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Aggressive Greenhouse Gas Policies: How They Could Spur Economic Growth

Mark R. Greer

Recent years have witnessed increasing concern about the environmental dangers posed by global warming. The buildup of atmospheric carbon dioxide and other greenhouse gases raises the possibility of climate change, including a change in the general circulation of the atmosphere and shifts in precipitation patterns. The environmental consequences of greenhouse gases are as yet uncertain, but they are a cause for concern.[1] Alarm about economic stagnation and unemployment has also gripped the public, as the major Western industrialized economies appear to have entered a period of stagnant growth. Many would undoubtedly agree that these two dangers, one environmental and the other economic, rank among the most important issues we face today.

It is important to understand what effect solutions to the environmental problem may have on the economic problem. Analysis of the economic impact of reducing greenhouse gas emissions has been dominated by neoclassical economics, which claims that any efforts to reduce them will come at the cost of foregone economic output [e.g., Manne and Richels 1990; Nordhaus 1991]. For example, Manne and Richels [1990, 68] state that it would cost the United States $3.6 trillion (discounted present value) to maintain its carbon dioxide emissions at 90 percent of their 1990 level through the year 2100. Claims such as these, coming as they do from professional economists, tend to undermine the political will to reduce greenhouse gas emissions, especially at a time when concerns about employment are foremost on people's minds.

The purpose of this essay is neither to criticize neoclassical analyses of reducing greenhouse gas emissions nor to question the assumptions upon which these analyses

The author is Assistant Professor of Economics, Dowling College. *He gratefully acknowledges the comments of the anonymous referees. Any errors and omissions are his own.*

are based.[2] Rather, this essay applies an alternative economic framework, that of Keynesian theory, to this public policy issue. Focusing on investment, this essay will demonstrate that, according to Keynesian theory, greenhouse gases can be reduced without adversely impacting economic growth. Once this point has been argued, the essay will examine a possible supply-side objection to the phasing out of fossil fuels, after which a counterargument to this objection will be made.

The essay will then demonstrate that Keynesian theory suffers a shortcoming in that it disregards how product and process innovation are associated with investment. Recognizing that product and process innovation are an integral aspect of economic growth but retaining the Keynesian insight into the relationship between investment and aggregate demand allows one to discern that reducing greenhouse gas emissions would likely stimulate economic growth and employment. The linchpin of this argument, to be presented at the end of the essay, is that reducing greenhouse gas emissions would stimulate investment in alternative energy technologies as firms strive to adopt these new technologies. This increase in investment would in turn stimulate aggregate demand and boost economic growth. Hopefully, by introducing alternatives to the neoclassical approach, this essay will help to engender the "paradigmatic pluralism" that Soderbaum [1990, 482, 486-7] calls for.

In order to keep a manageable focus, this essay examines just one facet of an overall strategy of reducing greenhouse gases: reducing the use of fossil fuels through gradually phased in excise taxes on their production. To be sure, other greenhouse gases, such as methane, pose potential environmental problems. However, since the burning of fossil fuels is the most significant potential cause of global warming [Ogawa 1991, 24], reducing society's use of fossil fuels would be the central component of any policy to alleviate the risk of global warming.

A Keynesian Analysis of the Effect of Phasing Out Fossil Fuels on Economic Growth

The point of departure for the forthcoming analysis is that firms' investment decisions are driven by their expectations of the future, especially their expectations of future demand for their products. The prospective character of the investment decision finds its expression in the Keynesian idea of the marginal efficiency of capital, wherein the future profitability of an investment project under consideration is paramount [Keynes 1964, chap. 11]. Of course, one of the primary determinants of the future profitability of an investment, and thus of whether the investment will be made, is the future extent of demand for the firm's product: the greater is the demand for the firm's product, the greater are the firm's capacity utilization rate and profit rate on the investment, at least up to the point of full utilization of capacity [Levine 1981, 93; Steindl 1952, 110-111].[3] Thus, if one were to assess the impact of imposing excise taxes on fossil fuels, one of the first places one would look is the

effect of such a policy on demand for firms' products. To the extent that this policy diminishes demand, it chokes off investment and growth, while to the extent that it stimulates demand, it promotes investment and growth.

Now, an excise tax on fossil fuels, like virtually every other tax, reduces aggregate demand. Therefore, imposing an excise tax on fossil fuels would lead firms to cut back on investment in new productive capacity as they perceive demand for their products falling. Analyzed from a Keynesian perspective, imposing an excise tax on fossil fuels would reduce economic growth. However, this stifling of economic growth could be avoided if the government automatically spent its excise tax collections. Or, if a conservative political environment precludes such a "tax and spend" policy, the adverse effect of the tax could be countered through an offsetting income tax cut, one ideally aimed at people of modest means who tend to spend, rather than save, any tax cut they receive. In this case, the combined policy of imposing an excise tax on fossil fuels and cutting income taxes for low income households would have a negligible effect on aggregate demand. From this point on, this analysis assumes that all excise taxes on fossil fuels are accompanied by an equivalent income tax reduction for low income households.

