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DYNAMIC PERSPECTIVES ON AGRICULTURAL POLICY ISSUES

by

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Dynamic Perspectives on Agricultural Policy Issues*

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Agricultural markets are often classic settings for the analysis of market behavior. Moreover farm and food politics tend to serve up a rich variety of policies to modify the operation of these markets. It is not surprising, then, that agricultural economists have been the source of many innovations in analysis of the economics of market behavior and the evaluation of policy measures.

Among the innovators, Fred Waugh was one of the most prolific. He made pioneering contributions in linear programming, statistics and econometrics, demand analysis, the welfare effects of price risk, and the analysis and explanation of commodity cycles. As a research leader, mentor and teacher at the USDA, he left his mark on the work of later generations of researchers. I find myself no exception, as will become clear from what I have to say in this paper. Even though I never met him in person, my work has been influenced by what he wrote, and by what his students wrote and taught.

Among the many topics that interested Waugh were the dynamics of free market behavior and the implications for policy formation.

In this paper I consider models of markets in which the dynamics run in two directions, forward from current conditions to expectations of future prices, and back from price expectations to current decisions. Both types of linkages can be crucial in competitive models of agricultural production, in which land has a prominent role as the quintessential fixed asset. A central challenge of market analysis from Waugh's time till now has been to infer from market observations whether markets are behaving in ways that could be improved upon with the help of public policy. When dynamic linkages are a two-way street, this question can be difficult, and errors in the direction of intervention can often seem as consistent with our economic intuition as they are pleasing to those who stand to gain therefrom. In the first section of my paper I consider agricultural supply as an example of dynamic behavior that has been subject to misinterpretation by policy makers, and analysts, including Waugh himself, and try to give some insights into how easily such misinterpretation can arise.

A second and related issue is the effect of agricultural policies themselves on market behavior and the consequences for market participants. The latter is fundamentally a question of policy incidence. When benefit streams affect asset values, incidence is a dynamic concept, even if market response has no dynamics. The welfare significance of a given benefit stream depends upon previous expectations as embodied in asset prices. When the market response is also dynamic, the evaluation of incidence becomes an interesting analytical question that can have counterintuitive answers. In section 2, I concentrate on two issues that illustrate these points, using models sufficiently stylized to be amenable to dynamic analysis. Each issue is chosen to incorporate a key aspect of current agricultural policy. One is the effect on market participants of introducing a price floor scheme in a commodity market subject to random shocks. The other is the incidence of changes in net returns to land in a deterministic overlapping generations model.

1. Interpretation of the Dynamics of Market Behavior

In the first example I revisit an issue first addressed by Waugh almost a half-century ago. In fact he initiated the literature on the subject.

The Welfare Effects of Fluctuations in Consumer Prices

A common theme in the literature in defense of agricultural price-stabilizing policies is that they are of benefit to consumers. This intuitively plausible idea seems to be based on the ample evidence from markets and experiments that individuals usually indicate that they are willing to pay to avoid risky gains relative to sure gains. Price fluctuations cause real income fluctuations, so consumers should be willing to incur some cost in support of price-stabilizing policies.

Fred Waugh had the originality to study this problem from a novel viewpoint. His 1944 paper on consumer gains from price instability cast the problem in a different light.

His fundamental insight was that a consumer with flexible consumption responses can take advantage of mean-preserving price variation, buying more of temporarily cheaper commodities, less of more expensive ones, and so increase consumer surplus averaged over time. In the intervening half-century, Waugh's discovery has typically been rephrased more or less as follows: The expenditure function is concave in prices (that is, its first derivatives with respect to prices, the Hicksian demands, slope down) and so by Jensen's inequality a mean-preserving spread in the price of a consumption commodity reduces average expenditure required to achieve a given utility level. Not much of substance is added, by this extra sophistication, to Waugh's original insight that consumers who can take advantage of changing economic environments can gain from price variability.

Indeed, Waugh's exposition is broader, since it addresses reallocation of a fixed expenditure over time to take advantage of time-varying prices. Thus he provides an example of the role of intertemporal smoothing of consumption in handling real income fluctuations. This dynamic approach was not emulated in most subsequent work on the welfare effects of real income fluctuations, perhaps due to the static nature of the dominant von Neumann-Morgenstern theory of behavior toward risk.[1] Specification of utility as a function of current income in much agricultural policy analysis may well have led analysts to overestimate the benefits of risk-reducing policies by implicitly assuming consumption to fluctuate as much as income.

Although its dynamic aspects were ignored, Waugh's piece successfully demonstrated that price stabilization could not be assumed to be Pareto optimal even if it were without cost, nor could it be assumed to favor consumers, even if they are risk-averse. In my view this achievement is much more significant than the error in Waugh's further conjecture that consumers and producers might both gain from variable ("unstable") prices as opposed to prices fixed at their means. The latter was quickly countered by Samuelson (1972) in a paper that must be a contender for a publication lag record.[2]

"Cobweb" Behavior

Production lags are not just a feature of the academic publication business; they are also crucial in the dynamics of markets. With a lag between input decisions and output, the ability to predict output price becomes an issue if price is variable. If foresight is not perfect, then the manner in which expectations are formed can induce dynamics into the market.

If expectations are static (depend only on current price) and lagged adjustment happens all at once, then the dynamic model is the famous cobweb model of supply. Waugh (1964) wrote thoughtfully about this model. Like Ezekiel (1938) he identifies the "basic idea" of the cobweb model in earlier econometric results, for example the finding of Moore (1917) that the price of cotton was determined by the size of the contemporaneous crop, but the size of the current crop was "influenced" by the lagged price.

The general insight that current farm output depended on lagged information variables was the foundation of all later work that successfully demonstrated a positive supply response of farmers in developed and developing countries, including adaptive expectations, partial adjustment and more recent "rational expectations" econometric specifications. This was a crucial achievement for agricultural price policy analysis. It implied that marketing boards in ex-colonial less-developed countries that depressed producer terms of trade would risk killing their industries. And excessively high price supports would leave the United States awash in surpluses. Subsequently, government policies of both types have confirmed the viability, if not the immediate persuasive power, of these conclusions.

But the structure of the model that yielded these cautionary conclusions regarding price supports or price suppression contained an apparent paradox upon which a rationale for a third popular type of policy intervention could be based. In a cobweb cycle, the producer response to lagged price exists only under collective producer irrationality; farmers produce more or less than is optimal, given their information. In fact in the basic model with no exogenous source of serial correlation in price, competitive producers with rational expectations would have the same expected incentive in each period in which the exogenous environment is constant, and the same planned output. Actual output should be independent of previous prices. The fact that it is not suggests a case for intervention by a wiser government, to set a floor price below the mean to damp this wasteful cyclical behavior. The government would buy in a high year, then sell back some of its stock the next year, as demonstrated approvingly by Waugh (1964 p. 742[3] Figure 5a). Waugh also found plausible the existence of limit cycles for agricultural commodities of the type that might be generated in a cobweb model with nonlinear demand.

Thus the case is made for a third classic type of public intervention; to stabilize the market by setting 'forward prices" at market-clearing levels, and thereby protecting producers from themselves. Interestingly, there appears to be a certain dissonance between Waugh's advocacy of such stabilization and his finding that consumers benefit from price instability. In fact, only one year after the his paper on consumer benefits from price instability he supported the concept of "a permanent program of 'forward prices' to guide agricultural production. Experience has shown that research and education in farm management are not enough." (Waugh 1945 p.778).

The simple cobweb model has declined in popularity in the face of the rational expectations revolution, although more complex models that share its feature of suboptimal producer investment response dependent only on current price, and that can generate limit cycles, are still being produced. (Recent examples include Lichtenberg and Ujihara 1989 and Chavas and Holt 1993.) But I venture to say the decline is due more to the superior intellectual appeal of rational expectations than to its demonstrated superiority in econometric applications, at least within agricultural economics. Why is cobweb-type behavior not more obviously inconsistent with the data? After all, the simple model itself suggests that if farmers' expectations were collectively accurate there would be no relation of production to lagged price.

One possible answer is that competitive storage activity makes a cobweb-type model seem plausible in a market subject to exogenous independent shocks. Such storage, under appropriate transversality conditions, satisfies the complementary inequalities:

$$
\begin{aligned}
&P_t + k - E_t[P_{t+1}]/(1+r) = 0, S_t > 0 \\
&P_t + k - E_t[P_{t+1}]/(1+r) \geq 0, S_t = 0,
\end{aligned}
\tag{1}
$$

where P_t is price of the stock at time t, k is marginal storage cost, S is the non-negative stock, and r is the interest rate. (See Gustafson 1958, Williams and Wright 1991.)

When storage is cheap and output is sufficiently variable ex post, storage occurs in this model the majority of the time, interspersed with typically brief stockouts. When stocks are positive, expected price, the forward price that is used by producers in their supply decisions, is a function of current price; the two move in lock step with current price assuming k is constant[4]. Only when a stockout exists is there no connection between marginal current price variation and future output. So lagged price is a proxy for the true incentive, which it measures with error.

