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1400 16th Street, NW / Suite 350
Washington, DC 20036
(202) 939 - 3450

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*Complementarities in the Transition from Socialism:
A Firm-Level Analysis*

Susan Gates¹, Paul Milgrom² and John Roberts³

Department of Economics, Stanford University^{1,2,3}

and

*Senior Research Fellow²
Institute for Policy Reform*

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Privatization of firms, price rationalization, free trade and competition policy are all important components of economic reform in former planned economies. We examine the conditions under which these are complementary instruments for improving performance at the level of the firm, so that the benefits from the whole reform package exceed the sum of the benefits of the individual reforms. We also study how the speed of implementation affect intertemporal resource allocation incentives.

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Complementarities in the Transition from Socialism: A Firm-Level Analysis

by Susan Gates, Paul Milgrom and John Roberts

Executive Summary

One of the key issues in the implementation of economic reforms is the timing and coordination of the various reform elements. Much of the attention given to this question in the past has focussed on money, banking, taxation, and the macroeconomy and on the safety net provided for workers who are certain to become at least temporarily unemployed in any mass privatization. We continue this investigation by examining the likely responses of firms to price reforms, privatization, free trade and competition policies. The first question is whether, for some packages of these incentive-related reforms, "the whole is greater than the sum of the parts."

The precise way to ask this question is to ask whether a package of reforms is *mutually complementary*. The reforms in a package are mutually complementary when two conditions hold: (i) implementing some parts of the package does not preclude implementing the other parts and (ii) the sum of the benefits from implementing one part of the package alone or another part of the package alone is less than the benefits from implementing the two parts together.

As we show, there are ample reasons—both theoretical and from case studies—to suppose that incentive-related reforms can be mutually complementary. For example, price rationalization without privatization leads to only limited responses on the part of the firm, since the firms have only a limited incentive to respond properly to the prices. Privatization without price rationalization similarly can enable and encourage firms to make large profits with negative value added activities, as when Polish producers grew tropical flowers in greenhouses using state-subsidized energy sources. Together, however, a system of market-determined prices and private ownership can provide powerful private incentives for firms to engage in value-creating activities. The tropical flower

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example can also be interpreted as one of complementarities among price reforms in different markets: allowing the price of tropical flowers to be high while maintaining an artificially depressed price of energy distorts firm-level decisions.

The same logic can be applied to complementarities among instruments used at different points in time. Price rationalization this year and next year are complementary instruments, because firms respond to anticipated future price changes by such unproductive activities as hoarding underpriced goods and dumping inventories of overpriced goods. That problem is solved when anticipated future price changes are implemented today. Together, the points of the last two paragraphs constitute an argument in favor of carrying out price reforms quickly and comprehensively once the decision to reform has been made.

There are two important caveats that need to accompany the message about complementary packages of reforms. The first is that not all reforms aimed at improving private incentives are mutually complementary. In China, for example, freeing the prices of goods beyond the quota has been an effective reform that would probably not be made more effective by freeing the prices for the goods produced up to the quota. Our theoretical analysis illustrates the proper pattern for evaluating complementarities, but the details need to be considered on a case-by-case basis.

The second point is that complementarities concern just one term in a benefit-cost analysis. The actual magnitude of the complementarity effect needs to be balanced with other benefits and costs in determining the best policies for encouraging value-creating decisions by firms.

1. INTRODUCTION

Most descriptions of economic reform in the formerly communist economies describe the benefits of the various reform elements in a piecemeal way. Thus, private ownership of a firm increases the incentive to produce highly valued outputs, to economize on inputs and to protect the value of assets; price liberalization/rationalization and the elimination of subsidies encourage managers to choose the right mix of inputs and outputs; free trade forces managers to face international competition, drives them to activities where they have a comparative advantage and permits them to achieve greater economies of scale; and competition policy prevents large state firms from using their scale to distort market outcomes. From these descriptions, one might observe that the various proposed reforms are all designed to enhance managerial performance incentives and, from this, be tempted to conclude that they are substitutes for one another, with diminishing returns to additional reforms. Not only is this position wrong, but the reverse conclusion is actually more accurate. There are significant complementarities among these various reforms. Correspondingly, each individual reform makes undertaking the others more attractive.