Additional complexities manifest themselves when one considers how an excise tax on fossil fuels raises firms' costs and how this cost increase, in turn, alters the distribution of income between wages and profits. As Kalecki [1971, 43-62] has demonstrated, the share of profits in national income (i.e., the ratio of total profits to national income) varies positively with the ratio of firms' unit non-labor production costs to their unit labor production costs. Consequently, as firms' ratios of non-labor production costs to labor costs per unit of output increase, the percentage of an economy's income going to profits increases. This happens because, as non-labor production costs increase, output prices rise as firms apply a constant percentage markup to their now increasing prime costs. Increasing product prices, combined with a constant nominal wage rate, shift income distribution from wages to profits. Since an excise tax on fossil fuels would raise firms' non-labor production costs but have no effect on their labor production costs, it would raise the ratio of non-labor production costs to labor production costs, thereby shifting the distribution of income toward profits.[4]

Now, properly conceptualized, profits are a form of saving, not spending; there is no reason whatsoever that a firm's profits are necessarily spent since the determinants of current profits and current investment are largely disjoint [Levine 1981, 90].[5] Since wages are spent and profits are saved, when the profit share of income rises, so does saving as a share of income.[6] In effect, an increase in the profit share of income boosts the overall propensity to save out of income, which chokes off aggregate demand and thus reduces investment, as Foster [1990, 417] has noted.[7] Since excise taxes on fossil fuels shift the distribution of income from wages to profits, they reduce total spending and thus exert downward pressure on economic

growth. This would happen even if the excise tax collections were offset by a low income tax cut. Moreover, since taxes on businesses' prime costs reduce the income multiplier [Laramie 1991, 592], an excise tax on fossil fuels, in so far as it amounts to a tax on firms' prime costs, would reduce the income multiplier and thus diminish aggregate income, aggregate demand, and investment.

The adverse distributional consequences of imposing an excise tax on fossil fuels would call for the enactment of redistributional tax policies to offset the shift of income from wages to profits and the resulting decline in aggregate expenditure. In addition to earmarking the excise tax collections for a low income tax cut, deliberate tax changes that shift the tax burden away from wages and toward profits would be desirable.[8] If an increase in the excise tax on fossil fuels is accompanied by a low income tax cut of equivalent magnitude and some redistribution of income from profits to wages through the income tax code, then this policy need not diminish aggregate demand or harm economic growth.

Before proceeding, it is worth examining the ramifications of this policy on international trade. To be sure, to the extent that other countries fail to raise their excise taxes on fossil fuels in lockstep with the United States, the competitive position of U.S. firms would decline, the U.S. trade balance would deteriorate, and aggregate demand and economic growth would suffer.[9] At the same time, one must also bear in mind that approximately one half of the United States' petroleum consumption is imported. Therefore, to the extent that this policy reduces the United States' reliance on imported oil, total imports would tend to diminish, resulting in an expansion of demand for domestic firms' products and a stimulus to growth. Moreover, as Porter [1990, 647-649] has noted, stringent environmental regulations can open up export markets for products impacted by such regulations. If the United States were to take the lead in phasing out fossil fuels, it could become a world leader in the manufacture and export of alternative energy technologies (a subject to be pursued later in this paper) once the rest of the world is eventually forced to move away from fossil fuels due to their exhaustion. Vice President Al Gore [1992, 194] reports that Japan is already implementing a strategy to manufacture and export environmentally friendly technologies.

A Possible Supply-Side Objection and Rejoinder

As already acknowledged, imposing an excise tax on fossil fuels would raise firms' production costs. This cost increase might lead one to mistakenly conclude that the tax would reduce profits and harm economic growth. In a moment, it will become evident why such a squeeze on profits and growth is unlikely to occur. Nevertheless, many people appear to be under the illusion that policies that raise firms' costs inevitably harm economic growth. This pernicious misconception stems from a supply-side economic way of thinking that has put much of the public and

many elected officials under its spell.[10] Since supply-side economic doctrine is perhaps the primary mental obstacle to garnering support for aggressive policies to eliminate greenhouse gases, a few paragraphs will now be spent examining how supply-side thinking would evaluate phasing out fossil fuels and critiquing this evaluation from a Keynesian perspective.

Supply-side economics is a saving centered theory of growth that posits that an increase in savings leads to an increase in investment [Dugger 1984, 800]. Business profits are the primary form of saving in a capitalist economy. By definition, a firm's profits are its revenues minus its costs of production. Therefore, anything that raises a firm's production costs also reduces its profits. Imposing excise taxes on fossil fuels would thus reduce firms' profits, or so it might seem at first glance. Now assume that the current level of profits in the economy is the primary determinant of the current level of investment.[11] This assumption might seem plausible on the grounds that current profits are used to finance investment in new capital. Excise taxes on fossil fuels, by raising firms' costs and squeezing their profits, would thus choke off investment, thereby undermining economic growth. This supply-side argument is deceptively simple, but it is actually more problematic than it may first appear.

One shortcoming of supply-side analysis is that it does not grasp the forward looking character of investment. Viewing investment as the automatic plowing back of profits into new capital is not altogether consistent with the *capitalistic* nature of investment. Investment is always an *advance* of money, and the rationale for investing wealth is to acquire additional wealth (profit) in the future. Investment is inherently prospective in character. Therefore, a superior conceptualization of the firm's investment decision would recognize that it is not the current, but rather the *expected, future* profit rate that has a crucial bearing on the firm's investment decision, as the Keynesian concept of the marginal efficiency of capital informs us. A firm will not invest in additional capital equipment unless it expects to turn a profit from it in the future, regardless of its current level of profits. Even if a firm's current profit rate were quite high, its investment in new capital would be zero if the expected profit rate on the new capital were negative. Therefore, firms' expected, future rates of profit on currently undertaken investments are more important than their current rates of profit in the determination of investment. This point has important implications for how we should view the impact of phasing out fossil fuels on economic growth and will be developed further.

