dynamically efficient (inefficient). In the United States, profit has exceeded investment in every year since 1929 which leads the authors to conclude that the United States economy is dynamically efficient.[3] A second approach found in the macroeconomics literature, and the one that forms the basis for the model that we develop below, is concerned with the innovation and the adoption of new varieties of products (See Spence (1976), Dixit and Stiglitz (1977), Ethier (1982), Grossman and Helpman (1991, Ch. 3), and Romer (1987, 1990). A key advantage of the modelling framework developed in this literature is that it can be exploited to illustrate the welfare effects of dynamic as opposed to static inefficiency under different approaches to regulatory policy.

In our model, the sector of the economy producing final consumption goods is competitive and innovation occurs solely in the production of the intermediate goods required for the production of these consumption goods. Innovation is embodied in costly capital investment required for the production of the intermediate good, but the investment benefits society because innovation in intermediate goods is the chief force driving long-run growth. The intermediate goods producers receive monopoly rights over the production and sales of the products they have invented. These monopoly rights may be thought of as deriving from establishment of proprietary rights over a particular technology (such as patents and trade marks) or from the ability of each intermediate goods producer to efficiently supply all of the market for the good that they have invented. Monopoly rights result in the intermediate goods producers earning profits above the marginal cost, but their ability to earn profits above the competitive level is limited by our assumption that free entry exists in the intermediate goods sector. This means that new entrants restrict profits to the amount necessary to cover fixed (set-up) costs associated with innovation. If the incumbents raise price above the level required to earn a return on fixed costs it will be possible for other firms to invest in an equivalent technology and enter the market with an equivalent product to that of the incumbents. Thus, in our model the "monopoly price' considered is the price at which firms obtain quasi-rents (a return on the sunk capital investment) rather than the price at which a single monopolist would maximise profits.[4]

[3] This empirical work has recently been questioned.
[4] Our assumption that it is possible for firms to earn quasi-rents but not monopoly rents is consistent with Van Witteloostuijn (1992)'s distinction between pure-contestability (perfect competition) and quasi-contestability (a credible threat of potential entry that forces incumbent firms to behave in the interest of customers). Quasi-contestability provides firms with incentives to develop new products while a credible threat of entry disciplines

The joint assumption that firms earn quasi-rents, that competition prohibits monopoly rents, and that new entry occurs through investment in innovations captures a variety of the key features markets in New Zealand where there are popularly perceived to be “competition issues” that regulation might solve (electricity, telecommunications). The New Zealand market is relatively small, so if there are scale economies it may be optimal for a small number of firms to supply the market. If the existing firms in the market price above average cost there may be new entry that bypasses the facilities of the incumbents, even without technical change. So long as the incumbents do not price above average cost, it is unlikely to be feasible for a new competitor with the same production technology to enter. Where the incumbents restrict their pricing to below average cost, then entry may only occur where it introduces a new technology to the market. The ability to earn quasi rents may be explained either by the fact that it takes other firms some time to copy the technology introduced by the entrant (either because of a patent or because of time involved in learning) and/or by the limited competition that results from the fact that one or a small number of firms supply the market. Thus, while no single model is capable of capturing all possible states of the world and institutional structures, we consider that our model is ideally suited to consider those politically interesting markets in which there are few competitors and technological change drives entry.

The scenario built into our model is illustrated in Figure 1 for the case where firms operate at levels of output in the New Zealand market where there AC is downward sloping. Here pc is the price that would prevail in a perfectly competitive market, and pr is the price above which entry would be feasible even with the existing technology.

Figure 1 : Quasi – Rents

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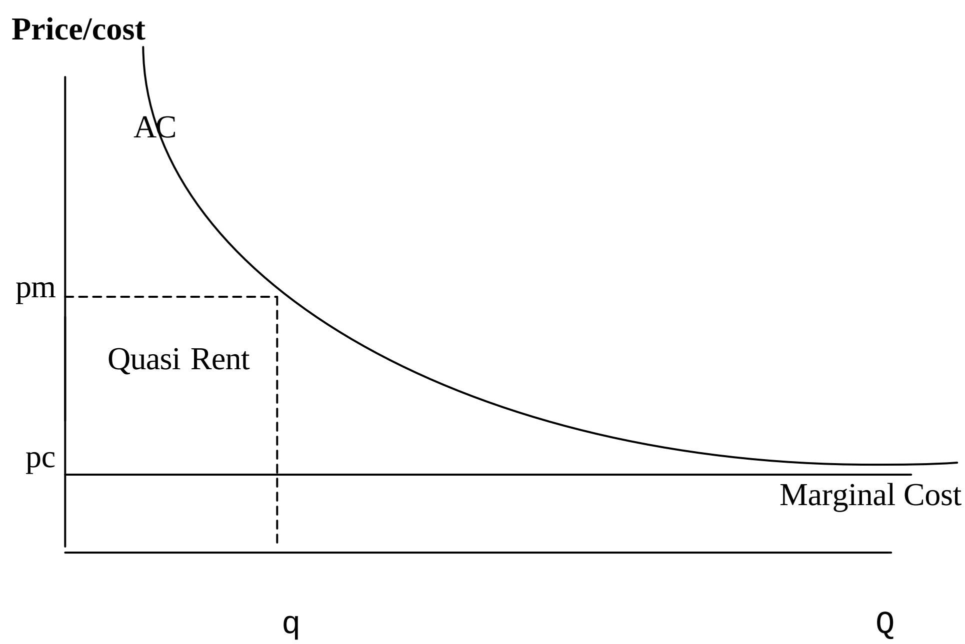
the incumbent firms’ behaviour. Our assumption is also consistent with the observations that, absent government monopoly franchises, we rarely observe examples of pure monopoly. In a world of technical change, relatively free flows of capital, and low entry barriers, we consider the ability of firms to price at levels that earn a return on their fixed investment to be the key issue of interest.



The quasi-rents earned by the intermediate goods producers result in a loss in static efficiency by comparison with prices set at marginal cost. This loss in static efficiency can be avoided by lowering the price to the marginal cost through price regulation or by not granting the monopoly right in the first place. With a price set at the marginal cost, however, intermediate goods producers cannot recover their investments in innovation, with the consequence that innovation ceases. As a result, society suffers a loss in dynamic efficiency, evident in the absence of any increase in the standard of living.