In this model, realized production is negatively serially correlated, as one would expect in a cobweb model. Here the dynamic linkages work in both directions, not just from the past to the future. A large current harvest depresses the expected future price via its effect on stocks, and the reduced price expectation in turn induces a cut in current planned production.

The link from future price to current production, neglected in cobweb-type models, is always in force. But the forward dynamic link from current output to future price, is not always operative at the margin in this model with constant k,[5] due to the non-negativity of stocks. A deficiency below the level at which a stockout occurs has no effect on future price, though it increases current price. In such states local variation in current price does not affect next year's harvest if fundamental exogenous disturbances are independently and identically distributed (i.i.d.). The lack of marginal response of future supply to current price in these states leads to an underestimate of producer sensitivity to incentives in the cobweb supply specification and its adaptive expectations and partial adjustment generalizations.

Monte Carlo experiments with a storage model with random production confirm this bias. With supply elasticity of 0.3 to lagged prices specified in the model, Williams and Wright (1991 p. 195) show an average elasticity of 0.14 from regressions on 1,000 trials of a sample size of 20, and 0.11 for a sample of 40. Adaptive expectations did about as well,[6] with coefficients of 0.15 and 0.12 for each sample size, respectively. Thus in these examples, regressions based on a cobweb specification actually bias *downward* the price elasticity by about one half. A two-stage "rational expectations" specification in the spirit of McCallum (1976) Ravallion (1985) was also tested. Price was regressed on lags of price and harvest and stocks, then harvest is regressed on the fitted value for price. The mean bias was as bad for the small sample (elasticity of 0.14) but the mean elasticity was less biased (0.20) for the larger sample size.

The storage-induced partial linkage between current price and expected prices can also be an important source of econometric bias in studies of the efficiency and allocative importance of futures markets. (See Williams and Wright 1991, Chapter 7.) If this bias is ignored, the case (supported by Waugh) for public intervention to set forward prices, rather than relying on private futures and forward trading to determine the price, might seem stronger than it really is.

2. Dynamic Incidence of Agricultural Policies

The subject thus far has been the dynamics of free market behavior and pitfalls in its interpretation. In a very simple market model with uncertainty, production lags and the possibility of storage can induce interesting dynamic behavior. This behavior is sufficiently subtle as to be easily misinterpreted, a possibility that can result in inappropriate policy measures.

Let us now turn to the effects of agricultural policies themselves. How do they influence the evolution of the market and, ultimately, how do they affect individuals' welfare? The latter is the question of policy incidence.

Historically, the standard framework of agricultural policy analysis is Marshallian partial equilibrium analysis. A positively-sloped output supply curve recognizes the special limiting role of land and its imperfect substitutability with other factors, assumed here for simplicity to be of infinitely elastic supply.[7]

This framework has served agriculture well. It is sufficient to provide qualitative insights on the implications for efficiency and for surplus flows of policy interventions such as commodity subsidies, taxes, quotas, variable levies, cartelization and so on, in the context of an otherwise undistorted world.

The fixity of the supply curve reflects the Ricardian insight about the special nature of land as a factor offering a relatively fixed service to farmers, repeatedly over time. The role of land lends a plausibility to the assumption of static equilibrium in agricultural markets. It stands as the intermediate case between reproducible capital, highly flexible from period to period, and finite resources.

Under the assumption of infinitely elastic supply of other inputs and exogenous output price, theory from Ricardo on predicts that policy changes will be fully and immediately reflected in land rents upon announcement, assuming they are a surprise. For a permanent policy change, in such a deterministic partial equilibrium model, the dynamic effects are quite simple: a once-for-all shift in land rent to a new constant level. The instantaneous change is also the change between steady states. That is, comparative statics analysis of the model gives all the information required for evaluation of the full dynamic effects of policy in this analysis.

But even in this simple model, the effects of policy must be interpreted with some care to draw correct welfare conclusions. In particular, students must be wary of two elementary mistakes of inference. The first is to conclude that future farmers in any year will have a net benefit equal to the increase in rent flows; that is, to ignore capitalization of rents in the price future entrants must pay for land. A second mistake for the perhaps slightly more sophisticated is to look at land asset rates of return in the steady states and, if they are found to be equal, to infer no benefit of policy to farmers at all.

The correct answer in the context of this model is, of course, that those who own land at the time the policy change becomes known have a once-for-all change in wealth equal to the present value of the change in flow of producer surplus. Later entrants receive no benefits, except via any changes in bequests.

When there is another interconnection between periods besides ownership of land, dynamics may be induced in the surplus flows themselves, making incidence analysis more interesting. Consider in turn models in which there is an additional link via either storage or savings response. These models demonstrate the possible incidence of stylized policies with essential features of policy measures designed to stabilize prices, increase producer surplus of farmers, or to increase the productivity of land. The focus here is on the importance of a dynamic perspective in policy analysis rather than on the implications of any policies considered.

2.1 Incidence of Introduction of a Floor-Price Scheme

Regardless of the validity of economists' attitudes toward market stabilization, many of the public interventions in agriculture have been defended with the argument that they are market-stabilizing. Their claim on the budget, it is argued, is justified because they help consumers by protecting them from price fluctuations.

To examine the welfare effect of a price stabilization scheme with storage, it is necessary, as made clear below, to take explicit account of the dynamics introduced by storage. Until Wright and Williams (1984), all welfare analysis of market stabilization (e.g., Newbery and Stiglitz 1981, Wright 1979, Massell 1969) had been conducted using comparative statics methodologies. Let us consider perhaps the simplest of such schemes, an open offer by the government to buy or sell at a price floor below mean price in the market for a commodity such as grain.[8]

Since the effects are dynamic, we must specify initial conditions and derive the evolution of revenues in the absence of intervention. Figure 1 illustrates a case in which the initial amount held by producers is unusually large (120% of R^N, where R is revenue. The superscript N here and below denotes a value that would obtain in the equilibrium in this model, in the permanent absence of any interventions or market disturbances). Free-market price is low; but not as low as if there were no private speculators to bring some of the overhand as stocks. Initial free-market revenue from sales to storers and consumers is R_0.

The evolution of expected revenues of producers in subsequent periods, conditional on information at period *0*, is indicated by the curve drawn through a sequence of points, one for each period starting at period *0*. Each point is derived as the mean of the values from thousands of stochastic simulations of a rational expectations storage model in which competitive private storage behavior is specified as the solution to a stochastic dynamic programming model.[9]

Figure 1 shows that producers in period *0* will anticipate reduced revenues from what they will produce in period 1, due to the "overhang" of private stocks acquired by storers from producers, the previous year. As this overhang is, in expectation, run down in subsequent years, the path of expected revenue of sales of current output subsequently rises to converge to its steady state mean.

Now consider the introduction of a price floor at 90% of P^N, under the same initial conditions. As Figure 2 shows, the immediate effect is to raise the value of sales by producers in period 0, by raising the current market price. In period 1, the price floor prevents, in expectation, part of the price depression otherwise induced by resales from private stocks. But subsequently, the slower selloff of larger government stocks is expected to prolong the downward pressure on price, so that expected revenues by period 4 fall below the free-market expected value. In the stochastic steady state in this model with constant elasticity of demand, the lower variance of consumption under the price floor favors consumers but penalizes producers so the new steady-state value is below the free-market value. (The reverse would hold if demand were linear, for then there would be no change in mean price, consumption variability would be proportional to price variability and Waugh's (1944) result would apply).

The true measure of incidence of the introduction of this (permanent) price floor is the net present value of the vertical difference between the two curves in each period to infinity. Assuming capitalization, it is the change in the value of initial supplies in period *0* plus the change in land value at that time.

The initial acquisition of stocks has a greater influence on initial land price than subsequent resale because of discounting. The higher the price floor, the larger is the initial stock acquisition and the longer is the expected time to approximate convergence to the new steady state. Therefore the steady-state effects have less influence on land price, and the comparative statics analysis is more misleading, for high price floors.[10]

This model can be used to dramatize the importance of a dynamic approach to policy analysis. The redistributive effects of price floors of various levels in the above model can be summarized in illustrations akin to the "surplus transformation curves" of Gardner (1983), except that, consistent with the dynamic perspective, the transfers are measured as changes in land values (including value of initial supplies), and the discounted present value of consumer surplus, rather than flows of consumer and producer surplus. For purposes of illustration I assume landholders finance the scheme, so their wealth changes reflect the expected present value of operating costs.[11]

The transformation curve calculated from the capitalized value of the (constant) period-by-period expected differentials in surplus flows between the steady states with and without the price floor, (the comparative statics effects), is shown in Figure 3. The redistribution for increasingly higher levels of price floor P^F is indicated by the dashed curve emanating from the origin, for an initial available supply 20 percent above mean output. The dotted diagonal line with slope of 45^0 represents lump sum redistribution with no deadweight loss. Note that consumers appear to gain and initial landowners to lose from the price floor, and the transfer appears very efficient. Indeed, it seems that the scheme can yield a deadweight *gain*, rather than a deadweight loss. That is, part of the transformation curve lies above the diagonal; consumers gain more than the loss in landowner wealth. Have we finally cooked up a free lunch for society? No such luck. The costs of previously acquiring the greater level of stocks expected in the new steady state with the floor are ignored in the comparative statics analysis.