Fixed capital also poses a problem for the supply-side argument against phasing out fossil fuels. As previously mentioned, the firm's profit rate on an investment in fixed capital varies positively with the rate of utilization of that fixed capital, at least up to the point of full utilization of capacity. Since the future profitability of a currently undertaken investment in fixed capital depends on how fully utilized that fixed capital will be in the future, the firm will not invest in more productive capac-

ity than it believes the market for its product will absorb [Levine 1981, 107-108]. Ideally, the firm would want to invest in such a way that the market for its product is just sufficient to absorb 100 percent of its productive capacity, for if the firm ends up investing in more fixed capital than it can fully utilize, then its profit rate will diminish. The market, then, acts as a real limit to economic growth: each firm invests in just as much productive capacity as it expects future demand for its product to absorb and no more. This Keynesian principle is the idea of the "market limit to growth" [Levine 1981, 130-134].[12] If firms expect a great deal of future demand for their products, they will invest in much productive capacity now, but if little demand is expected to be forthcoming, investment will dwindle. Through fixed capital, firms' perceptions of the future determine the present level of investment [Keynes 1964, 146].

The determinants of investment now appear to be quite a bit different than assumed in supply-side thinking. The *expected, future* profit rate on an investment the firm is currently contemplating undertaking, not the *current* profit rate accruing to investments to which the firm has committed itself in the past, determines whether the firm will undertake the contemplated investment. If the investment is not expected to be profitable, it will not be undertaken, regardless of how high or low the firm's current profit rate is. Furthermore, the expected, future extent of demand for the firm's product governs whether the investment project is expected to be profitable and, if so, how much productive capacity the firm should build as part of that project. It appears that economic growth has little to do with the current profit rate.

A supply-side critic might now retort that the current profit rate sets an upper limit to the rate of economic growth because profits provide the financing for investment. Consequently, if profits were squeezed by increasing energy costs, then investment would fall because funds available for financing it would dwindle. While there is a grain of truth to this point, there are two responses one could make to this criticism, one Schumpeterian and the other Keynesian. As Schumpeter [1983, 72-74] and, more recently, Arestis and Eichner [1988, 1004-1005] and Wray [1988] have demonstrated, bank credit does much to sever the financial dependence of investment on current profits. Through the creation of credit, the banking system allows current investment to exceed current profits: bank lending finances any excess of investment over profits. Furthermore, as Keynesians like Kalecki [1969, 45-47], Robinson [1962, 22-78], Steindl [1952, 237], and, more recently, Kregel [1986], Davidson [1986], Terzi [1986-87], Foster [1990], and Wray [1991] have shown, investment is self-financing anyway. If investment spending rises, then so do incomes (by a multiple of the increase in investment spending), aggregate demand, and firms' capacity utilization rates. This increase in incomes and utilization rates raises total profits up to an amount equal to the new level of investment spending.[13] Investment determines profits, not the other way around. This is the exact reversal of

the direction of causation in supply-side theory, so the supply-side critique of phasing out fossil fuels is undermined.

Why Phasing Out Fossil Fuels Could Increase Economic Growth

Keynesian economics informs us that eliminating society's dependence on fossil fuels need not adversely impact economic growth and employment. The remainder of this essay argues that reducing society's usage of fossil fuels may actually stimulate economic growth. This argument will be constructed in two stages. First, the Keynesian theory of growth will be criticized on the grounds that it overlooks an important dimension of capitalist growth: technological dynamism brought about through the competition of capitals in the form of the innovation and development of new production processes and new products. Since one way firms compete is by bringing new products to market or by innovating new production processes, and since such competition entails investment in producing structures for new products and new techniques, phasing out fossil fuels may stimulate economic growth. The crux of this step of the argument will be that excise taxes on fossil fuels will stimulate competitive product and process innovation and development of alternative energy technologies. Since firms must invest in order to engage in such innovation and development, phasing out fossil fuels may easily boost investment and growth.

In Keynesian theory, firms compete only on the basis of price. For example, according to Kalecki [1969, 11-27], competitive conditions within an industry are important only because they influence how much firms mark up price above production costs. In Steindl's version of Keynesian growth theory, "progressive" firms in competitive industries compete through cutthroat price competition whereas oligopolists in uncompetitive industries refrain from competing altogether since their financial resiliency prevents them from driving each other into bankruptcy [Steindl 1952, 1-55]. The salient feature of Steindl's view of competition is that competition is limited to price competition. Except for a brief discussion of some beneficial consequences of individualism in the closing chapter of the *General Theory*, Keynes's conception of macroeconomic processes is largely devoid of a theory of competition.

The predisposition of Keynesian theory to ignore competition over market share through process and product innovation and development reflects an underlying assumption that capitalist growth is largely devoid of structural change or qualitative economic development brought about through the competition of capitals.[14] If firms do not innovate new technologies or bring new products to market, then the economy ends up producing the same goods (just more of them), using the same production technologies, year after year. Keynesian theory regards growth as the quantitative expansion of a qualitatively unchanging economy.

The Keynesian position that the accumulation process is devoid of structural development is flawed. One insight of institutionalist economics is that progressive, cumulative development inherently characterizes technology [Ayres 1944, chaps. 6-7; Lower 1987]. Technology cannot stand still; indeed, it advances at an accelerating pace throughout history. The inherent dynamism of technology derives from the "tool combination" principle, which entails that accretions to society's accumulated body of technical knowledge occur when existing embodiments of current technology, i.e., tools, machinery, synthetic chemicals, etc., are recombined in novel ways. The farther advanced is a culture's technology, the greater is the variety of technical instruments it uses in production, and, therefore, the greater is the number of distinct new tool combinations that can be synthesized. Hence, technology progresses at an accelerating rate.[15]

Now, when thinking of technological development, one must distinguish between invention, which is the creation of a new tool-skill combination, and innovation, which is the adoption of a new tool-skill combination within the economy [Dugger 1984, 812]. The inventive process occurs basically independently of capitalist economic institutions; capitalism as compared to alternative economic systems is not particularly conducive to invention, as many institutionalists have established [e.g., Ayres 1944, 177-188; James 1987]. Indeed, the preponderance of research and development geared toward new products and processes takes place within the government and nonprofit sectors, not within firms [Dugger 1984, 814]. In a capitalist economy, the process of innovation follows that of invention, as firms innovate what inventors invent [Dugger 1984, 814]. Of course, the process of innovation is guided by entirely capitalistic concerns in that firms innovate only those products and processes they deem to be conducive to their growth. Whereas the process of invention is essentially unaffected by capitalistic social arrangements, capitalism steers innovation down a particular path: that dictated by the goal of profitability and the expansion of firms.