The literature already contains some consideration of policies that may improve welfare by addressing this trade-off between dynamic and static efficiency (Barro and Sala-i-Martin, 1995, Ch. 6.1.7). Pareto optimality can be achieved by imposing essentially lump-sum taxes to subsidize the final good production or the purchase of the intermediate goods from the monopolistic innovators, but surprisingly cannot be achieved by subsidizing the R\&D. Subsidizing the final goods production or the purchase of the intermediate goods can neutralize the direct effect of monopoly pricing by lowering the user cost regarding intermediate goods, while maintaining incentives for innovation. In contrast, subsidizing research cannot eliminate the static inefficiency of monopoly pricing. All the proposals are difficult to implement when lump-sum taxes are unavailable: the harm of distorting taxes may outweigh the benefit of subsidies. In the model that we develop below, we do not consider the issue of subsidies and taxes, but we extend the model developed by Barro and Sala-i-Martin to illustrate the dynamic/static efficiency tradeoff in the presence of potential price control.

2.2 Framework for the Model

The production of intermediate goods is through projects that require lump sum capital investments, and this investment may be for innovation or the adaptation of overseas innovations for local use. The lump sum investments mean that intermediate goods producers cannot break even by pricing at marginal cost. It also means that firms will not enter the market if they anticipate that they will not be able to price above marginal cost.

New investments in intermediate goods improve productivity in the economy without reducing the productivity of old intermediate goods[5]. There is free entry in all sectors. Free entry ensures that the profits of the intermediate goods producers is limited to full recovery of the sunk investment, since a higher level of profits would result in additional firms making the same fixed investment and entering the market to compete away the profits.

We use this environment to extend the existing research on the trade-off between static and dynamic efficiency by considering the impact of price controls in a relevant environment. We consider whether the government can use price control in the intermediate goods sector to improve or maximise social welfare.

We show that to assess the impact of price control on social welfare, policy makers must consider the trade-off between static and dynamic efficiency. On the one hand, a higher price

[5] This assumption is consistent with the fact that the copper wire telephone network continues to be valuable despite the development of all phone technology, and that electricity cables continue to be valuable even where gas is available as an alternative energy source. In effect we assume that there is some degree of product differentiation between goods.

for the intermediate goods provides a stronger incentive to invest in the projects and hence a higher rate of productivity growth. The expectation that firms will recover the costs of the fixed investments is necessary for the emergence of productivity-enhancing innovations. On the other hand, a higher price of intermediate goods results in higher static inefficiency. The desirable price is expected to range somewhere between the monopoly price and the marginal cost. Our model allows us to consider whether there is a price that provides a higher level of welfare than the monopoly price and the marginal cost price. If there is such a price, we can also consider whether it is Pareto optimal and how far away is it from the full quasi-rent price.

The Pareto optimal solution is represented by a social planner's problem. The solutions for the social planner's problem as well as for the decentralized equilibrium without price control are available in the literature (Barro and Sala-i-Martin 1995 ch 6.1.7). To answer the above questions, we plan to solve the decentralized equilibrium with a price control. The solution for the decentralized equilibrium with a price control involves two steps. First, given the prices of intermediate goods set by the government, the demand of firms in the final good sector for the intermediate goods as well as the investment in projects to supply the intermediate goods are calculated as a function of the controlled prices. As the controlled prices effect the demand for and supply of the intermediate goods, changes in the prices of intermediate goods have welfare implications.

It is assumed that infinitely lived, forward looking households consume the final goods and own all firms and projects. Taking the controlled price as given, households maximize the present value of discounted utility over an infinite horizon of consumption decisions, a setup that appropriately includes both static and dynamic gains/losses under a price control regime. Given the decisions of firms and households, the government can then maximize the households' welfare by choice of a sequence of the price of the intermediate goods. We can then compare the solutions among decentralized equilibria with or without the price control and the social planner's problem.

2.3 Final Goods Production with a Fixed Number of Intermediate Goods

At the beginning of a period, there are N intermediate goods available. Population is constant with a mass L.

The final good sector has a large number of competitive firms. A firm i uses X_{ij} units of intermediate good j and L_i units of labor which is inelastically supplied by workers to produce Y_i units of final goods:

$$Y_i = F(X_{ij}, L_i) = AL_i^{1-a} \sum_{j=1}^{N} X_{ij}^{a}, \quad 0 < a < 1 \tag{1}$$

As X_{ij}'s are additively separable, the marginal product of X_{ij}, $F_{X_{ij}}$ is independent of other intermediate goods. Obviously, $F_{X_{ij}} = aAL_i^{1-a} X_{ij}^{a-1} \to \infty$ as $X_{ij} \to 0$ and $F_{X_{ij}} = aAL_i^{1-a} X_{ij}^{a-1} \to 0$ as $X_{ij} \to \infty$. The implication of the features of marginal product of intermediate goods is: firms will use all types of X with positive quantities; there are diminishing returns to X_{ij}. By symmetry, $X_{ij} = X_i$ in equilibrium and then (1) becomes

$$Y_i = AL_i^{1-a} (NX_i)^{a} N^{1-a} \tag{2}$$

By (2) there are constant returns to scale in (L_i, NX_i); and N^{1-a} captures the technological progress with $\partial Y_i / \partial N > 0$. Thus, the form of technological progress here is to expand N.

Let P_j be the price of intermediate good j, and w the wage rate. Normalize the price of the final good to unity. The profit function of firm i in the final good sector is

$$\Pi_i = Y_i - wL_i - \sum_{j=1}^{N} P_j X_{ij} = AL_i^{1-a} \sum_{j=1}^{N} X_{ij}^{a} - wL_i - \sum_{j=1}^{N} P_j X_{ij} \tag{3}$$

Perfect competition in the final good sector implies $F_{X_{ij}} = P_j$ and $F_{L_i} = w$. The equation $F_{X_{ij}} = P_j$ gives the demand for intermediate good j

$$X_j = L(aA / P_j)^{1/(1-a)} \tag{4}$$

while $F_{L_i} = w$ leads to the demand for labor L_i

$$L_i = (1-a) Y_i / w \tag{5}$$

2.4 Expansions in the Variety of Intermediate Goods

The cost of a project (for creating/adopting a new type of intermediate good) is fixed at h units of the final good *Y*. Once the lumpy investment is made, one unit of an intermediate good is produced from one unit of the final good. In other words, investing a lump sum h sets up a project that can supply a new type of intermediate goods at a unit marginal cost. A new type of intermediate good is costly to create/adopt but used in a nonrival way with other types by all final good producers.