Let us now consider a different price floor scheme, wherein any stocks acquired by the government are immediately destroyed. As in a simple Marshallian one-period diagram, the effects of a stock overhang on later prices are ignored.[12] The results, shown in Figure 4, are in a literal sense diametrically opposed to the comparative statics results. Consumers lose, and initial landowners gain.

If stocks are not destroyed, but sold off when the price is at least equal to the floor, the full dynamic analysis of the effects of floor prices set at different levels are as shown in Figure 5. In this case, the possible redistributions actually cover three quadrants. At very low price floors, the comparative statics effects have more weight and consumer gain. At high price floors, consumers lose and producer wealth increases.

The three previous figures are combined in Figure 6. It emphasizes that the dynamic incidence is the opposite of comparative statics effects. Note, however, that the deadweight loss (the vertical distance from the 45° line) is in this illustration higher than if any government acquisitions were destroyed immediately. The waste of excess storage, in tying up capital and in costs of the storage activity, is no doubt much less obvious but can be more significant.

The correct dynamic perspective on policy incidence can help us understand why politicians might be tempted to introduce price support schemes, and when they might be most likely to do so. For example, it seems that most floor-price type schemes are introduced with a floor well below current market price, in contrast to the case just illustrated.

The dynamic effects of introducing a floor when current price is high enough that there are no initial carryout stocks are illustrated in Figure 7. The unforeseen introduction of a permanent scheme induces an immediate jump in the wealth of landholders, and comes at no current expense to government or consumer.

For subsequent periods, (and, perhaps, successor governments), the story is likely to be less happy. Over time the government deficit from the scheme is expected to rise, and consumers will suffer by having low-price spending opportunities truncated by the price floor, even though later they will tend to have some offsetting gains later due to resale of acquired government stocks. Producer surplus, on the other hand, is expected to rise due to increased initial stock acquisition, then be dampened by the effects of stock releases by the government, the expected value of which grows over time. Expected land values decline monotonically, after the initial jump. (This anticipated decline, of course, has no significance for the initial incidence of the floor-price policy.) This dynamic scenario might plausibly be an attractive one for a government with a short horizon seeking landowner support, if consumers and taxpayers are not sufficiently aware of the long-run losses they are likely to incur.

Finally, analytic treatments of buffer stocks and buffer funds often assume that the scheme is "self-liquidating" in that "on average" or "in the long run" the accumulated balance is zero, and hence that constant consumption from year to year can be achieved under the scheme. (See for example Turnovsky, 1983, Newbery and Stiglitz 1981, p. 204, Simmons and Stahl 1992.) This is an example of the type of error mentioned in Section 1 above: If a random variable has a zero conditional expected deviation in each future period one should not assume that the probability that the deviation is zero in each period is unity.

Consider for example the simple scheme where the government buys and sells at a price floor equal to mean output in a model with linear consumption demand and zero supply elasticity. If supply has a symmetric i.i.d. two-point disturbance, and there are no borrowing or lending limits at all, then if consumption is fixed at mean output, the probability conditional on information at the initiation of the scheme, time 0, that the balance in the scheme is zero at each subsequent even date $2t$ declines drastically with t. In fact, it is equal to the probability that the balance *never reaches zero before 2t.* (See Feller 1967, chapter 3, Lemma 1, p. 76.) An assumption that the balance is usually zero, or zero at the end of the scheme's time horizon, could hardly be less appropriate. Indeed in finite time, the accumulated positive or negative balance will cross any finite bound with probability one, making any scheme non-viable in the long run.

Fred Waugh saw that random walk theory had important implications for buffer stocks. Buffer stock operators in the intervening years might well have heeded his 1967 recommendation: "Further mathematical and statistical work is needed to make a detailed application of theories of runs and of random walks, to the practical problem of setting reserve levels for farm products" (Waugh 1967, p. 31).

2.2 General Equilibrium Incidence of Transfers of Surplus

Incidence of Rent-Increasing Policies

Although many agricultural policy measures are plausibly aimed at market stabilization, many others are rather clearly intended to increase average producer surplus. If we maintain our simplifying assumption that other factors have perfectly elastic supply, in partial equilibrium the transfers are fully capitalized in land prices, as noted above. The incidence of such policies, represented as land rent subsidies, can be substantially modified by general equilibrium dynamics.

In Chamley and Wright (1987) a formal investigation of the relevance of dynamic linkages in an overlapping generations model without bequest is made into the Ricardian question of the effects of a land rent tax on the price of land. This analysis can be used to analyze the symmetric case of a rent subsidy. For analytical tractability, it is necessary to resort to a highly stylized deterministic model created by adding a fixed productive asset (land) to the model of Samuelson (1958). Consider a population in which cohort t lives two periods, t and $t+1$, supplying one unit of labor in the first, and receiving a wage w_t. There is no population growth and no technical change and the horizon is infinite. The production function is $F(K, L, T)$ with constant returns to scale, where K is capital, L is labor and T is the fixed input ("land"). Capital and output are perfect substitutes in consumption.

The three inputs, the capital stock at the beginning of period t, (K_t), labor L and land T receive their positive marginal returns, r_t, w_t and m_t respectively, at the end of period t. At the end of the period t, consumption and saving decisions are made by the young generation t,

with perfect foresight. Savings are allocated to capital K_{t+1} or land T purchased from the older generation at price P_t. Capital does not depreciate and is a perfect substitute for the consumption good which is the numeraire. One period later, this generation, now retired, receives income $r_{t+1}K_t + m_{t+1}T$, where r and m are the interest rate and land rent, respectively, and also consumes K_t and the return from sale of land, $P_{t+1}T$.

Arbitrage ensures that land and capital earn the same rate of return in this deterministic model. For convenience, we normalize L and T at unity.

(2) $$1 + r_{t+1} = \frac{(1+z)m_{t+1} + P_{t+1}}{P_t}$$

where the return on land includes both rent (including any subsidy z) and price appreciation. The perfect substitutability of capital for consumption rules out any change in the value of the capital stock.

Saving by the young generation at the end of period t, (S_t) depends on the wage rate w_t and the anticipated rate of return, r_{t+1}

(3) $$S(w_t, r_{t+1}) = K_{t+1} + P_t$$

The wage w_t for work in period t depends upon the stock of capital K_t used in conjunction with the fixed supplies of labor and land, while the interest rate to be earned on savings therefrom depends on the capital stock in the subsequent period, K_{t+1}. Therefore (2) implicitly defines K_{t+1} as a function of K_t and P_t:

$$K_{t+1} = A(K_t, P_t) \tag{4}$$

Rearranging (2), P_{t+1} can be expressed as a function of K_{t+1}, P_t and z:

$$P_{t+1} = C(K_{t+1}, P_t, z) \tag{5}$$

Substituting from (4),

$$\begin{aligned} P_{t+1} &= C[A(K_t, P_t), P_t, z] \\ &= B(K_t, P_t, z) \end{aligned} \tag{6}$$

Equations (4) and (6) determine the dynamic evolution of the model.

Imagine that the economy is in a steady state in period 0 with no subsidies or taxes, with capital stock K and land price P_{SS}, as in Figure 8. Then just before the older generation sells the land in exchange for retirement consumption, a permanent subsidy on land rent at rate z is announced and implemented. Assume for now that the resources for the subsidy come from an exogenous donor.

The permanent subsidy shifts the steady state price P_{ss}. Under the partial equilibrium assumptions of a constant price of capital, that is, an infinite elasticity of supply of savings η, the land price will rise immediately by the present value of the future subsidy flow, $m_0 z / r_0$ to the new steady state and the capital stock remains unchanged. Assuming the initial intergenerational rate of return $r_0 = 1$, (that is, the annual interest rate is about 3 percent given a generation means 25 years), this rise equals the amount of the subsidy $m_0 z$ paid to the old generation immediately. Thus the old gain twice the subsidy; no subsequent generations gain at all. Thus, in partial equilibrium, comparative statics analysis correctly shows that the incidence is a one-time wealth boost to the older generation in period 0 equal to $m_0 z(1+1/r) = 2m_o z$.

But if the elasticity of supply of savings is finite, the steady-state price rise will be less than indicated by partial equilibrium analysis. Why is this so? When land rent is subsidized in the steady state, capital formation is "crowded out" by diversion of savings to land purchases. In the new steady state the interest rate must be higher to maintain equilibrium, unless the elasticity of supply of saving is infinite. The above result depends upon uniqueness and stability of the equilibrium price, and upon a very plausible crowding-out assumption; if and only if public debt financed by a wage tax decreases the steady state capital stock, so does the new subsidy. (See Chamley and Wright 1987 Theorems 1 and 2 for the symmetric case of a land tax.). Under the reasonable assumption that the marginal productivity of land falls when the capital stock falls, m is lower in the new steady state. This fact, and the fact that r rises, mean that the initial boost to land price is lower than in the partial equilibrium analysis.

