INDUCED INNOVATION THEORY AND ASIA'S GREEN REVOLUTION: A REAPPRAISAL*

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INTRODUCTION

Induced innovation theory as presented principally by Ruttan, Hayami, Binswanger, and others has appropriately earned an important place as an economic theory of agricultural development. The theory has evolved to offer special insights on two key processes in agricultural development which economic theory has frequently found difficult: technological and institutional change. Although originally based on analyses of American and Japanese historical experience, for various reasons the theory acquired special power with reference to Asia during the last two decades, where complex processes of technological and institutional change popularly known as the green revolution unfolded. In several places, the course taken by the green revolution was significantly influenced by agricultural research, extension, and price policies recommended and justified by induced innovation theory. Why, how, for whom, and with what consequences the theory acquired this power are important issues--not least for our understanding of the green revolution and for the roles of economics and economists in complex processes of socioeconomic change.

There are at least three ways to consider the relationships between induced innovation theory and Asia's green revolution. Two of these ways

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are routine. The third arguably should be, but in practice has been considerably less common.

(1) The persuasiveness of induced innovation theory as an economic theory of technological and institutional change can be assessed. In addition to the usual criteria for evaluating any economic theory, three additional points requiring careful consideration are: (a) the adequacy of the theory's understanding of institutions and institutional change given characteristics of agrarian change in rural Asia; (b) the robustness of the theory's depiction of the induced innovation process, given characteristics of the varied political and social contexts in which the "laws" of the process are presumed to operate; and (c) the sufficiency of the theory's econometric justification.

(2) Induced innovation theory is a dynamic and evolving body of thought. As the theory has been adjusted, refined, and revised--against a background of ongoing technological and agrarian change in rural Asia, change frequently interpreted in ways strongly at variance with the theory's explanations--there are possibilities that the theory's fundamental internal consistency can be stressed. These possibilities can be tested.

(3) Induced innovation theory has been utilized in important ways by decision-makers influencing a range of agricultural policies. This fact of utilization yields at least two issues that can be assessed. First, how have the course and characteristics of utilization (and abandonment) of the theory related to the fundamental interests of those who now or once found the theory

especially useful, interests in particular in the autonomy of agricultural science and the maintenance of a related claim that agricultural science is fundamentally neutral? Second, how has utilization of the theory by important agents of the green revolution influenced the theory's evolution as an "explanation" of the green revolution?

This paper will address each of these broad reassessment strategies, but primary emphasis will be given to the third, the fact of utilization.

DISCUSSION

Induced Innovation Theory as Economic Theory

Detailed assessment of induced innovation theory as an economic theory of technological and institutional change in agriculture is an overdue agenda for consideration by economists. Three points contributing to that agenda can be made here. First, the theory has had difficulties with the concept of institutions, offering definitions that purport to encompass phenomena ranging from the contracts implicit in landlord-tenant sharing agreements to patterns of structural change as broad as the Chinese revolution. The shifting and sometimes unclear definitions of institutions and innovation results in considerable loss of precision in the power of the induced institutional innovation hypothesis. At the least, it is not self-evident that the focus on discontinuous processes of innovation (and adoption) occurring at a micro institutional scale (e.g. changes in water-sharing arrangements between two farmers on an irrigation canal) have any analogy when the institutional scale becomes societal (e.g. changes in social societal (e.g. changes in social stratification systems in conjunction with agricultural intensification).

The second point is that the robustness of the inducement metaphor is seriously stressed by social and political contexts that simply do not correspond to the market (and ceteris paribus) assumptions the metaphor carries. These points have been well substantiated by Castillo (1983) who makes a distinction between induced and seduced innovation in the Philippines (where induced innovation theory had especially strong influence) and Burmeister (1988), whose excellent research on Korea builds on the distinction between induced and directed innovation in the Korean agricultural research system. Too frequently, proponents of the theory appear ready to rationalize technological outcomes and institutional conditions, when a more balanced interest in understanding these processes might reveal limits to the generalizeability of the induced innovation metaphor. It should be noted that these problems are not unusual in strongly functionalist theories of socioeconomic change.

The third point is that despite the enormous volume of publications associated with the theory,

> econometric justification of the theory is mostly confined to the developed countries. Even within these countries, the assumed relationship between the land-labor ratio and the relative prices of these factors does not fit the historical data of Japan as well as it does those of the United States (Sundrum, 1987: 542).