With a monopoly right over the production and sale of intermediate good X_j for project j, the present value of discounted profit streams is

$$V(t) = \int_t^{\infty} (P_j - 1) X_j e^{-r(v-t)} dv \tag{6}$$

where r is the interest rate. Without any state variable in the monopolist's problem, max $V(t)$ is equivalent to

$$\max_{P_j} [(P_j - 1) X_j] = \max_{P_j} [(P_j - 1) L(aA/P_j)^{1/(1-a)}] \tag{7}$$

Without price control, Eq. (7) implies that the intermediate goods producers set a markup rate on unit marginal cost to establish the price

$$P_j = P = 1/a > 1 \tag{8}$$

This yields the demand for an intermediate good

$$X_j = LA^{1/(1-a)} a^{2/(1-a)} \tag{9}$$

We now consider P_j as the controlled price. From (6) and (9), the present value of the profits from project j is

$$V(t) = L(aA)^{1/(1-a)} [(P_j - 1)/P_j^{1/(1-a)}] \int_t^{\infty} e^{-r(v,t)(v-t)} dv \tag{10}$$

When there is free entry in the intermediate goods sector, the net profit of project j is zero. That is, $h = V_t$ and hence

$$h = L(aA)^{1/(1-a)} [(P_j - 1)/P_j^{1/(1-a)}] \int_t^{\infty} e^{-r(v,t)(v-t)} dv \tag{11}$$

For a constant r, $\int_t^{\infty} e^{-r(v,t)(v-t)} dv = -1/r[e^{-r(v-t)}]_t^{\infty} = 1/r$. By symmetry, $P_j = P$, i.e., the prices of all intermediate goods are the same. Using this and (11)

$$r = (L/h)(aA)^{1/(1-a)} [(P-1)/P^{1/(1-a)}] \tag{12}$$

The equilibrium interest rate is a constant; namely, the expansion of the variety of intermediate goods eliminates the diminishing returns to intermediate goods. Note that $h = V(t)$ is the market value of a project that produces one type of intermediate good and hN is the aggregate market value of all such projects.

2.5 Households and the Equilibrium

The representative household's problem is given by

$$\max_{c} \int_0^{\infty} \left(\frac{c^{1-q} - 1}{1-q} \right) e^{-rt} dt \tag{13}$$

subject to

$$\dot{a} = ar + w - c \tag{14}$$

where c is consumption, a the amount of asset, and $\dot{a}$ a time derivative or investment. Let the growth rate of consumption $\dot{c}/c$ be g_c. The household problem has a solution

$$g_c = (r - r)/q \tag{15}$$

The aggregate asset is hN and investment $h\dot{N}$. In equilibrium, $a = hN/L$; $\dot{a} = h\dot{N}/L$. From (12) and (15) the growth rate is a constant as

$$g_c = (1/q)\{(L/h)(aA)^{1/(1-a)}[(p-1)/P^{1/(1-a)}] - r\} \tag{16}$$

Since N is the only state variable, there are no transitional dynamics. The growth in consumption is a function of P.

The aggregate output of the final good is $Y = AL^{1-a} NX^{a} = A^{1/(1-a)}(a/P)^{a/(1-a)} LN$. Then, output growth is $\dot{Y}/Y \equiv g_Y = g_N \equiv \dot{N}/N$. Namely, output growth of the final good is determined by the rate of investment in projects that produce intermediate goods. In equilibrium, $C = Lc = Y - hg_N N - NX$ (the resource constraint for the economy), and then it is obvious that $g_c = g_Y = g_N = g$. That is, the growth rate is the same for final good output, consumption, and investment in projects to produce intermediate goods.

Given N_0 initially, $N = N_0 e^{gt}$. Then, we solve consumption as a function of the price of intermediate goods:

$$c = N_0 e^{g\,t}\{A^{1/(1-a)}(a/P)^{a/(1-a)} - (h/L)(1/q)[(L/h)(aA)^{1/(1-a)}(P-1)/P^{1/(1-a)} - r] - (aA/P)^{1/(1-a)}\} \quad (17)$$

which is a function of *P*. Solving (13) by using (17) will provide a welfare function that varies with *P*. The static inefficiency of price control will be the responses of the welfare to a price change by holding investment and growth constant. Accordingly, the dynamic inefficiency of a price change arises from the corresponding welfare changes due to the responses of investment and growth. It is thus feasible to compute the static and dynamic inefficiency.

2.6 Pareto nonoptimality

We use the social planner's problem as a benchmark for Pareto optimality. The economy's resource constraint is

$$Y = AL^{1-a}NX^{a} = C + h\dot{N} + NX$$

where $h\dot{N}$ is the cost of investments in projects and NX the cost of producing

The social planner's problem is

$$\max_{c,X} \int_0^{\infty} \left(\frac{c^{1-q}-1}{1-q} \right) e^{-rt} dt \quad (19)$$

subject to

$$\dot{N} = (1/h)(AL^{1-a}NX^{a} - Lc - NX) \quad (20)$$

which comes from C=Lc and (18). The solution is

$$X_{planner} = L(aA)^{1/(1-a)} \quad (21)$$

$$g_{planner} = (1/q)\{(L/h)A^{1/(1-a)}[(1-a)/a]a^{1/(1-a)} - r\} \quad (22)$$

$$Y_{planner} = A^{1/(1-a)}a^{a/(1-a)}LN \quad (23)$$

As was known, X, Y and g are all higher in the social planner's solution than in the decentralized solution with monopoly pricing $P = 1/a$. It is obvious that price control cannot achieve the Pareto optimal solution, which can be easily confirmed by comparing (4) and (21). None the less, the existence of a controlled price that provides a higher level of welfare than marginal cost/monopoly pricing is of key interest and relevance. The simulation results reported in Table 1 exemplify the existence of such a second-best solution under the price control where the second-best price is lower than the monopoly price but higher than the marginal cost of the intermediate goods.