Invention and innovation have important ramifications for how the capitalist growth process should be conceptualized. With the continuous invention of new products and processes, and the innovation of a select subset of these new products and processes, structural change accompanies economic growth, as new items of consumption are integrated into people's consumption patterns and as new methods of production are integrated into firms' production processes. Moreover, since innovation is one facet of firms' competitive efforts to appropriate market share from each other, structural change inherently permeates the process of growth. Therefore, Keynesian theory, by abstracting from product innovation and development, overlooks an essential characteristic of capitalist economy.

In order to overcome this shortcoming within Keynesian economics, the concept of the competition of capitals through product and process innovation and development should be integrated into the Keynesian theory of market limited growth.[16]

One must recognize that firms (except for firms in "mature" industries to be described later) incessantly strive to appropriate market share from each other through product and process innovation and development.[17] By innovating a new product that better suits its buyers' needs, or by developing an existing product such that its buyers find the product more desirable, the firm can increase its market share beyond its present level and grow more rapidly. By adopting a production technique that reduces its direct or overhead costs, the firm can reduce the price of its product, which also expands its market. And if the firm does not engage in product and process innovation and development, it will lose market share to rivals who do. The competition of firms through product and process innovation contributes to (but is certainly not the sole cause of) the rapid development of people's patterns of consumption and technological change under capitalism.

Competition through process and product innovation and development requires investment. In order to actually implement a new technology, or bring a new product to market, the firm must invest in the appropriate producing and marketing structure because new technologies and the means for producing and marketing new products are embodied in new capital equipment and marketing networks. The Keynesian market limit to growth remains operative when investment is conceptualized as a competitive act: the firm will not invest in more productive capacity than it expects the future market for its product to absorb. But it is not the firm's *current* growth rate of demand for its product that governs how much capacity the firm invests in; rather, it is its *expected, future* growth rate of demand, which, in the context of competitive product and process innovation and development, can now differ quite markedly from its current growth rate. When a firm can increase its market share through innovative and developmental effort (or lose market share due to rivals engaging in these activities more vigorously than it does), the firm has no reason to believe that the future growth rate of demand for its product will equal its present growth rate. Expectations are all the more important in a world where firms compete through process and product innovation and development than in a world where they do not, since the firm's future economic environment may differ substantively from its present environment.[18]

If capital accumulation is a developmental process, and opportunities firms perceive for capturing or maintaining market share through product innovation and development influence their investment decisions, then insight into the structural determinants of economic growth can be derived by categorizing industries into three sectors: the sector of innovating industries, the sector of developing industries and the sector of mature industries.[19] The sector of innovation consists of those firms that are bringing new products to market. Since these products have never been produced and marketed before, investments undertaken in this sector are quite risky, although the potential profits from a successful innovation are significant. Firms in this sector have not yet established extensive markets for their products, so

current profits in this sector are small. However, since firms in this sector must invest in productive capacity in order to bring their newly innovated goods to market, investment in this sector is much larger than current profits. Since investment (which is a form of spending) exceeds profits (i.e., saving) in the sector of innovation, this sector provides a net demand stimulus to the economy. By stimulating demand in the economy, this sector promotes investment in other sectors as well. Contemporary examples of industries in the sector of innovation are the biotechnology industry and certain segments of the semiconductor industry.

The sector of development comprises firms that are producing products and services that have previously been innovated and are advanced in their product life cycles, but not so advanced that opportunities for further profitable product development have been exhausted. Firms in this sector compete on the basis of product development, and since markets for these products have been established (and are growing), positive profits may exist in this sector. However, since vigorous competitive product development takes place in this sector, firms' rates of investment are high, and investment exceeds profits in this sector. Thus, this sector also provides a net demand stimulus to the economy. The sector of development often incorporates innovations emerging from the sector of innovation, as the pharmaceuticals and telecommunications industries (two industries that appear to belong to the sector of development)[20] capitalize on innovations emerging from the biotechnology and semiconductor industries, respectively.

The mature sector of the economy consists of industries wherein opportunities for further product development have been largely exhausted. This sector is characterized by a lack of substantive product development, and, consequently, rates of investment, relative to profits, in this sector tend to be quite low. Industries in this sector generally do not exhibit substantive product innovation, since the products they produce have already been around for a considerable time. Of course, with relatively little product innovation and development occurring here, firms in mature industries refrain from engaging in substantial investment and do little to stimulate aggregate demand, or at least they do not do so commensurably to their size.[21]

It is of considerable relevance to the argument being made here that fossil fuels industries exhibit the characteristics of a sector of maturity. Indicative of the maturity of these industries, in constant cost terms, the net stock of fixed private capital actually *decreased* by 22 percent, 16 percent and 10 percent in coal mining, oil and gas extraction, and petroleum and coal products, respectively, from 1982 to 1988.[22] A recent study of corporate research and development (R&D) spending published in *Business Week* [June 27, 1994, 78-100] points to a dearth of product innovation and development occurring within the fossil fuels industries. Whereas all U.S. industries spent, on average, 3.8 percent of sales and 64.1 percent of profits on R&D, the fuels sector spent 0.8 percent of sales and 12.0 percent of profits on such activity. The oil, gas and coal group within this sector devoted only 0.6 percent of sales and 9.0

percent of profits to R&D. This group devoted a smaller fraction of sales to R&D than any of the other 38 sectors and industry groups studied, except the steel industry group, which tied oil, gas and coal for the distinction of having the lowest percent of sales devoted to R&D. If these R&D statistics are any measure of product innovation and development, then there is sound reason to believe that the fossil fuels industries constitute a mature sector.