Within Southeast Asia, the theory has received some econometric support from the Philippine case, but the Thai and Indonesian cases have not followed the theory's expectations as well. Unfortunately, concentration of the theory's econometric work on the Philippines has obscured interpretation of the significance of this variation for the theory. Ruttan has written:

> I do not always expect that the induced innovation hypothesis will hold. Indeed, the really interesting issues for social science theory are when the induced innovation theory is not successful in interpreting technical and/or institutional change (Ruttan, 1987).

This is certainly a partial answer, but the answer is more complete if it includes the implications of unsuccessful interpretation by induced innovation theory for the theory's status as an economic hypothesis.

Induced Innovation Theory as an Evolving Theory

The fact that the theory has evolved and periodically offers new positions is certainly not a basis for criticism. However, when this evolution fails to abandon old positions but continually adds new and sometimes contradictory positions the integrity of the theory itself can be at risk. This problem is closely related to the theory's imprecision, since imprecision has helped open the door to evolution that is uneven and ad hoc. For example, Binswanger (1987) insists on the importance of:

> the material determinants of technical change, or what I called fundamental biases in "Induced Innovation." These include the fact that the development of a short, fertilizer responsive variety of rice for South and South-East Asia was far more likely to succeed in 1960 than developing high yielding or stress resistant varieties for upland areas. Indeed, if IRRI [the International Rice Research Institute] had decided not to develop IR8, the Philippines, Indonesia or Indian research system would have come up with a similar variety within a few years. China, for example, developed virtually the same technology at about the same time, and the other countries could have borrowed from there if they had not by then already developed their own. Material determinants influence both what can be done and what cannot be done. If developing high yielding varieties for upland conditions had been an easy task, we would by now have seen a green revolution in upland rice.

That selected national agricultural research systems would have come up with varieties similar to IRRI if IRRI had not, hardly absolves IRRI from connections with any problems that may have resulted (which appears to be the brunt of the argument), especially if there was reasonable

foreknowledge that there would be problematic consequences, as in fact there was (Oasa, 1981) and continued to be. More to the point, what is the theory actually saying if "material determinants" become a residual category influencing "both what can be done and what cannot be done?" When do we know which? How do we know whether we are being presented with a reproducible conclusion or interesting insight? More troubling, how do we know when we are being presented with a theoretically based explanation (ex ante or ex post) or a theoretically related rationalization?

Induced Innovation Theory as Utilized Theory

Why was induced innovation theory widely accepted by agricultural research decision-makers and why is there now some evidence that they are reconsidering this support? This is a complex issue closely related to the strong belief within the agricultural research community that what it does is neutral; that it does not favor anyone in any consistent social, political, or economic sense (Levy, 1982; Tweeten, 1983). Two crucial claims follow:

(1) First, it is not responsible for negative consequences associated with adoption of its products, even if those consequences are systematically distributed.

(2) Second, because what it does is unbiased and non-political, it is inappropriate for agricultural research to be politically accountable.

The connection of induced innovation theory to these claims is close; indeed it is crucial for understanding the theory's evolution, successes, and problems.

> The ethos of neutrality in agricultural research apparently is not simply a perverse outcome of bureaucratic culture or a carefully transmitted delusion. During the last twenty-five years, as the role of science and technology in Third World agricultural development has been affirmed, an ethos of neutrality has co-evolved with an ideology of development, the theory of induced innovation, that supports the neutrality claim. The co-evolution is crucial because it suggests that an ideology of neutrality has influenced and, in turn, has been influenced by how agricultural research defines and assesses its mission, by how the mission is practised, and by how institutions outside the agricultural research system understand and assess their own relationships with the system (Koppel and Oasa, 1987: 34).

By suggesting that a theory about institutional change acts as an ideology for particular patterns of institutional change, it does not necessarily follow that induced innovation theory simply legitimizes specific patterns of technological and institutional change. What does follow is that there is a relation between the evolution of induced innovation theory and the performance of international agricultural research. Wuthnow (1985) argues that understanding an ideological movement, that is, a process which institutionalizes (and de-institutionalizes) an ideology, requires focusing on the question of who controls critically important social resources (such as the state or in this case the agricultural research system).

> Ideology requires social resources to be produced and maintained, it defines moral obligations which influence the distribution of social resources, and it becomes institutionalized in organizations, in professional roles, in collective rituals, and in relations with the state (Wuthnow, 1985: 815).