This idea that there may be complementarities among the individual reform elements within an economic reform package is not new. Indeed, the idea has sometimes been offered as a logical underpinning for the "big bang" strategy for economic reform, in contrast to any policy of partial or gradual reform. As Lipton and Sachs (1990b) put it:

"The transition process is a seamless web. Structural reforms cannot work without a working price system; a working price system cannot be put in place without ending excess demand and creating a convertible currency; and a credit squeeze and tight macroeconomic policy cannot be sustained unless prices are realistic, so that there is a rational basis for deciding which firms should be allowed to close. At the

same time, for real structural adjustment to take place under the pressures of this demand, the macroeconomic shock must be accompanied by other measures, including selling off state assets, freeing up the private sector, establishing procedures for bankruptcy, preparing a social safety net, and undertaking tax reform. Clearly, the reform process must be comprehensive.”

This idea has been repeated and made the basis of policy prescriptions. For example, *The Economist* notes that “[b]ecause all the required reforms are so interlinked, trying to identify the best sequence was always a phony goal. No single measure can bring much benefit without at least some progress towards the other reforms.” These arguments, however, are all informal ones. The relationships among the various reform elements are not well defined, and the implications of those relationships are not rigorously explored. To what extent are all these economic reforms complementary? Does such complementarity really imply that the “big bang” reform strategy is optimal, or does that argument entail some additional implicit assumptions?

The word “complementarity” has various uses and meanings within economics, but we shall use it only in a particular, formal sense. A pair of reforms or policies or activities is complementary if (1) adopting one does not preclude adopting the other and (2) whenever it is possible to implement each reform separately, the sum of the benefits to doing just one or just the other is no greater than the benefit of doing both together. An equivalent phrasing of the second condition is that the incremental return to implementing any one of the reforms is greater if the other has already been implemented. It is a theorem (Topkis, 1978) that if each pair of reforms in a package is complementary, then implementing any subset of the reforms raises the incremental return to implementing the remaining ones.

While the case for complementarity among the incentive-oriented reforms is not an

unqualified one, some plausible sources of pairwise complementarities are easy to identify. First, a policy that strengthens management's incentive to generate profits may cause managers to devote more effort to low value-added or even negative value-added activities when profits are measured using artificial, administered prices, but the very same policy may inspire increased efforts for highly valued activities after prices have been rationalized. Or, what is really just the flip side of the same effect, price rationalization has a greater salutary effect on managers' decisions if the managers are first given incentives to maximize profits.

The rise and fall of private Polish greenhouses demonstrates this phenomenon. In the late 1980s, the Polish government relaxed restrictions on cooperative and private enterprises. Entrepreneurs soon realized that they could make large profits by building greenhouses, heating them with the energy which was heavily subsidized by the state, and growing tropical flowers to be sold domestically at uncontrolled prices, or exported. With the price liberalization of 1990 and the subsequent increase in energy prices, the entrepreneurs quickly fled the tropical flower business, presumably directing their resources and efforts toward more socially valuable activities.

A second plausible complementarity is that between privatizing firms and promoting competition, whether by breaking up oligopolies, encouraging entry, or opening up markets to international competition. The reason is much the same as that which makes price rationalization and privatization complementary: Managerial incentives to increase output are based on marginal revenues, rather than the competitive price of output, and policies to promote competition in an industry reduce the gap between price and marginal revenue. If the other prices in the economy are set competitively, this is an unambiguous improvement.

A third complementarity may be found between privatization policies implemented in different sectors or at different times. For setting different incentives for different sectors encourages

managers to shift effort and even capital toward the high incentive sector. Similarly, delayed implementation of a privatization policy encourages activities that shift profits forward in time, when the managers' shares are larger. In both cases, managers are encouraged to reallocate resources without regard to the efficiency of the resulting allocation.