2.7 *Numerical Simulation of the Static – Dynamic Efficiency Tradeoff*

An illustration of the tradeoff between static and dynamic efficiency may be obtained by simulating the results of the model over a range of plausible values for the key variables. We consider the potential for price control in the range from the marginal cost pricing level, 1, to the quasi-rent pricing level, $1/a = 1/0.3$ which is about 3.33. (See the parameterization given in Table 1.) As the price rises, initial period consumption, C_0, and initial period final output, Y_0, decline and so does the input of an intermediate good, X, causing a static loss in efficiency. Such declines raise the interest rate, r, and therefore encourage, along with the rise in the price of intermediate goods, more investments in new projects, leading to rises in the growth rate g and thereby a gain in dynamic efficiency. However, the interest rate must be sufficiently high for investment in new projects to be ever taken (i.e. $r > r$ for $\dot{N} > 0$), otherwise there is no investment in new projects and no growth ($N = 0$ and $N = N_0$ for an initial N_0).

Starting at the marginal cost price, the growth rate is zero and there is no investment in new projects as long as the interest rate is below the critical level ($r = 0.05$). In this case, a rise in the price of intermediate goods causes static inefficiency without any dynamic gain, leading to a decline in welfare (see the range of Table 1 for $P \in [1, 1.5]$). When the interest rate exceeds the critical level, there are investments in new projects and positive growth, so that a further rise in the price of intermediate goods is conducive to investment and growth and creates a dynamic gain in efficiency. Starting with low growth rates, the dynamic gain dominates the static loss in efficiency, providing a net gain in welfare U_0; see the range of Table 1 for $P \in [1.5, 2.4]$. As we approach the monopoly price, the relative strength of the opposing forces reverses and there is a net loss in welfare for $P \in [2.4, 3.4]$. In between, the net gain in efficiency or welfare yields the optimal price level of $P = 2.4$ where the growth rate is about 2% and the interest rate is 7.2%, which are close to the observed values of the growth rate and the interest rate in countries like New Zealand.

While the optimal price level is quite close to the price at which full quasi-rents are recovered, it might be tempting to presume that some limited attempt at price control would make a positive contribution to welfare. We would caution against this approach for two reasons. First, it is extremely difficult for any regulatory authority to establish where the optimal price is. This implies that the really important lesson of the model is that it is plausible that attempts at price control could produce welfare-reducing outcomes even when the regulated price is still well above the marginal cost. Second, we have not included any of the costs of regulation. Included in these costs of regulation are the costs associated with compliance and the welfare reductions associated with changes in organisation, strategy, accounting policy and production techniques driven by attempts to minimise the impact of price control. When the costs associated with regulatory intervention are considered, therefore, our model suggests that attempts to preclude firms from earning quasi-rents may well be welfare reducing. Policies that required the incumbent in a market to provide subsidies to entrants would risk the double welfare losses resulting from entry with less than the efficient level of sunk investment and the removal of incentives for the incumbent to undertake new fixed investments in innovation in the future.

The structure of our model could be modified to consider multiple suppliers of each individual intermediate good, thus capturing the operation of oligopolistic interaction in these markets. To achieve this we would need to assume a relation between the size of the lumpy investment for a project and the size of the market. The larger the investment per project, the larger the market size a supplier of an intermediate good needs to break even and hence the smaller the number of suppliers per intermediate good. This structure is observed in small countries and some industries (such as electricity and telecommunication), but we do not believe that the technical complexity of capturing oligopolistic interaction would pay off in the sense of providing insights about the dynamic/static efficiency tradeoff that go beyond those that we have demonstrated.

2.8 Conclusion

Our model illustrates the tradeoff between static and dynamic efficiency in an environment where the ability to recover quasi-rents provides incentives for innovation that may ensure that social welfare is higher than at the marginal cost price. The model illustrates the potential for regulatory intervention and price control to reduce welfare. This potential will be strongest in industries undergoing rapid technological change, and where large scale investment is required to produce or bring into production the innovations that drive increases in national income. We consider that telecommunications is one sector to which the results of our model would apply quite directly.

3 Empirical Studies of Dynamic Efficiency

3.1 Introduction

A review of empirical measurement issues associated with dynamic efficiency begins with the observation that it is not feasible to calculate dynamic efficiency per se. What is conceptually feasible is to identify some benchmark level of consumer welfare that we may assume to approximate the outcome of dynamic efficiency. It may then be possible to calculate the costs of dynamic inefficiency by estimating the deviations from this level of welfare over time. The topic is, however, so large that all that can be contemplated here is a short review of the issues.

One approach to quantification is provided by assuming that cost-benefit analysis (CBA) provides the appropriate metric for the *ex ante* evaluation of investment opportunities and the *ex post* appraisal of past decisions. *Ex post* and *ex ante* evaluations are quite different applications of the same technique (Evans 1999): Both require a counterfactual against which to appraise a project, but *ex post* the realised state of the economic environment may confound separating the counterfactual from the project. As a result, robust conclusions may typically only be drawn from *ex post* studies of decision-making in markets where it is possible to benchmark the results across markets or time.

Innovation and adoption of changed processes and technology are a material part of dynamic efficiency. Conceptually, CBA can be modified to indicate the appropriate timing of the introduction of innovations by altering the hurdle rate from the required rate of return[6] by a factor that reflects uncertainty that is inherent in the arrival of new information (innovations) gained by waiting. In what follows we focus on examples and case studies that take a cost-benefit approach to the measurement or identification of dynamic efficiency gains. No attempt is made to review the large set of empirical studies of the links between dynamic efficiency and productivity growth (eg Christiansen and Haveman 1981; and Nelson 1990).

3.2 Telecommunications

Hausman (1997) argues that although the potentially adverse effect of regulation on dynamic economic efficiency is often mentioned, the literature on the effects of regulation has largely ignored the actual effects of regulatory delays in new services. He considers how to value the introduction of new services in telecommunications. Because of the network structure of telecommunications, public policy has always played a large role in its production and regulation. By demonstrating how to value new telecommunications services the author allows for a more reasoned approach to the necessary benefit-cost calculations, an approach which can help both to guide public investment in telecommunications infrastructure and to evaluate the effects of regulation.

The introduction of new telecommunications services can lead to very large gains in consumer welfare. The gain from the introduction of voice messaging services introduced by local telephone companies in the United States in 1990 is estimated at $1.27 billion annually by 1994. Similarly the introduction of cellular telephone services has led to estimated gains in consumer welfare of about $50 billion per year.