The effects just discussed indicate that the new steady state has lower land value than the initial situation just after the subsidy is announced. The path of land value after the initial price jump slopes down to the left. Welfare of each generation beginning with the currently young decreases relative to its antecedent, under assumptions that might be considered to represent the usual situation. (These assumptions are Hicksian stability in the supply and demand for capital holding land price fixed, that is $\partial S / \partial r_{t+1} > \partial K_{t+1} / \partial r_{t+1}$, and the previously introduced assumption that the land price and capital stock are positively related in the steady state.) Under the same assumptions, the initial land price rises, but by less than the partial equilibrium amount $m_0 z / r_0$. The initial landowners also gain from the period 0 rent increase $m_0 z$; given the initial intergenerational interest rate is 1, their aggregate gain is less than $2m_0 z$, the increase in the wealth of the landowners under partial equilibrium. A possible linearized dynamic path, accurate for a sufficiently small subsidy, is shown in Figure 9; the initial land price gain is less than what would be indicated by comparative states analysis and the new steady-state price is below the initial price P_0.

It is possible that land price might even jump down after a subsidy is announced! This can occur if the demand for second period consumption is sufficiently inelastic with respect to its price $1/(1+r)$, or equivalently the elasticity of supply of savings is sufficiently negative. Then the above static Hicksian stability condition is violated, (that is, $0 > \partial K_{t+1} / \partial r_{t+1} > \partial S / \partial r_{t+1}$), but $\partial S / \partial r_{t+1} > \partial (K_{t+1} + P_t) / \partial r_{t+1}$ so that the dynamic model is nevertheless stable.

But initial landowners still have a net gain. The maximum, immediate land price fall under the minimal requirements of uniqueness and stability of equilibrium and the other assumptions introduced above is only *half* the initial gain from the rent subsidy.[13] The *long run* land price fall is larger; comparative statics analysis could erroneously imply that the initial landowners would lose from introduction of a subsidy.[14] The dynamic perspective is essential here.

The Paradoxical Incidence of Land-Productivity-Increasing Technical Change

What I have shown thus far is that an increase in land rent that is by assumption a free lunch from outside the model can have negative effects on future generations. Since the young do not directly finance this transfer at all, these results are equivalently what would be achieved by a costless new production innovation that additively shifted the marginal product of land while maintaining homogeneity and leaving the productivity of other factors unchanged. An admittedly stylized example of such a change could be new knowledge that transforms the production function

$$Y = F(K,L,T)$$

to

$$Y = F(K,L,T) + aK, \qquad a > 0 \ .$$

Such technical change, which could seem to be an unambiguously beneficial achievement, is indeed a boon to the older generation, but may well leave later generations worse off, with a lower capital stock and lower wages. Indeed, if the innovation were announced one period before it came into effect, the older generation could lose, if the elasticity of supply of savings is sufficiently negative that land price jumps downward upon announcement.

Obviously a similar shift in productivity of labor would have quite different effects. The point here is that the existence of tradable property rights in land, so beneficial for its incentive effects, can dramatically affect the distributional effects of different types of technical change across generations[15].

The Implications of Endogenous Financing

Consider now the case in which a subsidy to rent is financed with a wage tax on the young. This tax makes all generations worse off in general, including the initial older generation. This is true even though there is no conventional static deadweight loss from a change in labor supply, since labor is fixed here. Rather, the wage tax is a lump sum tax on the young that reduces their saving, both in land and in capital accumulation. The old suffer from the reduced land prices, and the long-run capital stock is also further reduced.

One question Fred Waugh might have asked about these conclusions is whether they are significant in practice. The simplicity of the one-sector analysis and the assumption of a closed economy, and our uncertainty about fundamental parameters including the savings supply elasticity, make it injudicious to quantify the dynamic effects of actual agricultural policies based on this model. But I do note that similar effects of inflation, as a tax on money, on capital formation have been given serious attention by Tobin (1965) and others. Given the value of land in relation to the monetary base, the effects of land subsidies should be worthy of attention. Furthermore, the cost of the implicit subsidy to residential housing, via effects analogous to those considered here, has been estimated by Skinner (1990), for specific functional forms and parameter choices, at 2.2 percent of GNP.

This type of fiscal transfer is a stylized representation of many agricultural policies like target prices with deficiency payments and payments for the conservation reserve, that affect the price of land. Transfers that are truly "decoupled" from land and other fixed assets might have different dynamic implications. But unless they do not affect individuals' behavior in any way, they are likely to have dynamic implications that merit attention.

Dynamic Incidence on the Consumer Side?

A less researched question is the dynamic general equilibrium effect on consumers via changes in consumer surplus flows. The comparative statics change in consumer surplus in incidence analysis is generally assumed to accrue as a gain or loss to consumers present and future, in each period when consumption occurs. Since food consumption entails no significant fixed costs, the argument presumably goes, there is no capitalization of the flow of consumer surplus. But is this conclusion satisfactory? Not always. Reports from China indicate that some rural workers are paying ten times their annual salary for permission to become urban residents. It is very plausible that a part of this cost is the capitalized value of benefits, including food subsidies, available only to urban residents. More generally, the idea that cheap food might mean cheap wages has long been current among development economists.

In more developed economies, do lower food costs mean higher prices of residential housing? The results of hedonic studies suggest this is true in the cross section (Roback 1982). It seems at least plausible that this could also be true for housing as a whole due to intergenerational trade. The implications for agricultural political economy seem interesting.

The above discussion assumes that land is traded over time between finite-lived individuals in different generations experiencing a constant environment.. But what if the environment is undergoing secular change? The better-off are the buyers, the higher they will tend to bid in equilibrium, given that future consumption is a normal good.

This linkage may be significant in considering the political economy of anticipated environmental degradation for future generations caused by current policy choices. In the highly informative inaugural Waugh lecture, Marc Nerlove (1991, p. 1335) observed that "[I]n a two-period overlapping generations model without altruism, there is no scope for a discussion of welfare losses to the present generation resulting from the unpriced character of environmental and natural resources because those members of the present generation are no longer around to experience the effects of environmental deterioration and do not care about their children's welfare."

If the older generation is not befuddled by an intertemporal version of the mercantilist attitude that seems to be gaining ground in trade negotiations, it might have a selfish incentive to cooperate in actions that are recognized to cause future environmental improvement in return for a higher sale price for its fixed assets including land. Institutional arrangements would be needed to prevent free-riding within the older generation. The selfish children will pay their selfish parents more for their assets because they are better-off, and hence want to save more. It is a commonplace that markets can reduce environmental degradation. Including intergenerational trades of land in the dynamic perspective increases the scope of this insight.

3. Conclusion

Dynamic behavior of agricultural markets requires careful interpretation, even if we exclude complexities induced by population variation, technical change, serial correlation in weather, business cycles and other market-disturbing phenomena. Indeed if the only link between periods is competitive storage arbitrage that is sporadically interrupted by stockouts, the induced price responses can make supply behavior under rational expectations seem to be evidence of sub-optimal private behavior such as irrational expectations formation.

It is also possible to show that these intertemporal linkages can make futures markets seem to be biased predictors when they are not, and can make their informational content appear lower than it is. (See Williams and Wright, 1991, chapter 7). In samples of modest size, usually available to economists, it might be difficult to detect these problems.

The lesson I draw from these observations is that the analyst should be cautious in accepting plausible evidence of opportunities for corrective government policy. In particular, intuition from the linear models that are our stock in trade can lead to interpretation of rational but nonlinear dynamic behavior as irrational. If this caution is relevant for the simple model considered here, it must be all the more apposite for the far more complex situations encountered in real markets.

Proper consideration of dynamics is important not just in the evaluation of market performance but also in the analysis of the allocative and distributive effects of policy interventions. The example of a simple floor-price market stabilization scheme drives home this point; a traditional comparative-statics approach can show the wrong sign for both the excess burden of the policy, and also the direction of redistribution between landowner and consumers, via the endogenous dynamics of public and private stockholding activity.

Even in a deterministic model, policies that increase the marginal return to a fixed stock of land, including farm subsidies and land-enhancing research, have dynamic general equilibrium effects via capital accumulation that can modify or, in extreme cases, reverse the Ricardian analysis of capitalization. More important, either policy in an overlapping generations framework will lead to crowding out of private capital accumulation even if the means of funding is ignored. The effect is exacerbated if wage taxes must be increased to finance these polices. Similar dynamic intergenerational linkages might be important in determining the extent to which environmental effects that are foreseeable but will not occur within a life span are considered by a selfish currently old generation.

The models considered here, though dynamic, have static parameters that are assumed to be common knowledge. In fact, as Gardner (1981) has emphasized, most important policy decisions relate to novel situations or new types of interventions, the reactions to which cannot necessarily be predicted based on known parameter values or empirical investigation of historical experience. One aspect of the dynamics of policy analysis that is very important, but is not considered here, is the dynamics of endogenous learning about the effects of changes in the natural or social environments or in policies, as those effects unfold.

[*] I am indebted, with the usual caveat, to my friend anc colleague Jeffrey C. Williams, who offered insightful comments on this paper, and is jointly responsible for all the material on commodity storage contained in this paper, and to Paul Winters for research assistance.