In 1977, the CGIAR (Consultative Group for International Agricultural Research), the donor consortium that supports the network of international centers, explicitly identified the induced innovation framework as the perspective practiced by the international centers.

> Although most of the present centres were functioning before that theory [induced innovation] was formally presented and verified from historical materials, it is precisely the reasoning that led to the creation of the older centers. Their founders believed that if more highly productive technologies were developed and made available, these technologies would stimulate leaders of national research and production programs to build up the other activities that would take full advantage of the new technologies (CGIAR, 1977: 18).

Koppel and Oasa (1987) use Wuthnow's perspective on ideology to examine the co-evolution of the practice of agricultural research at the International Rice Research Institute and induced innovation theory, which had a continuing base in the Economics Department at the Institute. The examination explores the ideological roles, in the sense just indicated, that induced innovation theory assumed for IRRI. Two points are especially crucial. One was the role induced innovation theory played in reassuring IRRI and the CGIAR that increasing documentation of problematic consequences of the green revolution were incorrect, biased, or even if correct, were not the responsibility of the international centers, but rather were the fault and responsibility of concerned national governments. The second was the theory's continuing insistence that technological and institutional change in rural Asia was not a political issue (since the new technologies offered constant returns to scale), but a matter of continuing and in a specific sense (appropriate factor bias) efficient economic adjustment. This was important, because increasingly social science research was pointing to issues of politics, power and social organization--not simply as consequences of technological change in Asian agriculture, but also as the context for technological change. While both sides saw technological change in some sense as an endogenous process, where the two sides differed was on how to evaluate the

significance of rural institutions for the course and outcomes of technological change.

> Binswanger and Ruttan (1978) argued that ultimately what was problematic about rural institutions was not the institutions as such, but rather the steps taken by governments to improve, modify or otherwise alter the evolution of rural institutional arrangements. The CGIAR echoed this position in an important attempt to walk a fine line between acknowledging broader rural institutional problems and maintaining the research system's claim of neutrality in relation to these problems. The CGIAR's Technical Advisory Committee (TAC) reported in 1979 that issues related to distribution of benefits from new technology needed more attention. While therefore calling for 'due account' of the processes which distributed benefits from new technology, the TAC warned that new technology alone cannot solve the problems the rural poor face. There were fundamental institutional issues involved. However, 'the benefits derived from international agricultural research by different social groups would very much depend on the conditions of the country concerned and are a matter of consideration by the individual governments in establishing their development plans and policies' [TAC, 1979: 11; also CGIAR, 1981]. In other words, if rural institutional arrangements were somehow skewing the benefits of new technology, it was not appropriate for the centers to accept any direct relationship between their mission and this problem. After all, the work of the centers was neutral (Koppel and Oasa, 1987: 48-49).

The implication that the centers were really not terribly influential was disingenuous at best. Consequently, debate arose (and continues) on appropriate relationships between the international centers and national agricultural research systems. This was a debate that held clear potential to limit the autonomy of the centers, to establish new forms of accountability and management, to influence what problems were worked on, and to impact the level and terms of financial support. What the Centers needed, and what induced innovation theory provided in its ideological role, was an affirmation that agricultural development could be depoliticized. Hence agricultural research could also be depoliticized.

> Here, then, was the primary ideological function of induced innovation theory: not to rationalize the claim of neutrality as a goal, but

> rather to institutionalize the autonomy (and hence the non-accountability to non-scientists) of the agricultural science establishment. The dependence of the international centers on external funding and, more subtly, on the performance of national research systems created a potentially fundamental incompleteness in the institutionalization of agricultural science represented by the CGIAR network. What the agricultural scientists wanted was support as an entitlement, not as a qualified dispensation (Koppel and Oasa, 1987: 50).

In the final chapter of Induced Innovation, Binswanger and Ruttan conclude:

> Our review of the green revolution experience and of the historical process of agricultural and rural development leads us to suggest that it is possible to distinguish between two broad paths of institutional change: one path weakens, another strengthens the control of the community, or of society, over the allocation of resources and over the partitioning of income streams (Binswanger and Ruttan, 1978: 410).