He first estimates the demand curve and expenditure function for voice messaging and then calculates, using market penetration estimates, the loss in consumer welfare due to regulatory delay. A comparable analysis is followed to estimate the loss due to regulatory delay of the introduction of cell phones. He then develops an alternative approach to valuing these new services that involves calculating a cost-of-living index for telecommunications services that includes cellular telephone and voice messaging services, then comparing this index to one that excludes these services. He calculates the loss in consumer surplus and also the effect on the telecommunications consumer price index from the introduction of these new services. Either alternative measure of consumer welfare demonstrates the significant consumer gains from their introduction and the very large cost imposed by regulatory delay in that introduction.

Hausman notes that these estimated losses in consumer welfare cannot be regained in subsequent periods, and that regulation in the United States as currently implemented may be

[6] We shall take as the required rate of return an entity's average required return on weighted equity and debt (WACC).

unable to keep up with the fast-paced changes that are typical of technologically driven sectors. Consumer welfare losses are likely to be quite large in the future because of regulatory delays and pricing distortions.[7]

3.3 Banking

Dynamic efficiency in the United States banking industry after the lifting of regulatory restrictions is described by Jayaratne and Strahan (1998). The authors point out that relatively little is known about how price and entry regulations affect market structure, industry evolution, management quality and, through these, dynamic efficiency. They find that the severe restrictions imposed on the geographic scope of banks retarded the natural process of selection by which better-managed, lower-cost banks expand at the expense of inefficient ones. As a consequence, these restrictions raised the costs associated with the average bank asset. The banking industry is a unique source of evidence on the dynamic effects of entry regulation of the following types:

- Banks were subjected to extremely severe entry barriers in the form of branching restrictions at a relatively early stage of the industry's development. Banks have traditionally been prevented from crossing state lines, and until the 1980s were prevented from crossing county lines in many states, policies that resulted in the formation of chain banks in the 1980s which were commonly owned by a group of individuals to circumvent branching restrictions. These long-standing restrictions have contributed to the extremely fragmented structure of the US banking industry, with thousands of banks and bank holding companies, a structure that contrasts sharply with other countries where a few very large institutions dominate.
- Geographic restrictions on banking have gradually been lifted over the last two decades. Because these were imposed at state level and states lifted the restrictions at different times, states that did not change their policies can be used to control for potentially confounding effects such as the business cycle.

[7] Ariel Pakes (1997) agrees with the fundamental thrust of Hausman's paper and emphasises that the order of magnitude of the losses caused by regulatory delay are such that the regulatory authorities should carefully consider their practices. However he questions Hausman's analytical strategy by noting that since estimation of matters relating to the introduction of new goods involves analysis based on slopes in a region of the curve relating to price ranges never observed, such slopes may be insufficient and involve too many assumptions.

The findings of this study are that banks' efficiency improves sharply once restrictions on intrastate branching are lifted and to a lesser extent after interstate banking is permitted. Loan losses decrease by about 29 basis points in the short run and by about 48 basis points in the longer run after statewide branching is permitted; operating costs decrease by about 4.2% initially and about 8% in the longer run.

Much of the efficiency improvement appears to have occurred because branching deregulation triggered a process of selection, whereby better-performing banks expanded at the expense of high-cost, low-profit banks. Although better-performing banks grow faster than underachievers before intrastate branching is allowed, the authors find that low-cost, high profit banks grow even faster once branching restrictions are lifted. This suggests that branching restrictions imposed binding constraints on the ability of better-managed banks to grow. Once these restrictions were lifted, better banks expanded at the expense of their poorly managed rivals, thereby improving the efficiency of the average bank asset.

3.4 Industry Arrangements and Industry Structure

Groenewegen (1994) provides an interesting account of dynamic efficiency in the construction industry in the Netherlands, specifically focusing on the bidding process for new contracts. He uses the concept of double-organised markets (where markets are both publicly and privately organised) which are prevalent in the Netherlands. In Dutch competition law, dominant firms and agreements or cartels are permitted unless they are deemed to be against the public interest by the Minister of Economic Affairs. After the Minister has been notified of and has approved the existence of a cartel, it is entered into a secret cartel register. The Netherlands is the only European country to keep such a register. A problem in the construction industry is the unequal distribution of power: the customer invites tenders for a specific project and is a monopsonist in power. In such a buyer's market the customer can employ the strategy of bid-shopping whereby bidders are played off against one another until the price has been forced down to the lowest level. At this low level possibilities for innovations are endangered because of lack of finance. The industry privately organised itself and established a superior process with positive dynamic efficiency implications.

The bidders meet secretly and tender their bids secretly. The lowest bidder is awarded the contract, the customer is informed and the contract is signed, thus eliminating bid-shopping. The exercise of preparing a bid is costly to the point where it may be prohibitive, so in order to stimulate the bidding and increase competition the firm who wins the contract increases the bid to compensate competitors for the costs of participating in the bidding process. The consumer therefore pays indirectly for the competitors' bid preparation costs. Efficiency is increased when the customer pays the costs of additional competitors participating in the bidding process; such a system is more efficient than a general markup in all projects.

In 1982 the Dutch government considered this cartel to be in the 'general interest' and approved it. However, this cartel was later banned by the European Commission as an inefficient private organisation of the market under a law that forbids implicit and explicit agreements that distort competition. Agreements can be exempted if specific conditions for dynamic efficiency are fulfilled, but these conditions preclude marketing and price setting. The Directorate General of the EC responsible for competition (DG IV) considered the Dutch construction cartel illegal, amid a political atmosphere that favoured an unfettered internal EC market. The case of the Dutch construction cartel was used as a warning to the Dutch government to reform their tradition of publicly approved cartels.

The Dutch construction cartel was fined in 1992, but in the appeal case the authorities admitted that a counterveiling power against bid-shopping by the customer is an efficient private organisation, but that another organisational procedure should be developed. The construction cartel developed a new code of behaviour which still protects the lowest bidder. All firms inform a newly created regional bureau of their bid. The bureau decides the lowest bid and from that moment further negotiation about price by any bidder is forbidden. The competing firms no longer actually meet, and compensation for bid preparation is abandoned entirely. This example shows that cartels can be defended on efficiency grounds: the cartel probably increased efficient allocation.

An argument that competition policy in both Japan and Korea was oriented towards creating dynamic efficiency, defined as the highest long term productivity growth rate, is the basis of a paper by Amsden and Singh (1994). The policy achieved this by measures operating at both the industry and firm level, which sometimes restricted competition and sometimes encouraged it.