[1] Much later, Binswanger's results from gambling experiments rejected the existence of a von Neumann-Morgenstern utility function the arrangement of which integrates assets with current income. These results, confirmed by subsequent studies, discouraged the integration of risk analysis with dynamic resource reallocation. Newbery and Stiglitz (1981, p. 100-105 *et seq.*), for example, recognize the smoothing possibilities of saving but, influenced by Binswanger, concentrate on the analysis of risk as a function of current income, using the coefficient of partial risk aversion, $P \equiv Y V_{yy} / V_y$, where $V(Y)$ is utility of current income. This in true even where individuals are explicitly modeled as involved in intertemporal resource allocation related, for example, to productive investments, such as the planting of a crop.

[2] Waugh (1944) actually emphasized that stabilization of quantities consumed at their means could not benefit both parties. As he recognized, stabilization with a convex demand curve implies an increase in average quantities produced and consumed.

[3] The papers of Waugh referenced here are available in the book *Selected Writings on Agricultural Policy and Economic Analysis, Frederick V. Waugh.* James P. Houck and Martin E. Abel, Editors. Minneapolis, Minn.: University of Minnesota Press, 1984.

[4] In empirical studies it usually seems that stockouts never occur, even when the measured return to storage seems negative. These observations have given rise to the theory, or more accurately the hypothesis, of convenience yield as an unmeasured service of stocks that rationalizes the empirical evidence. In a study of detailed microeconomic data from the Western Australian wheat marketing system, Brennan, Wright and Williams (1992) show that convenience yield can occur as an aggregation phenomenon in a spatial and intertemporal market in which stocks are never held at a loss and stockouts occur locally without appearing in the aggregate data.

[5] If k can fall sufficiently below zero that a stockout never occurs, as in some models with "convenience yield," the link is always operative but the response is correspondingly nonlinear.

[6] The cobweb type supply model estimate is $\overline{h}_t = \alpha + \beta P_{t-1} + U_t$ where $\overline{h}_t$ is planned harvest for period t from a crop planted in period t-1, P_{t-1} is price in period t-1, and U_t is an independently and identically distributed disturbance in supply in period t, the distribution of which is known in period t-1. The adaptive expectations model adds a lag of the dependent variable: $\overline{h}_t = a + b P_{t-1} + c \overline{h}_{t-1} + U_t$ where the slope of the long-run supply curve is estimated as $\hat{b}/(1-\hat{c})$ where a hat denotes an estimated coefficient.

[7] In practice, the quasi-fixity of other factors, in particular human capital in agriculture, is important for policy, but I want to focus on the dynamics that arise apart from any that might be induced by factor supply response. I consider imperfectly elastic capital supply below.

[8] Some readers may wonder why I choose a price floor, not a price band as the simplest scheme. The reason is that, given the possibility of private storage market behavior under a price band is much more complex than it might at first appear. (See Williams and Wright 1991, Ch. 14.)

[9] For a more detailed exposition of such calculations, see Williams and Wright (1991, Chapters 5 and 13). This illustration is derived from 100,000 strings of simulations of a model with consumer demand elasticity -0.2, supply elasticity 0, interest rate 5 percent per period constant marginal storage cost of 0.025 P^N, and a symmetric supply disturbance.

[10] To be consistent with existence of a steady state, the price floor must be below the steady state mean.

[11] (See Wright and Williams (1988), Williams and Wright (1991) for an expanded exposition of the incidence effects discussed here).

[12] There are still some intertemporal effects via the endogenous response of private storage.

[13] The symmetric case for a land tax appears as Theorem 3 of Chamley and Wright (1987, p. 13).

[14] See Chamley and Wright (1987) Theorem 3, p. 13. Thus Feldstein (1977, p. 353) conjectured from his comparative statics analysis that landowners could lose from the imposition of a tax on rent.

[15] See also Drazen and Eckstein (1988).

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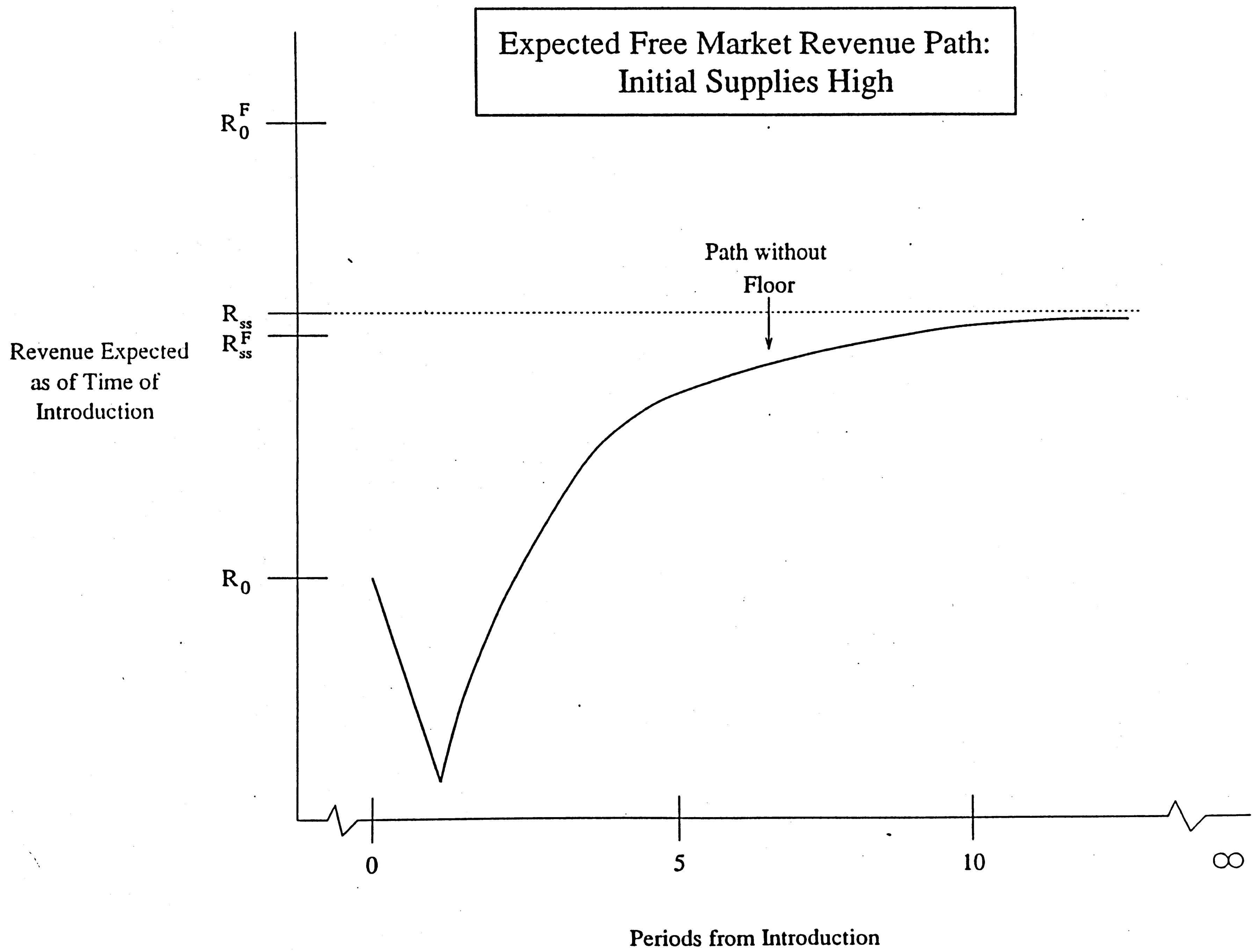
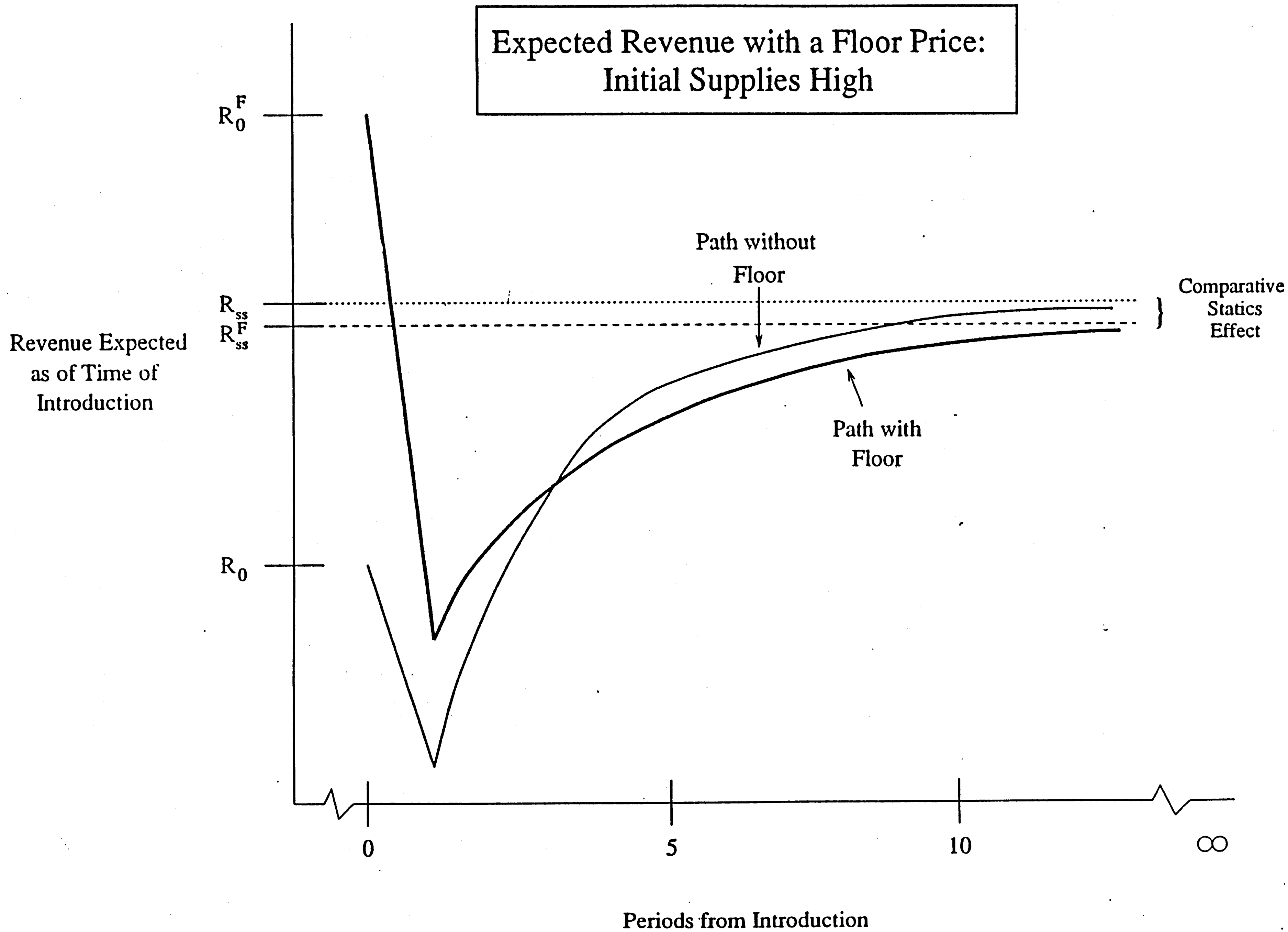
Figure 1