A rapidly growing capitalist economy will have a large sector of development, with a sector of innovation whose new products complement those produced in the sector of development [Levine 1981, 232]. Complementarity between the products emerging from the innovative sector and the sector of development stimulates competitive investment in the latter. For instance, new computer chips stimulate investment in the computer industry, as computer firms attempt to incorporate the latest semiconductor technology into their products. If such complementarity did not exist, investment in the sector of development would be much lower. Ideally, products coming out of the sectors of innovation and development should not replace those being produced in the mature sector, for in this way, whatever investment occurring in the mature sector will be maintained. If new and developing products replaced mature products in people's modes of consumption and firms' methods of production, then firms in the mature sector would cut back on investment. For example, to the degree that personal computers and word processing software are displacing typewriters, investment in the typewriter industry is reduced by ongoing development in the computer industry.

With this concept of the sectoral character of the growth process in mind, one can discern that a governmentally imposed gradual elimination of fossil fuels would stimulate the emergence of a sector of development centered around the development and refinement of alternative energy technologies. In addition, phasing out fossil fuels would foster the creation of a sector of innovation, from which currently unused energy technologies would emerge. Also, this policy should stimulate innovation in the area of fossil fuel conservation. These consequences of reducing society's dependence on fossil fuels would stimulate investment, growth and employment. It needs to be noted, though, that investment in certain mature industries threatened by the emergence of alternative energy technologies, e.g., the coal industry, would diminish. However, since these industries are mature, they have low investment relative to profits; therefore, their loss would not entirely offset the stimulative effect of a new sector of development surrounding new energy technologies.

Using fossil fuels would clearly become more costly as excise taxes were imposed on them. This would stimulate a need for alternative energy technologies, as firms witness the energy component of their costs rising and as households watch more of their income being used for fossil fuels. This change in households' and firms' needs would open up profitable opportunities in rapidly growing markets for

those firms that innovate new energy technologies or that develop existing alternative energy technologies in a way that caters to these new needs. It would do the same for firms that innovate and develop fossil fuel saving technologies. For example, any firm(s) that developed a battery technology and electric motor that make an electric automobile as useful as a gasoline powered one would find a vast market of households and firms willing to pay a considerable price for the car. Firms innovating and developing wind power, solar power, geothermal power, and hydrogen power would find similar markets waiting for them. With the price of fossil fuels currently quite low, such investment opportunities do not exist.

Investment in the alternative energy sector would inevitably rise under this scenario. First of all, energy technologies that are now uneconomical for households and firms to use would become economical, given that the price of the next best alternative, i.e., fossil fuels, would have risen. Thus, due to the growing demand for alternative energy technologies, many of these technologies would become profitable to supply, leading to investment in these industries.[23] Furthermore, and much more importantly, the developmental potential of alternative energy technologies is largely untapped, since firms have not yet found it profitable to develop these technologies in the context of inexpensive fossil fuels. This means that the alternative energy industries have the technological properties of a sector of development. They produce and sell a product whose potential for further technological development remains largely unrealized. Therefore, if society could get markets for alternative energy technologies to expand (which would happen if substantial excise taxes were imposed on fossil fuels), firms in this sector would have a tremendous incentive to develop their products for competitive reasons outlined earlier. And product development requires investment not only to produce new energy technologies, but to integrate them into people's patterns of consumption and firms' methods of production, i.e., market them, as well. Therefore, by bringing into existence a sector of development centered around alternative energy technologies, phasing out fossil fuels would help to stimulate rapid economic growth.

The innovation and development stimulated by excise taxes on fossil fuels should be expected to appear initially in the form of new processes instead of new products. As Thurow [1992, 45-47] has documented, advances in reverse engineering have entailed that firms can quickly copy new products. Consequently, excise taxes on fossil fuels should lead to more intensive efforts at process innovation than they do efforts at product innovation. One must bear in mind, however, that process innovation almost inevitably generates product innovation within the producers' goods industries, since new processes usually cannot be implemented without also using qualitatively new inputs and capital equipment.

In order to assess whether an increase in fossil fuel prices brought about through an excise tax on them would stimulate innovative activity, investment, and growth in the manner just described, it is worth examining the economic adjustment in the

United States to the energy price increases of the 1970s.[24] One of the most striking consequences of these energy price increases has been a decoupling of real GNP growth and energy consumption: whereas before the 1970s, economic output and energy consumption increased in lockstep, real GNP growth has since vastly outstripped growth in energy consumption [Goldemberg et al. 1988, 75]. For example, energy used in residential buildings decreased 18 percent per household, and industrial use of energy per dollar of real GNP declined 33 percent from 1973 to 1983 [Fulkerson and Carlsmith 1985, 112, 114]. For the purposes of this essay, the important question is, how did this reduction in the energy intensity of the U.S. economy come about?