Amsden and Singh analyse how industrial policy has dominated competition policy both in Japan and in South Korea. The central objective of competition policy in these economies has been dynamic rather than static efficiency. Instead of maximum competition, these countries have therefore deliberately restricted it in many directions in order to increase their investment rate and to accelerate their technological development. However competition of other than the textbook variety has also been encouraged in important ways: both Japan and South Korea have fostered intense oligopolistic rivalry in individual industries among competing conglomerates.

The paper shows that during much of the high growth period in Japan, despite all the government restrictions on competition, industrial concentration actually fell. This was due to the fact that investment and output rose rapidly, leading to a sizeable new entry and fast growth of small firms. Thus in contrast to the conventional paradigm in economic development, it was growth which led to increased competition and reduced concentration, rather than the other way around. Moreover, contrary to this paradigm, it is certainly arguable that without the government control of competition and monitoring of investment 'races', such high growth rates may not have materialised in the first place. This suggests that the policies of Japan may have enhanced dynamic efficiency even though they did not enhance short term static efficiency.

3.5 Examples from New Zealand

In the context of New Zealand, examples of empirical work that may provide a measure of the costs of dynamic inefficiency may be most easily provided with reference to public vs private sector investment. We re-iterate that, as with any substantive policy question that requires *ex post* evaluation, a range of studies are generally required to reach anything but a tentative conclusion, because of the difficulty of establishing the counterfactual *ex post*.

In the past, a large proportion of the investment decisions relating to infrastructure in New Zealand have been taken by the public sector. There is a substantial literature on the optimisation of investment decision-making under private and public ownership (for a recent example, see McFetridge 1997). This literature generally suggests that there is negligible reason for the discount rate to differ between public and private firms (see (Hathaway 1994), but that accountability for shareholder interest will differ and may affect the efficiency of the investment decision-making process. Also, it is well established that the inability of government-owned firms to access capital as they would if they were private firms has reduced the efficiency of investment decision-making in the past: in many countries it has been a prime argument for privatisation (see Galal et al 1994).

Prior to the advent of state-owned enterprises in 1986, investment and regulation were affected by the multiple objectives stemming from the political demands of the day, and from discrete changes in the pricing and investment policies (in the case of telecommunications see Evans 1996 for price setting, and Mason-Morris 1985 for investment). In addition, public entities were not subject to the tax regime facing private firms, and the government operational - usually departmental - structure did provide a framework for accountability and decision-making equivalent to that associated with private sector firms.

Competition and regulation intersect with ownership in determining dynamic efficiency. Although it is likely that New Zealand's infrastructure firms would have been regulated in a manner that prohibited entry had they not been in government ownership, the effects of these on investment would have differed because of the wider range of objectives of government-owned firms (see Willig 1993).

Electricity

The supply of electricity in New Zealand has undergone complete restructuring since the mid-1980s. Prior to that time electricity generation and supply was government owned and centrally planned. Despite the introduction of corporate governance structures in 1987 and the earlier separation of the grid from generation, in essence central planning dominated wholesale electricity supply until the separation of Contact Energy and the formation of the electricity pool in 1996.

Under public ownership, central government undertook the responsibility to provide the nation's future electricity requirements. There were no long-term sales contracts to underpin new construction. None were needed as the electricity distributors were required to purchase most of their future electricity requirements from central government. Specific approval was required from the Minister of Energy for the construction of power stations. As a consequence, the Electricity Division generated 96% of the country's electricity requirement with the balance being provided by a large number of small power stations owned by distribution firms.

Wholesale price levels were set by central government and bore little relationship to prices that would have been set in the market, or to the cost of providing new generating capacity. [8]

This decision-making structure resulted in substantial over-investment in generation capacity (see the New Zealand Official Year Book 1980 p.505, for example) where by 1980 growth in consumption had been overestimated by something in the region of 33-52%. Besides planning to be able to fulfill demand without concern for cost, a report published in the mid-1980s notes that it was considered legitimate in that era to embark on projects as a way to keep a specialised work force employed [9].

Administered prices have had a long history in electricity in New Zealand. Jenkins (1999) notes that as early as 1959 a Commission of Inquiry into the Distribution of Electricity noted that 'in nearly two-thirds [of the various supply districts] the charge for domestic supply is less than the actual cost per unit of all units sold.' Through the 1980s distributors maintained a high degree of cross-subsidisation in retail pricing. Typically, this favoured domestic customers at the expense of commercial and industrial customers. This culminated in considerable pressure on central government to supply large industrial customers directly, so that by 1985 a group of large companies were able to receive direct supply[10].

Both the excess supply and the administered price regime provide a basis against which an *ex post* assessment of dynamic inefficiency can be undertaken. This would require a study of the welfare losses over time that resulted from excess supply (in effect the present value of the operating cost of the surplus generating capacity and the opportunity cost of the capital invested). The calculation of the costs of dynamic inefficiency associated with the administered pricing regime is more complex, since it should incorporate both the present value of the static welfare losses resulting from consumers paying prices that did not reflect their true cost, together with the costs of the distortions in investment decision-making and consumption patterns resulting from those prices. The anecdotal evidence implies that the dynamic inefficiency may have been very significant indeed.

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[8] The Enterprise New Zealand Trust 1993 p1.

[9] Galvin, p10.

[10] These were: Winstones, Carter Holt pulp and paper plants, Comalco, Tasman Pulp and Paper, New Zealand Steel and New Zealand Railways.

In a Treasury report (Galvin, 1985) that preceded the reforms in the electricity sector, it was estimated that power from each selected existing power stations was generated at a cost of between 3.0c and 13.7 cents per kWh (p3, constant $1983), with a weighted (according to typical output) average cost of 5.6 cents per kWh. This power was then sold for 3.08 cents per kWh[11] in 1983 (and for 3.04 cents in 1984, and for 3.21 cents in 1985, for example). For investment in electricity to be dynamically efficient it should *ex ante* and generally across all options *ex post* have covered the cost of capital. To the extent that it did not it would be dynamically inefficient. The fact of government ownership meant that the deficit has been carried by higher taxes. In addition to the deadweight loss that this would imply there would be a intergenerational shifting of the tax burden resulting from having brought forward the construction of generation plants that, if electricity were priced appropriately, would have been built later. Adding to this situation, if there is any technological change at all in generation technology and/or methods of construction, the optimal timing literature suggests that significant gains in efficiency could be had by delaying investment. Indeed, it is sometimes argued that this is a social benefit of monopoly in that it can choose when to invest: it does not seem to have been realised in electricity to the mid 1980s. Finally, to the extent that electricity has been subsidised through taxation in the past, measured consumer costs per unit since the reform period may fall in real terms without any fall in the real price of electricity transacted within the industry. This may be especially relevant over the periods of corporatisation and privatisation; indeed to the extent that excess generation was installed in the past, falling real electricity prices do not provide a measure of social welfare gains in that sector over time. This last point illustrates the level of detail of analysis that is required to empirically assess changes over time from society's point of view, and dynamic efficiency.