What follows are some singular conclusions. Military dictatorships and authoritarian politics in South and Southeast Asia are labelled as "experiments" in "attempting to evolve a system of political and economic organization that is capable of mobilizing the region's natural and human resources to achieve more rapid development" for peasants negatively affected by the rapid expansion of plantation agriculture. The Chinese revolution is characterized as an institutional innovation induced by a "long period of secular economic stagnation in China "(Binswanger and Ruttan, 1978: 410). Against the allegation increasingly well documented by the late 1970s that green revolution strategies encouraged more aggressive confirmation of land and water rights and significant extensions of the state's role in rural economic life, frequently to the detriment of the less politically and socially powerful, induced innovation offers two answers. First, the theory says the matter is not political, but rather part of a natural and efficient correlation of

economic and institutional development (through appropriately biased technical change). Unless politically distorted, the bias of agricultural research will also be appropriate since agricultural research is induced by the same broad correlations. Second, if growth or decline in a society's income induce institutional changes affecting the significance of property rights and the control society exercises over resource allocation and the partitioning of income flows, then since technical change is a primary engine for income growth, the implication is that technical change is also a primary engine for altering society's control over resource allocation.

At a strictly empirical level, it is troubling that the major developing country research site for the theory, the Philippines, where induced technological innovation did receive some econometric support, there is such poor empirical corroboration for induced institutional innovation. In part this is because the strongly micro perspective on technological change deferred attention from wider linkages between technological and institutional change than the theory happened to be expecting. To many it grew increasingly clear that technological change in Philippine agriculture (among other things) was inducing greater state involvement in resource allocation and the partitioning of income streams, a process that was unfolding all around IRRI, but was only noticed by the theory when state actions subsequently inhibited wider or more effective utilization of new technologies. However, empirical misfit or myopic perception are not even the point. The more important issue is the arguments offered.

> Are these really plausible as explanations? What do they actually explain? Why and how do they fundamentally trivialize the political significance of technological change?...The answer is that the theory is not playing the role of theory as the foundation of an experimental science--it is playing the role of an ideology that assigns all institutional change to the same category of significance. What is important is not the strength of the explanation or the credibility of the category, but rather what implicitly has been denied by the imperative of inducement--the accountability of political choice (Koppel and Oasa, 1987: 51-52).

Induced innovation theory is not simply a theory for economists to refine at their meetings. The theory has acquired and served an ideological role, guiding and interpreting the practice of international agricultural research and, in turn, being influenced by that same practice.

> In the garb of theory, induced innovation has been a Trojan horse, insinuating an ideology of political neutrality into what is fundamentally a political process--changing relationships of power within agrarian society. The theory...claims that political accountability would be redundant at best--the agricultural research system is already 'accountable' to fundamental economic 'laws' which ensure that what is done is what is needed. The theory assumes that political accountability would be 'biased,' distracting agricultural research from its appropriate objectives and distorting its performance. From the assertion of political neutrality, it is a very short path to the declaration that agricultural research, especially publicly supported agricultural research, cannot be 'publicly accountable for politically significant consequences (Koppel and Oasa, 1987: 58).

Recently, the theory's proponents have drawn away from these positions--with arguments made for everything from increased accountability of agricultural research in the United States to advocacy of land reform in the Philippines--but it is important to understand the difference between personal viewpoints and theoretical positions, however they may be presented.

It is also important to understand the consequences of the theory's highly selective and eclectic evolution. As the theory now finally comes under closer scrutiny, the inconsistencies become a bigger problem. Binswanger's answer to deal with the incidence of variable conclusions from the same premises, "material resources," is hardly falsifiable and lacks the precision to help. Ruttan grants that the "tests of the induced technical change hypothesis were much more rigorous than the tests of the induced institutional change hypothesis," (Ruttan, 1988: S247) but concludes that only when anthropology can more adequately

> "identify the sources and impact of cultural change..will it become feasible for anthropologists and economists to collaborate in incorporating the role of cultural endowments into economic development analysis and into institutional design and reform" (Ruttan, 1988: S265).

The conclusion is well-intended, but proceeds from an assumption that the pieces of the puzzle on the economic side are already in place thanks to the microeconomic verification of induced innovation theory. The assumption is debateable. Indicative of the problems that persist are these two rather different recent conclusions from two of the theory's principal proponents.

> There is no question that technology is a very powerful force in affecting the distribution of income. But from that it does not follow...that those who develop technologies have a lot of power over income distribution. They can of course make some limited tradeoffs with distributional relevance...[b]ut the extraordinary income distribution problems of developing countries do not, unfortunately, have an easy technological solution (Binswanger, 1987).