In Poland, these perverse incentives associated with piecemeal, delayed privatization is evident in the wave of *nomenklatura* privatization that occurred between 1987 and 1989. In 1987 and 1988, the communist government of Poland legalized stock issue by state owned firms to transform themselves into joint stock companies. Slay (1992) notes that "managers who had links with the PUWP [Polish United Workers' Party] *nomenklatura* could legally transform state enterprises into private joint-stock companies. This meant that party-state officials controlled the composition and price of issues of stock during these transformations and used their positions as insiders to become owners of the previously state-owned enterprises." These firms came to be known as *nomenklatura* companies. Staniszki (1991) reports that in 1987, there were already 80 such companies in Poland, and by the beginning of 1990, there were over 40,000. These *nomenklatura* companies generally enjoyed success at the expense of the state enterprise. In many cases, the managers would expropriate only the profitable elements of the state firm, leaving the rest in state hands.

This wave of *nomenklatura* privatization triggered outrage among the population and debate among academics over both the ethics and efficiency of such privatization. For our thesis, the important point of this episode is that it illustrates the reason that increasing incentives for some activities makes it important to increase the incentives for all. For while the plundering of state assets inherent in *nomenklatura* privatization may actually have led to improved efficiency at some of the newly created firms, it also resulted in both resource misallocation among sectors and over time and an unnecessary loss of revenue for the government.

To analyze timing, it is helpful to take an abstract point of view, regarding policy stances this year and next year as separate policy instruments. For example, there may be private appropriability of returns this year and next, or just next year; there may be price rationalization this year and next, or just next year (or perhaps just this year); and so on. The arguments we have already made then suggest that why there is complementarity between privatization and price rationalization within a given year, between privatization this year and next, and between privatization in one sector and another. The threat of hoarding induces a complementarity between price rationalization this year and next. To the extent that input price rationalization for a firm requires effective antitrust policies to be applied to suppliers, those policies are complementary as well. The whole reform package is rife with complementarities at the level of the firm.

This paper attempts a detailed theoretical study of the joint effect of various policies on the behavior of a firm's managers to formalize the kinds of arguments made above. The general problem is, of course, quite complex, and we need to abstract from some of its complexities to obtain a tractable representation. Our formal approach to studying issues of complementarity follows Milgrom and Roberts (1990) while our modeling of incentives draws mostly from Holmstrom and Milgrom (1987).¹ The formal analysis tends to confirm that complementarities among reform policies of the sorts just discussed are possible, but that the conclusions we derive do depend on certain assumptions about the conditions prevailing at the time of transition of the former socialist economy. The analysis also identifies some likely cases of substitute policies.

We emphasize that the mere finding of complementarities across reforms (or other kinds of activities) does *not* by itself imply that the reforms (or activities) should all be installed

¹Holmstrom and Milgrom (1993) introduced the idea that different incentive instruments used to regulate employees and agents are complements. The main differences between the two analyses are ones of context, which determine the incentive instruments and the way they are used.

simultaneously. This is most clearly illustrated by taking the argument to a ridiculous extreme. Observe that work experience and productive work are complementary, because working certainly does not preclude gaining experience and experience increases the productivity of work. Yet it would be absurd to argue from this alone that inexperienced workers should not be permitted to work, for work must precede the accumulation of experience. It is similarly absurd to argue on the basis of complementarities alone that it is unwise to rationalize prices without privatization, or that one should prohibit the creation of new private enterprises until the government can create a suitable means of taxing them.

The logic that supports big bang policies involves two elements besides complementarity among reform instruments. The first is *complementarity over time*. For example, the mere fact that price rationalization is expected for tomorrow makes it valuable to implement it today, in order to prevent distortions such as hoarding and dumping. Such complementarity of reforms over time is a reason for speedy implementation. The second element is nonconvexities, which are endemic in incentive problems. These nonconvexities make it quite possible that each reform individually has an adverse effect on managerial performance even though the whole package of reforms has a decidedly salutary effect. We illustrate this possibility in an otherwise well-behaved example in section 4, using a concave production function and a convex cost function. This possibility implies that piecemeal implementation of these reforms can add to the costs of transition and increase pressures to reverse reforms that are already in place.