Apart from the large number of electricity distribution entities, electricity was in all other respects centralised. A de-centralised structure was put in place in 1996 by means of the electricity pool. It has a price discovery process based on the interaction of supply and demand where prices are struck at locations on the grid around New Zealand: and it is conditioned by the fact that participation is voluntary. While there are live issues to be considered about appropriate network signals for investment efficiency, the locational price signals are an important input to geographic choices of investment in electricity, gas lines and generation plant. Implementation of the electricity market may have altered the flows of electricity in the

[11] New Zealand Annual Statistics in relation to Electric Power Development and Operation, 1982, 1983, 1984, 1985, 1986. The wholesale price is the weighted impact of the component rates - day, night, etc - of the bulk

grid to the point that investment in grid expansion has been delayed. This would be a manifest gain in efficiency from decentralisation.[12]

The first notable decision to deliberately locate large generation plant near population centres and thereby minimise transmission losses[13] was in 1995-6 when the local distribution company Mercury Energy built a 100 MW capacity natural gas fired power station at Southdown near Wiri in South Auckland. For ECNZ the next generation site to be developed was the Beaumont Dam on the Clyde River, but in the face of the Mercury Energy development and other opportunities that existed in the North Island such as the Stratford combined cycle gas fired station, it was decided not to proceed with the Beaumont Dam. Contact Energy chose to locate a large (380 MW) plant at Otahahu, again close to the large Auckland market. While research is required to specify exactly the reasons for the recent appearance of large gas-fired plants located near population centres – as opposed to other sources of generation located at greater distance from major centres - and the costs and benefits of doing so, the ability for individual companies to make these choices and the requirement of their accountability can be expected to have facilitated dynamic efficiency.[14]

The importance of the pricing and management of capital in creating dynamic efficiency is also illustrated by the electricity distribution industry. The more than 50 distribution entities had trust ownership or were departments of local government. Their prices were set to the breakeven revenue requirement on the basis of anticipated maintenance and capital works. Any surplus was used for cost stabilisation over time, including capital financing[15]. In pricing no allowance was made for the opportunity cost of capital in the business. The approach essentially bundled the required equity return into the prices that were charged consumers. To the extent that the consumers served matched the "owners" of the distribution companies, this approach went a considerable way to improving allocation over that of a local investor-owned monopoly.[16] But it meant that capital was not fully costed in prices. Since the Energy Companies Act 1992 energy companies are required to be commercial enterprises and operate as successful businesses, with an implied imperative to make profits and a requirement to pay

tariff.

[12] It is proposed to analyse this conjecture, made by a person in the electricity industry in an informed position.
[13] Transmission costs including transmission losses are a significant component of the final price of electricity.
[14] Prior to 1987 local distribution companies had their own very small generation plants.
[15] Kask 1987 p3-4.
[16] There are certain inefficiencies associated with this institutional arrangement to be considered.

tax (unlike their pre-reform equivalents).[17] In the transition, prices might reasonably be expected to rise to reflect incorporation of the opportunity cost of capital. While pricing capital fully in all its uses should improve dynamic efficiency through its effect on the choice of investments, in the case of electricity distribution companies there is a trade-off between this effect and that of any local monopoly power in aspects of the distribution business.

New Zealand Railways

The publicly owned New Zealand rail network did not produce revenue that was significantly in excess of operating costs for the full period 1943 - 1993 (Orr 1981 updated by Boles de Boer et. al 1999). Huge operating losses were produced for the late 1980s and early 1990s after regulations that protected the railways from competition had been lifted in 1984.

Operating costs do not include the opportunity cost of capital. Boles de Boer et. al. show that if capital is included at its replacement cost and valued at a reasonable WACC, rail has not made an economic profit over the full period of analysis 1983-1997, although it improved substantially between 1990 and 1996. In 1989 the board committed to the strategy of privatisation and in 1993 was privatised to form Tranz Rail. Under private ownership Tranz Rail has continued investment in its core-business capital assets and has modernised them to reduce costs and meet customer requirements. It has done this while rail's economic surplus has continued to be negative.

If the revenue and operating cost data provide an accurate representation of society's valuation of rail outputs and operating inputs, the data suggest that the negative economic surplus has persisted from the early 1940s. During this period tax payers through the government have injected vast sums – $1.1b in 1997 prices between 1983 and 1989, the worst period – and have over invested in rail because the opportunity cost of capital has not been covered throughout this period.[18] The financial cost understates the welfare lost because of the cost of taxation and potential alternative uses of the capital employed, even if released by running down the stock.

[17] McFadyen p 6.

[18] Rail under government ownership was directed to carry out functions that produced benefits but not revenues. For the period from 1983 these were not of sufficient magnitude to much affect efficiency. Data are not available to assess this for the period 1943-1983, but the non-transport outputs would have to be very large to yield a non-negative economic surplus.

If competitive modes of transport are paying their full social costs, a negative economic surplus indicates that the outputs produced are valued by society less than the value society places on the inputs in other uses; that is, continuing with business as usual for the railways is dynamically inefficient. It follows that the present value of the negative economic surplus may also be used as an empirical measure of dynamic inefficiency.[19] This approach relies on assumptions about asset valuations and cost of capital which will be crucial to the result, but it has the advantage of simplicity and tractability as an indirect measure of the reductions in social welfare flowing from dynamic inefficiency.

[19] The private owners of Tranz Rail seem to have accepted the challenge to preserve the rail business by productivity improvement, without materially running down the existing physical infrastructure in those parts of its business that are making economic losses.

4. Conclusion

Markets will be characterised by dynamic efficiency when they provide incentives for decision-making that result in the present value of social welfare being maximised. We distinguish dynamic efficiency from the two types of static efficiency that are commonly the focus of public policy and regulatory action: productive and allocative efficiency.