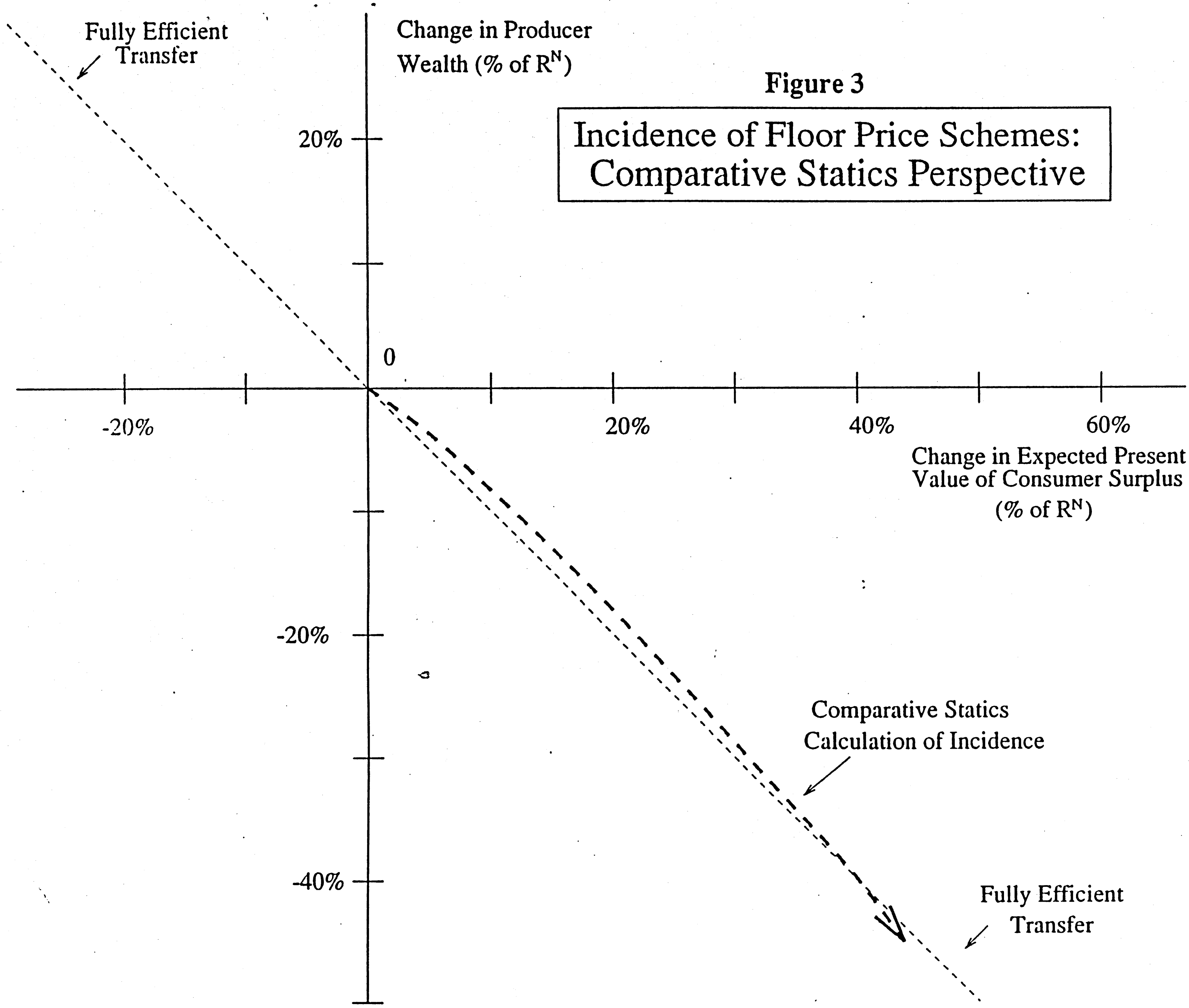
Expected Free Market Revenue Path:
Initial Supplies High
R_0^F
R_{ss}
R_{ss}^F
R_0
Revenue Expected
as of Time of
Introduction
Path without
Floor
0
5
10
∞
Periods from Introduction

Figure 2



Expected Revenue with a Floor Price:
Initial Supplies High
Revenue Expected as of Time of Introduction
R_0^F
R_{ss}
R_{ss}^F
R_0
Path without Floor
Path with Floor
Comparative Statics Effect
0
5
10
∞
Periods from Introduction

Figure 3



Incidence of Floor Price Schemes:
Comparative Statics Perspective
Change in Producer
Wealth (% of R^N)
Fully Efficient
Transfer
20%
0
-20%
-20%
20%
40%
60%
-40%
Change in Expected Present
Value of Consumer Surplus
(% of R^N)
Comparative Statics
Calculation of Incidence
Fully Efficient
Transfer