For the most part, the energy conservation that occurred during the 1970s and 1980s was attained through "good housekeeping" and behavior changes, such as turning down thermostats, insulating pipes and controlling heating and cooling processes more carefully, rather than through technological innovation [Fulkerson and Carlsmith 1985, 113]. However, opportunities for further energy conservation through good housekeeping and behavior changes appear to be exhausted, and, thus, any additional significant reductions in the energy intensity of the U.S. economy will have to come about through innovation in energy technologies [Peck and Beggs 1986, 72]. Consequently, if imposing an excise tax on fossil fuels encourages their conservation, then such conservation should be expected to come about through technological innovation. Another consequence of the energy problems of the 1970s has been a profusion of inventive activity geared toward energy conservation [Goldemberg et al. 1988, 110-152]. In the past two decades, government laboratories and university researchers have created a large number of fossil fuel conserving and alternative energy technologies. As expected, most of this inventive activity took place in the government and nonprofit sectors.

Although recent strides in energy conservation have come about through means other than product and process innovation and development, the increase in energy prices during the 1970s did stimulate significant innovation in certain sectors. For example, in response to increasing oil and natural gas prices, firms in the residential heating industry innovated high efficiency oil and gas furnaces, high efficiency space heaters, and high efficiency gas-fired hot water heaters [Goldemberg et al. 1988, 112]. Major energy saving innovations in refrigeration technology have occurred also [Goldemberg et al. 1988, 112]. In the industrial sector, significant innovations occurred primarily in highly energy intensive industries, such as cement manufacturing, in which a dry process kiln that significantly reduces energy usage was introduced [Peck and Beggs 1986, 83-84]. Selling a homogeneous product, firms in the cement industry had a competitive imperative to keep their costs down in order to compete on the basis of price. The transportation sector has witnessed energy saving innovation, such as new aircraft and jet engine technologies, that significantly reduce jet fuel consumption [Goldemberg et al. 1988, 130-131]. It is not

known how much investment spending was undertaken to implement these innovations, although in the cement industry it was quite large.

What does the economic adjustment to the energy price increases of the 1970s tell us about the likely effect of a future excise tax on fossil fuels? One lesson we can draw from this experience is that increases in fossil fuel prices would spur innovation and the investment spending associated with it. Although behavior changes have been much more important in conserving energy up to now, future conservation of fossil fuels will have to come about through innovation since, as previously noted, opportunities for further energy conservation through behavior changes have been largely exhausted. Furthermore, all of the fossil fuels saving and alternative energy inventions generated over the past two decades will make the innovation and development of alternative energy technologies all the more feasible, for invention is the prelude to innovation. Many of the inventions necessary for a radical transformation of the energy technologies we employ are already in place. With the price of petroleum currently quite low and the prices of other fossil fuels fairly moderate in real terms, the movement of alternative energy and fossil fuel saving technologies from the laboratory to the production plans of firms (that is, from the stage of invention to that of innovation) is being stifled. A steep excise tax on fossil fuels would reverse this.

Recent history provides an example of how government policy stimulated (albeit unwittingly) a sector of development that acted as a catalyst, and then an engine, of economic growth. The semiconductor industry finds its origins in the military-industrial complex of the early cold war era [Borrus et al. 1983]. By granting cost-plus contracts that guaranteed a profit to suppliers of semiconductors and equipment incorporating semiconductors, the U.S. military give birth to a dynamic sector of innovation surrounding semiconductors. Once technological innovation within the semiconductor industry advanced sufficiently far, firms discovered ways of integrating semiconductors into consumer and capital goods, and consumer and business related markets for semiconductors began to emerge. Semiconductors and related industries then underwent a transformation from a sector of innovation to one of development. This sector eventually comprised several industries, including not only the semiconductor industry, but numerous spin-off industries whose products incorporate semiconductors, such as digital computers, video cameras, and numerically controlled machine tools, as well. It is hard to fathom just how much this sector has contributed to economic growth, not just in the United States but worldwide, in recent decades. The important point is that were it not for a government policy that created markets for semiconductors, this sector would have emerged at a much later date, or, conceivably, it may have never come into existence at all. A policy designed to reduce dependence on fossil fuels might have a similar long-term effect on the U.S. economy.

It is true that phasing out fossil fuels would eliminate a few large industries, such as the coal, natural gas and petroleum industries.[25] In effect, a form of capital destruction would occur within these industries as the technologies they are so closely allied with become obsolete. Now, certain forms of capital destruction can certainly lead to job losses and a diminution in economic growth, as, for example, when a major earthquake brings about the physical destruction of capital and infrastructure. The type of capital destruction entailed by the policy advocated here, though, is not the destruction of capital in a physical, job destroying sense, but rather the economic destruction of a mature, rather stagnant sector brought about by its displacement by a dynamic, job creating sector composed of alternative energy technologies producers. The ascendency of a sector of innovation and development over a mature sector can only contribute to economic growth, despite the hastening of the depreciation of capital in the mature sector, since sectors of innovation and development have much higher rates of investment than do mature sectors. Nevertheless, if significant excise taxes of fossil fuels are imposed abruptly, rather than somewhat gradually, the adjustment costs in terms of growth and employment could be substantial in the short run. Moreover, as England [1994, 757-764] has argued, a fairly rapid switch to alternative energy technologies poses two dangers: (1) society may prematurely lock into an energy technology that turns out in hindsight to be less desirable than other energy technologies, and (2) social practices and customs may not adjust rapidly enough to the new energy technologies. In order to avoid these adjustment costs, it is advisable to adopt a somewhat gradualist approach to levying these excise taxes so that the transition to other forms of energy technologies will be smooth. It is noteworthy that taking such an approach to phasing out certain ozone depleting chemicals has certainly not led to any disruptions of industry.