A second important caveat is that the analysis offered here is built on the particular structure of the reforms. Generalization to other reform packages is unwarranted and, indeed, we see no reason to suppose that all packages of reforms must be characterized by extensive complementarities. China's dramatic successes since the late 1970s with its partial reforms (McMillan and Naughton,

1992) indicates the extreme degree to which details determine the conclusion of the analysis. Agricultural reforms in China, implemented in an environment where capital and effort were not fungible across agricultural and industrial activities, did not suffer the disadvantages we have described. Provided that the government is strong enough to enforce fulfillment of the plan, we find no reason to suppose that price reforms which allow only output beyond the plan to be traded at uncontrolled prices would be complementary to price reform for the remaining planned units as well, even though the two parts together constitute what might be called full price liberalization.

Section 2 gives an account of the incentives for managers in Poland just before and during the recent transition. In addition, we discuss the problem of monopoly power and look at the various ways in which the Polish government tried to improve competitiveness. The Polish experience provides the motivation for several of our modeling decisions. The simplest version of our formal model, which excludes trade and competition policies, is developed in section 3. Readers who wish to skip the technicalities can skip section 3 and proceed directly to section 4. Complementarities within the formal model are developed and described in non-technical language in section 4. That section also includes an example showing the possibility of a "policy-by-policy optimum" that is not a global optimum.² That is, we illustrate a collection of policies which are coherent in the sense that any change in one policy alone would be undesirable even though a package of changes is desirable. Section 5 extends our analysis to include the effect of trade and competitiveness policies along with price reform, privatization and timing. We conclude, in section 6, with a discussion of the lessons of the model.

²Similar messages can be found in Murphy, Shleifer and Vishny (1992) and Shleifer and Vishny (1992), who argue that partial price reform in the context of a planned economy can distort the allocation between the public and private sectors, leading to worse overall economic performance.

2. MANAGERIAL INCENTIVES IN POLAND

A series of reforms were introduced in Poland during the communist era, in an attempt to improve profit making incentives for managers (Frydman and Wellisz (1991)). That attempt was generally regarded as a failure. The continuation of price controls, enterprise subsidies, and reverse taxation rendered any sort of profit based "managerial incentive plan" ineffective as a means of motivating managers. According to Fan and Schaffer (1991), the "profit" upon which the profit tax and wage bonus were based was profit after the subtraction of turnover taxes and the addition of subsidies. Such manipulations of the final profit of firms were widespread and were normally used to make sure that most (if not all) state firms were profitable on paper, no matter how poor their actual performance.

These subsidies were quite extensive, suggesting that the government spent a lot of money in order to maintain the "profitability" of various state firms. Holzmann reports that in the 1980s Eastern European governments spent about 15% of GDP on budgetary subsidies. Western countries, on average, spend less than 5% on direct subsidies. Moreover, the subsidies to Eastern European enterprises (through artificially low prices on inputs, negative turnover tax, etc.) were generally much larger than direct subsidies to consumers. The main reason for this disparity is that as the Eastern European governments abandoned strict quantity planning mechanisms, tax preferences and other subsidies became a substitute method of control. "Since most prices were initially administered, differences between prices and costs resulting from the distorted price structure had to be compensated for. Consequently, producer subsidies (and taxes) were generally used to bring enterprise accounts into balance." (Holzmann p.158).

In a detailed study of subsidization in the 500 largest Polish firms for 1988, Schaffer (1990) notes that not a single firm was a loss maker after its subsidies were included. There were two major

types of subsidy given to Polish enterprises. The first was a product specific subsidy, which was supposed to compensate enterprises for any unfavorable implications of price controls. The second was an enterprise specific subsidy, "which might be paid, for example, to enterprises with old equipment and therefore high operating costs.... There is, however, anecdotal evidence that nearly all these subsidies were allocated according to a number of informal, enterprise-specific criteria, in particular profitability." (Schaffer, 1990 p.190) The discretion the government exercised in determining subsidies to individual firms weakened the link between managerial compensation and the real value of the firm's activities.