Figure 4

Incidence of Floor Price Schemes: Government Acquisitions Destroyed

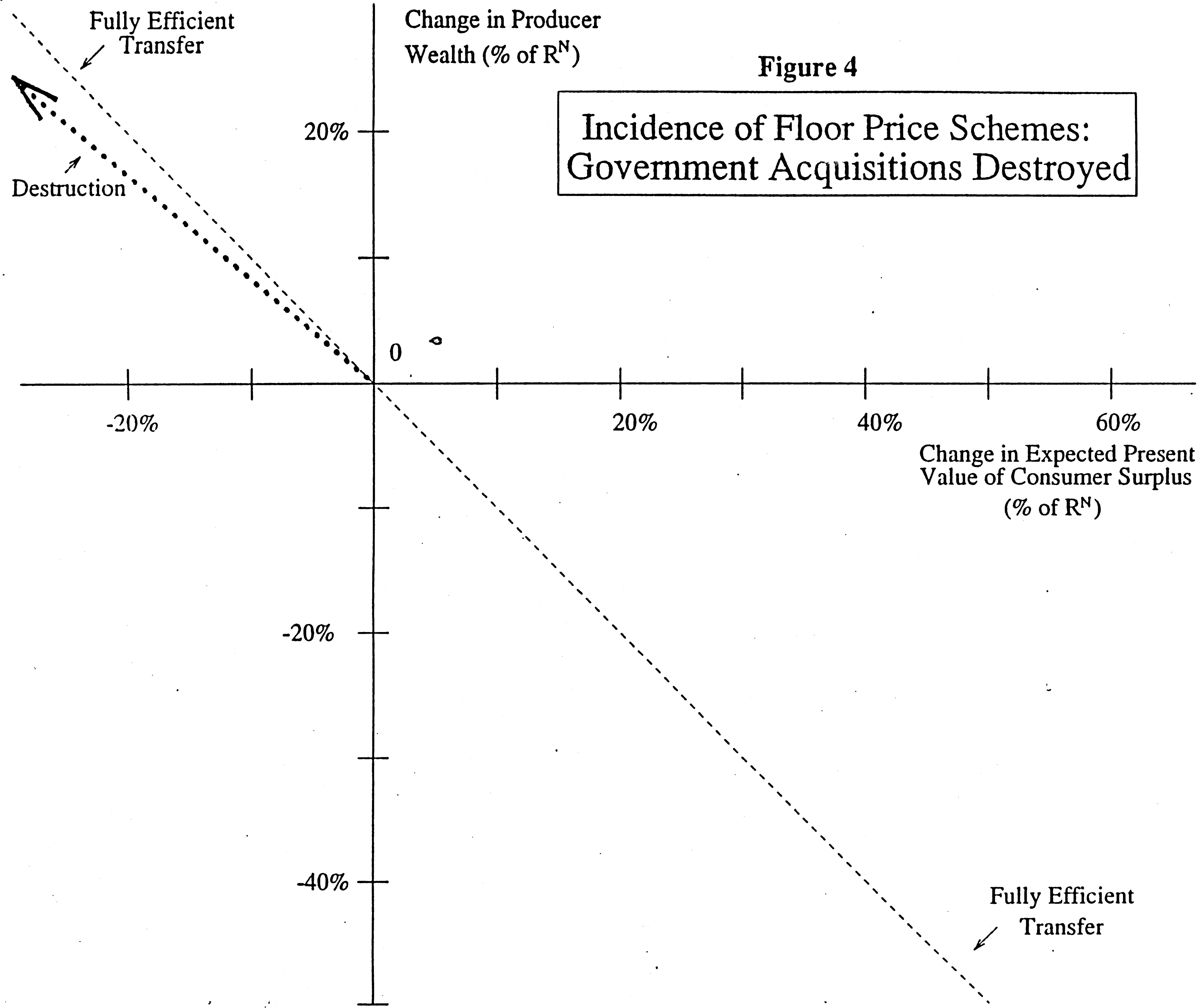


Figure 5

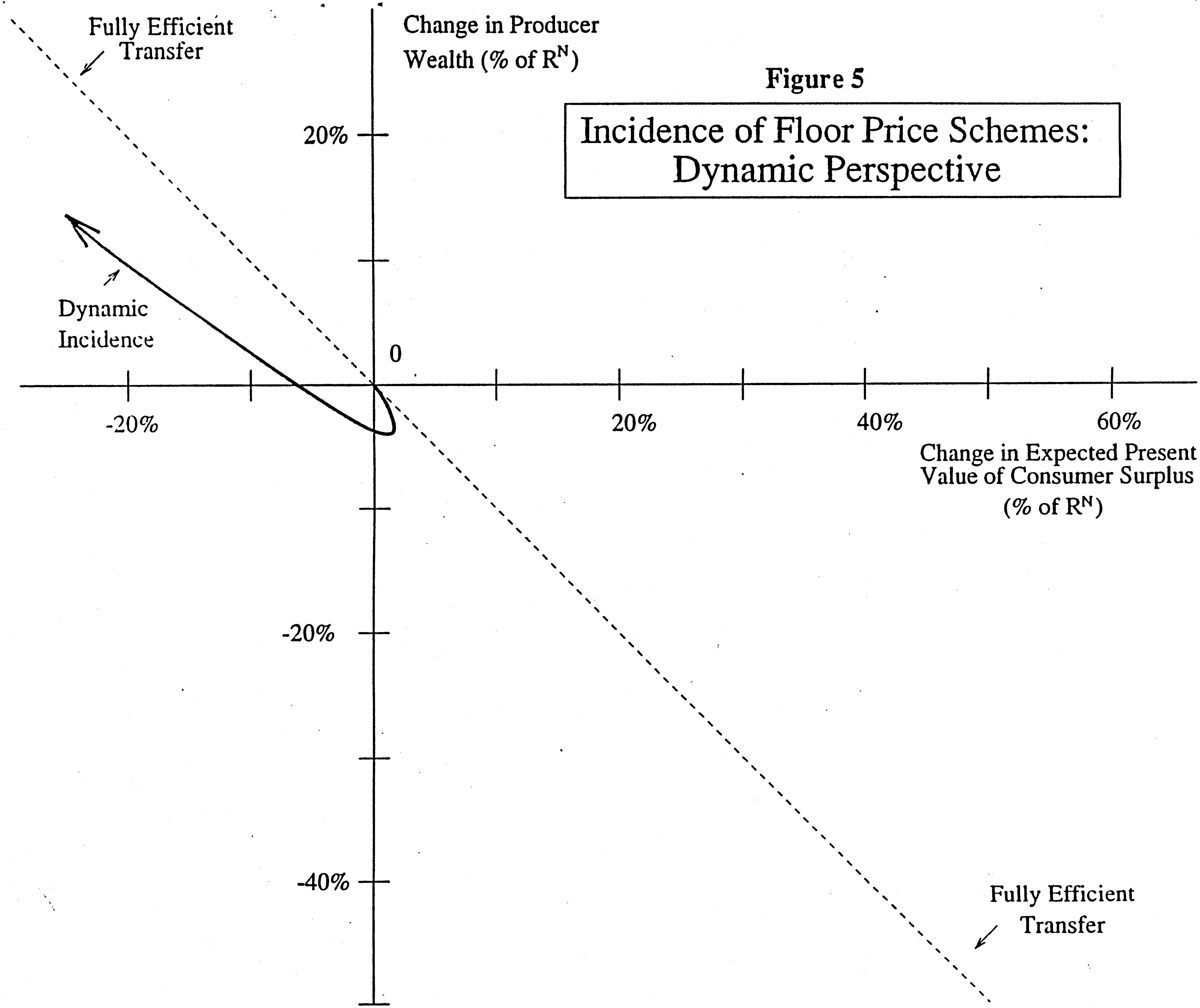

Incidence of Floor Price Schemes:
Dynamic Perspective
Change in Producer
Wealth (% of R^N)
Fully Efficient
Transfer
20%
Dynamic
Incidence
0
-20%
20%
40%
60%
Change in Expected Present
Value of Consumer Surplus
(% of R^N)
-20%
-40%
Fully Efficient
Transfer