Notes

1. Nowotny [1989, 1075-1077] discusses the consequences of global warming in detail.
2. For a critique of the cost-benefit approach to resolving environmental problems, see Soderbaum [1987, 146-153] and Swaney [1987, 1767-1769].
3. The firm's profit rate rises with the degree of utilization of its fixed capital because total gross profits (total sales less total prime costs) rise with its capacity utilization rate. The firm's overhead costs do not change as the firm utilizes more of its capacity. Thus, the firm's net profits (gross profits less overhead costs) and profit rate increase as its degree of capacity utilization increases.

   Once capacity utilization comes close to 100 percent, prime costs per unit begin to rise. If this increase in prime costs cannot be passed along in the form of a higher price for the firm's product, then the firm's profits may begin to decrease.
4. The wage share of national income (w) is determined by the formula, $w=1/[1+(k-1)(j+1)]$, where j is the aggregate cost of materials to total wages and k is the aggregate ratio of sales proceeds to prime costs [Kalecki 1971, 62]. Reinterpreting j as the aggregate

cost of materials and energy to total wages, it follows that the wage share of national income falls (and thus the profit share of national income rises) when energy costs rise.

5. The firm's current profit rate is determined by investment projects it has undertaken in the past (e.g., how much productive capacity it decided to invest in some years ago), in conjunction with the current demand for its product: the higher is the firm's current utilization of capacity, the higher are its current profits. The firm's current investment, a form of spending, is governed by its expected, future demand for its product. The determinants of current profits are different from the determinants of current investment, so profits need not be automatically spent as investment.
6. For simplicity, the possibility of consumption out of profits is ignored.
7. Also, Sawyer [1985, 80] and Laramie [1991, 585] demonstrate that a reduction in the wage share of income reduces the income multiplier, thereby decreasing national income.
8. If tax increases on profit income are politically unfeasible, then a tax cut on wage income of sufficient magnitude could offset the distributional effect of the excise tax.
9. However, the experience of Japan and Germany, who impose stiff taxes on petroleum yet remain trade powerhouses, suggests that a country's competitive position in international trade is not strongly affected by taxes on energy.
10. For an elaboration on and critical assessment of supply-side economics, see Dugger [1984].
11. The classical and neo-Ricardian theories of growth, while not exactly variants of modern supply-side economics but savings centered theories of growth nevertheless, make this assumption. See, for example, Smith [1976, book 2, chap. 3] and Harris [1978, 104].
12. Smith [1976, book 1, chap. 3] also develops a concept of the limitation of growth by the market; however, the Smithian conception of this issue differs somewhat from the Keynesian in that the former considers how the extent to which laborers will specialize is limited by their access to markets.
13. Of course, the rise in profits would occur some time after the rise in investment. Thus, at least initially, an increase in investment would require an expansion of bank lending [Foster 1990, 418; Wray 1991, 961-962]. Investment spending remains self-financing because once profits rise in response to rising demand and capacity utilization rates, they can be used to pay off debts incurred to finance the initial increase in investment spending. Arestis and Eichner [1988] explore the affinities between the Post Keynesian and institutionalist views on money, credit, and investment.
14. The term "structural change" refers here to qualitative development of the economy over time, including changes in market structure brought about through the competitive efforts of firms, changes in technology, and the introduction and adoption of new products. In so far as Keynesian theory allows for changes in market structure (e.g., from competitive to oligopolistic) through time as a result of price competition, as in Steindl [1952, 40-52], structural change is present in Keynesian theory. However, by abstracting from competitive product and process innovation and development, which also leads to structural change, Keynesian theory overlooks what is perhaps the most important form of structural change.
15. Cultural contact, in which technological knowledge is transmitted from one culture to another, augments technological development [Ayres 1944, 118]. Since such cultural cross fertilization is extraneous to the argument presented here, it will not be pursued further.
16. Levine [1981] develops one such integration.
17. Schumpeter [1983, 74-94] asserts that entrepreneurship amounts to this.
18. In fact, it is not at all clear why expectations would even be important in an economy where no structural change, in the form of process and product innovation and development, occurred. In such a world, the future would be essentially the same as the present.
19. This categorization of industries and the following description of them are based largely on Levine [1981, 229-233].

20. In constant cost terms, the stock of fixed private capital in the telephone and telegraph industry increased by 20 percent from 1982 to 1988 [U.S. Department of Commerce 1990, 102], which is evidence that this is a sector of development.
21. As long as *some* investment takes place in mature industries, their presence stimulates aggregate demand.
22. See U.S. Department of Commerce [1990, 102].
23. To illustrate the magnitude of the investment that could arise from replacing power plants currently burning fossil fuels, but not to advocate nuclear energy as an alternative, it is worth mentioning that approximately $930 billion of spending would have to be undertaken in order to build nuclear power plants to replace ones that now burn fossil fuels [Nowotny 1989, 1078]. Such spending would do much to stimulate the economy.
24. Except for coal, all major sources of energy exhibited real increases in price during this period, with petroleum increasing in price the most.
25. It is highly questionable that the automobile industry would be threatened, for there is no reason why automobiles must burn fossil fuels in order to be automobiles. An electric automobile or a hydrogen powered one is still an automobile. If the U.S. automobile industry were forced to incorporate alternative energy technologies into their product, then this industry might even begin to take on the characteristics of an industry of development.

References

Arestis, Philip, and Alfred S. Eichner. "The Post-Keynesian and Institutionalist Theory of Money and Credit." *Journal of Economic Issues* 22 (1988): 1003-1021.