Much of our study has focussed implicitly or explicitly on the tradeoff between dynamic efficiency and static efficiency. This tradeoff has important implications for public policy because we have argued that dynamic efficiency may be reduced by:

(i) policies that are designed to address static efficiency problems; and

(ii) policies or institutional structures that address objectives other than economic efficiency, but that appear to have no adverse impact on productive and allocative efficiency.

In section 2 of this paper we developed a model that illustrates the potential for a tradeoff between dynamic and static efficiency resulting from the fact that prices above marginal cost provide firms with quasi-rents. These profits act as a stimulus to the development of the innovations that drive the rate of economic growth. We show that it is plausible that attempts at price control could produce welfare-reducing outcomes even when the regulated price is well above the marginal cost. The potential for welfare to be reduced by attempts to control prices is greatest in industries undergoing rapid technological change, and where large scale investment is required to produce or bring into production the innovations that drive increases in national income.

We have, in addition, provided a number of examples of institutional structures that are and are not consistent with dynamic efficiency. For example, we have argued that government ownership of enterprise is not consistent with dynamic efficiency because it establishes centralised decision-making with limited accountability and financial responsibility for the decisions made. Dynamic efficiency is increased by the dispersion of decision-making, and the more direct allocation of returns from the investment decisions that are made. Even State Owned Enterprises are not fully consistent with dynamic efficiency because the managers and owners of these entities have different incentives from those of private sector firms, and these in turn may not provide for optimal investment decision-making. Conversely, we have suggested that there may be circumstances in which co-operation or collusion among firms is welfare enhancing. For example, this can occur where short-term static efficiency losses are outweighed by dynamic efficiency gains from establishing prices that are consistent with growth-rate maximising investment in innovation.

We have used as examples a number of public policies (such as the granting of exclusive franchises to telecommunications firms and geographical restrictions on branching of banks in the US) that were introduced to advance particular political and social objectives. These policies created obvious concerns about static efficiency in the economy, and these problems were (imperfectly) addressed by the creation of industry specific regulators. Even where the regulators were successful in dealing with static efficiency problems, the literature that we have canvassed and the examples that we have cited suggest that the regulators could not address, and indeed exacerbated, reductions in dynamic efficiency. Consideration of any similar public policy initiatives will benefit from careful analysis of the dynamic efficiency implications of the interventions or regulations proposed.

The examples that we have cited also suggest that the losses in social welfare resulting from long periods of dynamic inefficiency can be quantitatively very large. This is in part because of the impact on consumer welfare and the rate of economic growth that comes from slower development and introduction of innovations. The losses also stem from the very high costs associated with inappropriate investment decisions (for example poorly located electricity plants and over-investment in railway lines) the existence of which may go on influencing the efficiency of the market for long periods after initial construction.

Policies that impose on large incumbents the requirement to subsidise entry to the market (for example, by requiring that access to network facilities be provided at marginal cost) may have particularly important implications for dynamic efficiency. The subsidy may result in entry occurring with a level of sunk investment that is sub-optimal, with obvious implications for the incentives and potential of the incumbents to subsequently achieve a viable operating position in the absence of the subsidy. In addition, the requirement to subsidise entrants may reduce or remove the incentives for the incumbent to undertake new investment in innovation in the future. In this case, the dynamic efficiency losses resulting from the poor incentives for the incumbent will not be offset by the emergence of the new entrants as viable and dynamic new competitors in the market.

The most general conclusion to be drawn from this paper is that in markets where politicians and officials have concerns about efficiency, social-welfare maximising public policy will focus on dynamic efficiency and any impediments to it. This is because allocative and productive inefficiency will not persist in a dynamically efficient market, but policies focussed on allocative and productive efficiency may have the unintended effect of reducing dynamic efficiency. Our model provides a rigorous representation of circumstances under which there will be a trade-off between static and dynamic efficiency, and suggests that there is a substantial risk that regulations aimed at perceived static efficiency problems will in the long run have the net effect of reducing efficiency in the market as a whole. The need to explicitly consider the impact of proposed policy on the dynamic efficiency of a market is enhanced by the existence in New Zealand of a relatively short electoral cycle. Three year parliamentary terms may focus political interest on policies that address perceived short-term allocative and productive efficiency concerns even though these policies may reduce economic growth and welfare in the long run.

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Table 1: Simulation Results

$a = 0.3$, $q = 1.1$, $h = 1.0$, $r = 0.05$, $A = L = N_0 = 1$						
P	C_0	X	Y_0	r	g	U_0
1.0	0.418	0.179	0.597	0.0000	0.0000	-18.238
1.1	0.417	0.156	0.573	0.0156	0.0000	-18.295
1.2	0.414	0.138	0.552	0.0276	0.0000	-18.437
1.3	0.410	0.123	0.553	0.0369	0.0000	-18.634
1.4	0.406	0.111	0.517	0.0443	0.0000	-18.865
1.5	0.401	0.100	0.502	0.0502	0.0002	-19.058
1.6	0.392	0.092	0.488	0.0549	0.0045	-17.692
1.7	0.384	0.084	0.475	0.0587	0.0079	-16.667
1.8	0.376	0.077	0.464	0.0619	0.0108	-15.902
1.9	0.369	0.072	0.453	0.0644	0.0131	-15.339
2.0	0.362	0.067	0.444	0.0665	0.0150	-14.935
2.1	0.356	0.062	0.434	0.0683	0.0166	-14.657
2.2	0.350	0.058	0.426	0.0697	0.0179	-14.480
2.3	0.344	0.054	0.418	0.0708	0.0189	-14.384
2.4	0.339	0.051	0.410	0.0718	0.0198	-14.354
2.5	0.334	0.048	0.403	0.0725	0.0205	-14.378
2.6	0.330	0.046	0.396	0.0732	0.0211	-14.446
2.7	0.325	0.043	0.390	0.0737	0.0215	-14.551
2.8	0.321	0.041	0.384	0.0740	0.0219	-14.685
2.9	0.317	0.039	0.378	0.0743	0.0221	-14.844
3.0	0.313	0.037	0.373	0.0746	0.0223	-15.024
3.1	0.310	0.036	0.368	0.0747	0.0225	-15.220
3.2	0.306	0.034	0.363	0.0748	0.0225	-15.430
3.3	0.303	0.033	0.358	0.0748	0.0226	-15.651
3.4	0.300	0.031	0.353	0.0748	0.0226	-15.882