Figure 6

Incidence of Floor Price Schemes: Alternative Perspectives

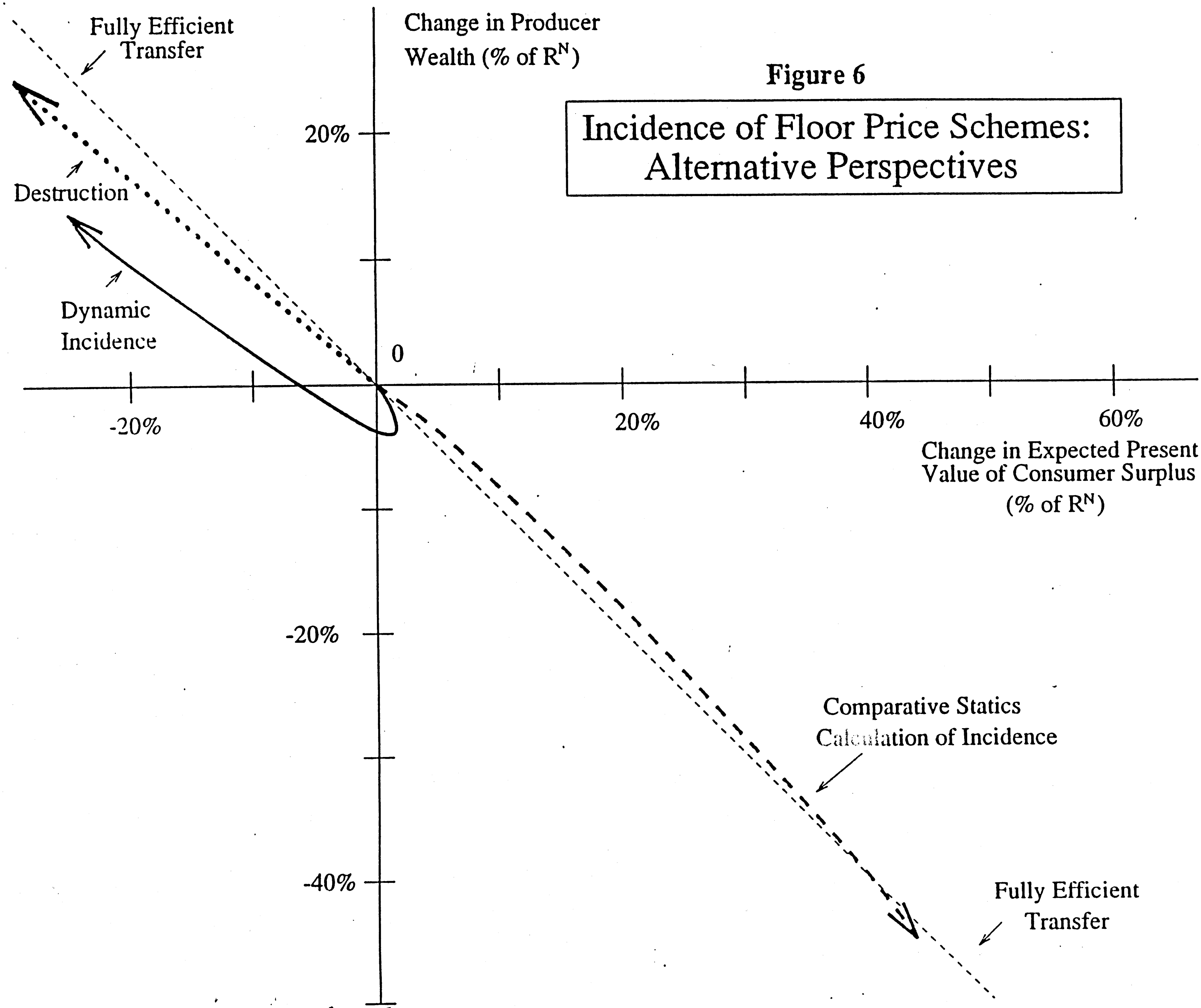


Figure 7

Expected Effects of a Price Floor: Initial Price High

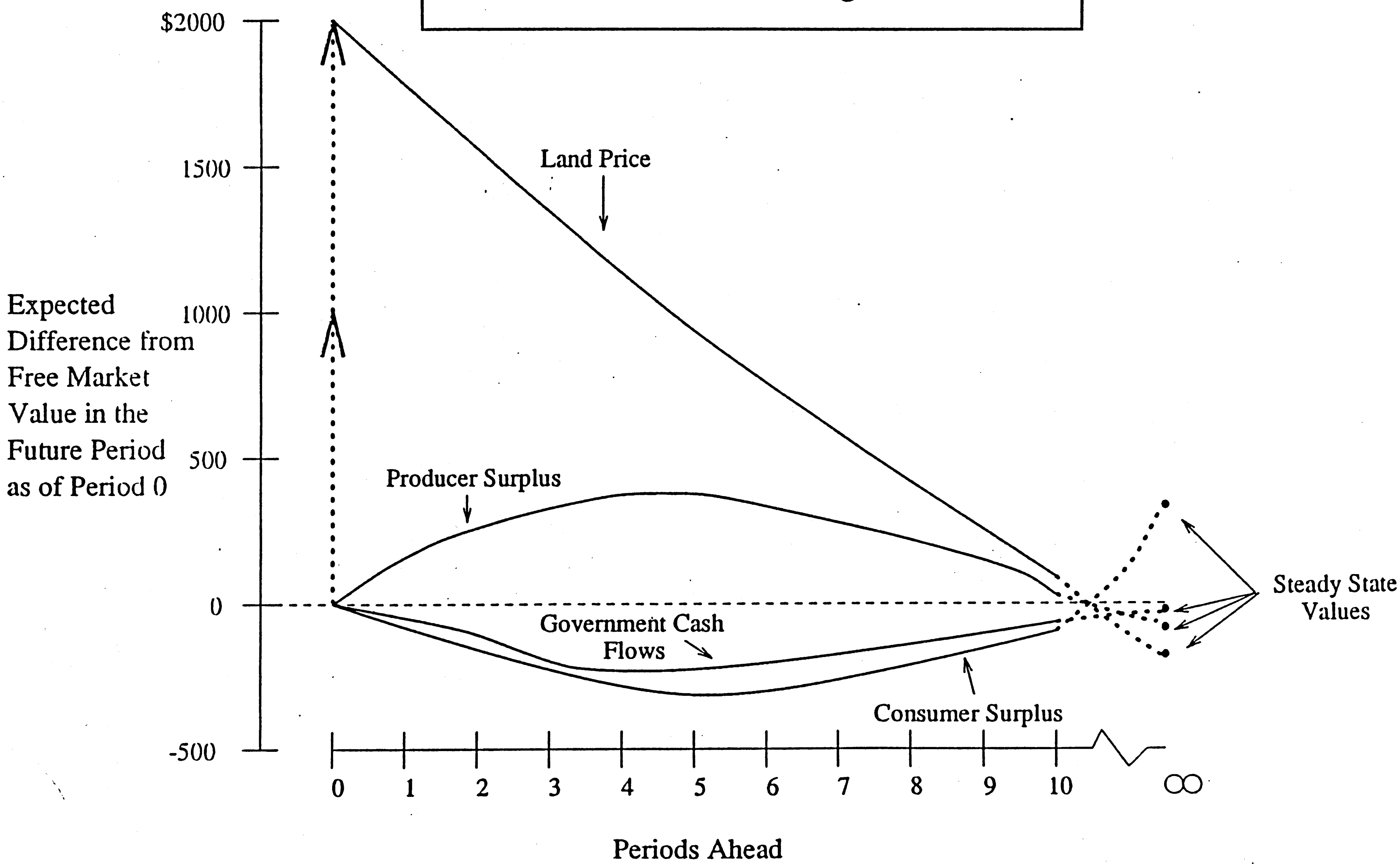


Figure 8

Incidence of Land Rent Subsidy with Interest Rate Constant at 1.00 per Generation

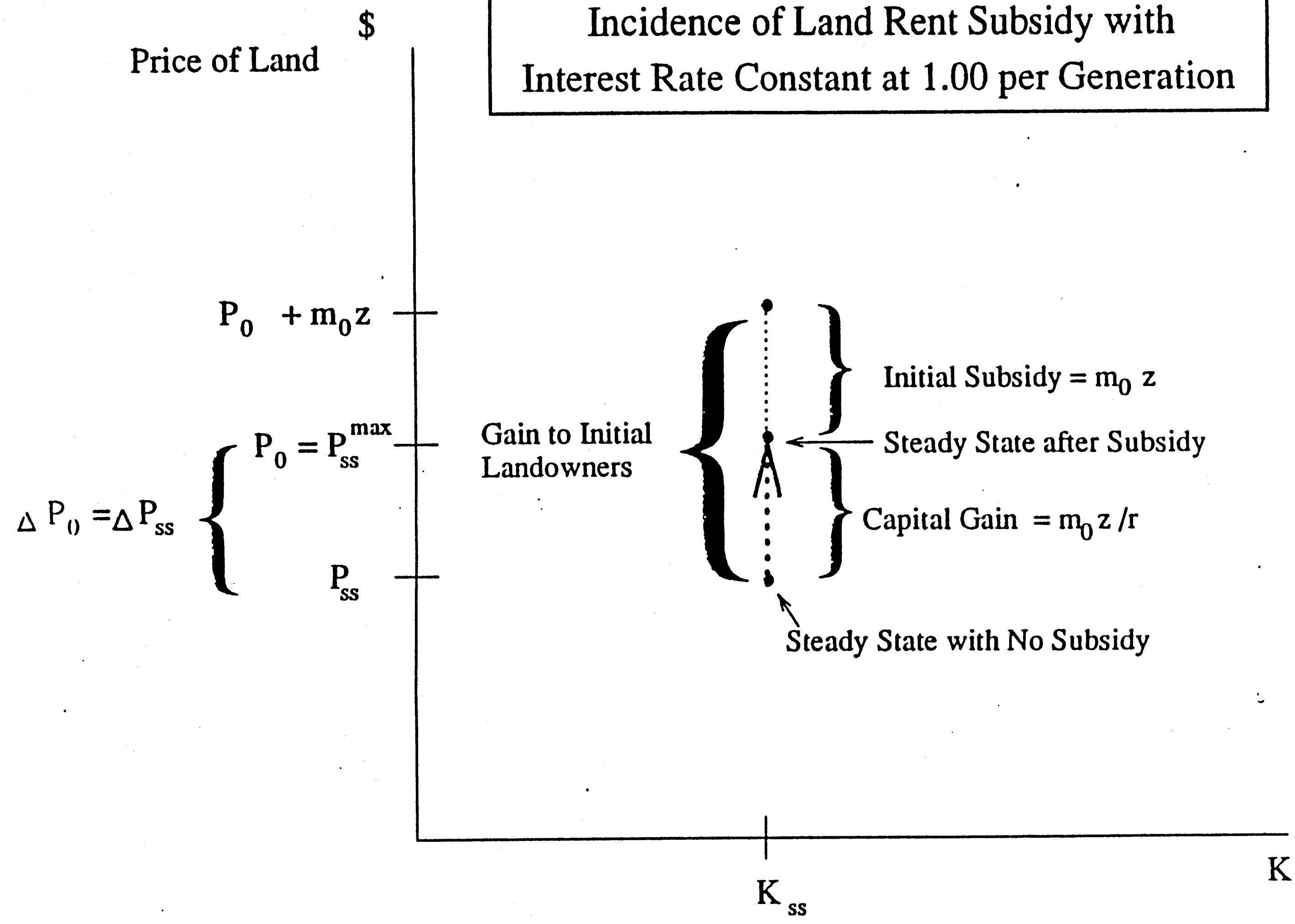


Figure 9

Incidence of Land Rent Subsidy with Crowding Out (low elasticity of supply savings)