Ayres, Clarence E. *The Theory of Economic Progress*. Chapel Hill, N.C.: The University of North Carolina Press, 1944.

Borrus, Michael, James E. Millstein, and John Zysman. "Trade and Development in the Semiconductor Industry: Japanese Challenge and American Response." In *American Industry in International Competition*, edited by John Zysman and Laura Tyson. Ithaca, N.Y.: Cornell University Press, 1983.

Davidson, Paul. "Finance, Funding, Saving, and Investment." *Journal of Post Keynesian Economics* 9, no. 1 (Fall 1986).

Dugger, William M. "The Nature of Capital Accumulation and Technological Progress in the Modern Economy." *Journal of Economic Issues* 18, no. 3 (1984): 799-823.

England, Richard W. "Three Reasons for Investing Now in Fossil Fuel Conservation." *Journal of Economic Issues* 28, no. 3 (1994): 755-776.

Fulkerson, William, and Roger S. Carlsmith. "Energy Security and End Use: Efficiency and Fuel Switching." In *Improving U.S. Energy Security*, edited by Richard J. Gonzalez, Raymond W. Smilor, and Joel Darmstadter. Cambridge, Mass.: Ballinger Publishing Company, 1985.

Goldemberg, Jose, Thomas B. Johansson, Amulya K. N. Reddy, and Robert H. Williams. *Energy for a Sustainable World*. New York: John Wiley & Sons, 1988.

Gore, Al. *Earth in the Balance: Ecology and the Human Spirit*. Boston: Houghton Mifflin Co., 1992.

Harris, Donald J. *Capital Accumulation and Income Distribution*. Stanford, Calif.: Stanford University Press, 1978.

James, Dilmus D. "The Economics of Technological Progress: A Comparison of Non-Institutionalist and Institutionalist Dissent from the Neoclassical Position." *Journal of Economic Issues* 21, no. 2 (1987): 733-741.

Kalecki, Michal. *Theory of Economic Dynamics*. New York: Augustus M. Kelly, 1969.

_____. *Selected Essays on the Dynamics of the Capitalist Economy, 1933-1970*. Cambridge: Cambridge University Press, 1971.

Keynes, John Maynard. *The General Theory of Employment, Interest and Money*. New York: Harcourt Brace Jovanovich, 1964.

Kregel, J. A. "A Note on Finance, Liquidity, Saving, and Investment." *Journal of Post Keynesian Economics* 9, no. 1 (Fall 1986).

Laramie, Anthony J. "Taxation and Kalecki's Distribution Factors." *Journal of Post Keynesian Economics* 13, no. 4 (Summer 1991): 583-594.

Levine, David P. *Economic Theory*, vol. 1. London: Routledge and Kegan Paul, 1978..

_____. *Economic Theory*, vol. 2. London: Routledge and Kegan Paul, 1981.

Lower, Milton D. "The Concept of Technology within the Institutionalist Perspective." *Journal of Economic Issues* 21, no. 3 (1987): 1147-1176.

Manne, Alan S., and Richard G. Richels. "CO2 Emmission Limits: An Economic Cost Analysis for the U.S.A." *The Energy Journal* 11 (1990): 51-74.

Nordhaus, William D. "The Cost of Slowing Climate Change: A Survey." *The Energy Journal* 12 (1991): 37-65.

Nowotny, Kenneth. "The Greenhouse Effect and Energy Policy in the United States." *Journal of Economic Issues* 23 (1989): 1075-1084.

Ogawa, Yoshiki. "Economic Activity and the Greenhouse Effect." *The Energy Journal* 12 (1991): 23-35.

Peck, Merton J., and John J. Beggs. "Energy Conservation in American Industry." In *Energy Conservation: Successes and Failures,* edited by John C. Sawhill and Ricard Cotton. Washington, D.C.: The Brookings Institution, 1986.

Porter, Michael E. *The Competitive Advantage of Nations*. New York: The Free Press, 1990.

Robinson, Joan. *Essays in the Theory of Economic Growth*. London: Macmillan, 1962.

Sawyer, Malcolm C. *The Economics of Michal Kalecki*. Armonk, N.Y.: M.E. Sharpe, 1985.

Schumpeter, Joseph. *The Theory of Economic Development*, translated by Redvers Opie. New Brunswick, N.J.: Transaction Books, 1983.

Smith, Adam. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Chicago: The University of Chicago Press, 1976.

Soderbaum, Peter. "Environmental Management: A Non-Traditional Approach." *Journal of Economic Issues* 21 (1990): 139-165.

Steindl, Josef. *Maturity and Stagnation in American Capitalism*. New York: Monthly Review Press, 1952.

Swaney, James A. "Elements of a Neoinstitutional Environmental Economics." *Journal of Economic Issues* 21 (1987): 1739-1779.

Terzi, Andrea. "The Independence of Finance from Saving: A Flow of Funds Interpretation." *Journal of Post Keynesian Economics* 9, no. 2 (Winter 1986).

Thurow, Lester. *Head to Head: The Coming Economic Battle Among Japan, Europe and America.* New York: William Morrow and Company, Inc., 1992.

United States Department of Commerce. "Fixed Reproducible Tangible Wealth in the United States, 1982-89." *Survey of Current Business* 70, no. 9 (September, 1990): 99-106.

Wray, Larry Randall. "Profit Expectations and the Investment-Saving Relation." *Journal of Post Keynesian Economics* 11, no. 1 (Fall 1988): 131-147.

_____. "Saving, Profits and Speculation in Capitalist Economies." *Journal of Economic Issues* 25 (1991): 951-975.