> [P]ersistent rural poverty and inequality in developing Asia have resulted not from the green revolution, but from insufficient efforts to develop and diffuse the new agricultural technologies. This strongly supports the view that the way to escape the Ricardian trap resulting from population pressure on land is to concentrate on developing land-saving and labor-using technologies that increase

> demand for labor faster than the supply of labor is increasing, and food supply more rapidly than demand for it is increasing (Hayami, 1988: 59).

There is now some evidence that the theory's ideological role is being de-institutionalized. Issues of rainfed food production, continuing rural poverty, ecological and environmental sustainability, rural economic differentiation including the rising significance of non-farm income and employment, more serious interest in improving the contributions the international centers make to national systems (TAC, 1982:vi), and the rising interests in biotechnology and privatization of agricultural support services are all forcing a recasting of the neutrality claim for agricultural research (Buttel et al. 1983; Lipton, 1985).

To the degree that induced innovation theory's ideological role is being de-institutionalized, it is important to understand that this is happening not because the centers are abandoning their claim of political neutrality, but because in fact, control of the international agricultural research centers and for that matter control of policy arenas that are most influential on agriculture is now a considerably more complex issue in Asia (Koppel and Zurick, 1988) and the United States (Koppel, 1984). It is the acknowledgment of this complexity that is undermining the foundations of induced innovation theory's ideological role.

Ironically perhaps, the theory's insistence that technological and institutional change are endogenous ultimately placed the centers in an untenable position. If they accepted it, they would ultimately have to accept accountability to wider institutional forces, a step that would be incompatible with the cherished neutrality claims. However, the theory

has consistently refused to accept this accountability as a logical conclusion of its premises, falling back instead on the traditional argument that market signals were enough, the incidence of market failure overestimated, and policy intervention inefficient, a stance appropriately criticized by de Janvry and Dethier (1985) as too narrow.

A recent CGIAR report reveals a strategy to harden division of labor within the international agricultural research system, and by so doing, disengaging the centers from wider linkages and the accountability claims that they bring.

> TAC recommends that the national systems should gradually take over the responsibilities for the social science research since the majority of social and economic factors influencing agricultural production and food consumption and distribution are inherently location-specific (CGIAR, 1985: 73).

This is a key development because induced innovation theory developed its ideological role from a position within the international agricultural research system. The effect of the TAC recommendation would therefore be to unseat induced innovation theory from one of its most crucial positions.

In fact, induced innovation theory cannot provide a consistent guide for a disengagement strategy. Stripped of the ideological shield, inconsistencies and nonsubstantiation problems pointed out earlier are now being exposed more clearly. Induced innovation theory as an economic theory of technological and institutional change in agriculture will remain important, but it may not offer any extraordinary advantages for its former clients.

CONCLUSION

The application of induced innovation theory to the technological and institutional change associated with Asia's green revolution represented an important extension of economic analysis. That the extension has been uneven does not detract from the essential contribution of the extension. Economists should build in part on the foundation the theory has constructed (e.g. by more rigorous specification, testing, and comparative analyses) to generate more comprehensive understanding of the complexity of technological and institutional change in agrarian Asia. However, the experience of the green revolution strongly suggests that economists will also need to go beyond the theory to incorporate more fully the realities of social power, economic exploitation, politicization, and state aggrandizement that are crucial to any portrayal of rural Asia. If Little is correct, this may not happen easily, since according to him, development economists "have not been active in exploring the political consequences of different economic policies, although most, when in the role of advising governments, will have been very conscious of political constraints"(Little, 1982: 17). Future work by economists on issues of technical and institutional change in Asian agriculture should try to prove Little wrong.

Finally, the experience of induced innovation theory's relationship to the green revolution also suggests that economists (and other social scientists) need to be continuously cautious of who they are handmaidens to. Induced innovation theory has too often been the sound of one hand clapping, the hand of the politically, socially, and economically

well-off, well-connected, and well-protected in rural Asia. The theory's affinity with the neutrality claims made by agricultural research systems successfully muffled this imbalance for two decades. On this point, future work by economists in a position to influence problem identification and resource allocation within the agricultural research system should be sensitive to a conclusion reached by Lowell Hardin after he interviewed economists at several of the international agricultural research centers:

> In appropriate ways, social scientists [have] become involved in the conception of changes that may result in advances. In doing so they too become accountable for the outcome (Hardin, 1981: 484).

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