The reform package of January 1990 included reforms releasing enterprises from central control and significantly reducing subsidies. The discretionary tax subsidies were abolished. Although profits might now be a better signal of managerial performance, the compensation system was not designed to reward managers for such performance. In addition to these reforms, the Polish government introduced a tax on excessive wages in state enterprises. This tax applied to both worker and managerial wages and bonuses. The policy for 1990 called for the partial indexation of a firm's total wage bill to inflation. Each month, the government established a maximum allowable wage bill increase, or wage norm. The norms provided for wage increases which were smaller than the rate of inflation. Any firm whose wage bill exceeded that norm was subject to a tax of between 100% and 500% on those excesses. (Coricelli and Revenga, 1992) Although this policy was designed to force a decline in real wages and prevent the return of a wage-price spiral which plagued Poland throughout 1989, it had the additional effect of limiting incentive pay in state enterprises. Also, because the excessive wage tax did not apply to private enterprises, many workers and managers viewed the ability to increase wages as a great incentive to privatize.

In summary, the Polish government has been trying to improve managerial performance

incentives at least since the early 1980s. Although the reforms of the 1980s linked managerial compensation to firm profits, the reforms did not achieve the goal of increased production for a variety of reasons. Importantly, firm profits were directly manipulated by the government through turnover taxes and subsidies, and profits were measured by controlled, centrally determined prices, so that measured profits bore little relation to real value added. Although these distortions were largely removed in 1990, it appears that direct profit based incentives for state managers were weakened by policies that restricted wage payments (including bonuses for both workers and managers) at state firms. Since wages at private firms are not regulated, these managers do have higher powered profit incentives. And many of those large firms currently under state ownership are targeted for participation in the mass privatization program.

Even if profit-based incentives are successfully instituted, however, the resulting managerial behavior may not be in the social interest. Many economists suggest that because of the high degree of industrial concentration in Eastern European countries (Slay, 1989) as well as trade restrictions which shield firms from international competition, incentive-based economic reforms may induce monopolists and oligopolists to continue restricting output while increasing prices to increase profits. Studies by Slay (1990) and Schaffer (1990) indicate that the industrial structure of Poland immediately prior to the "big bang" reforms of January 1990 was oligopolistic, suffering from a lack of small competitors. Slay suggests that the lack of competition in many sectors (eg. glass, printing, machine tools, and wood products) before 1990 was due in large part to government policies restricting the creation of private enterprise, state administrative restrictions, and underdeveloped supply networks. One would assume that market reforms alone would significantly improve competition in these sectors. However, Slay argues that other sectors, such as coal, paper, and metallurgy, are so highly concentrated and integrated that additional measures may be needed to

introduce competitive forces into those industries.

Lipton and Sachs (1990a), in an early blueprint for privatization in Poland, argue that monopoly power is not an urgent problem in a country like Poland if trade restrictions are removed and domestic producers are subject to stiff foreign competition. In their view, trade liberalization is a perfect substitute for an active competitiveness policy. With the benefit of hindsight, Blanchard, Dornbusch, Krugman, Layard and Summers (1991) argue that trade liberalization was not strong enough to prevent the exercise of market power by large state enterprises in Poland in 1990. Price liberalization gave state managers the ability to set prices at the monopoly level, and most state-owned enterprises took advantage of this opportunity.

“Anecdotal evidence has it that some firms, having always operated under excess demand conditions, thought it safe to choose a high price, only to discover over time that the price far exceeded even the monopoly price and that some price increases had to be rolled back. More quantitative evidence is provided by the behavior of profits of firms since the stabilization: profits have been unexpectedly high, especially so in the face of a sharp decrease in domestic demand, to which we return below. The constraints on prices from convertibility and a fixed exchange rate do not appear to have been powerful enough to have prevented monopoly pricing in large segments of the economy, at least for the time being.” (Blanchard *et al* p. 18)

Blanchard *et al* go on to recommend an extensive restructuring program for state industries which would, among other things, reduce monopoly power.

Studies of the behavior of Polish state enterprises after the “big bang” reach conflicting conclusions as to the extent to which these firms have exercised monopoly power. In a study of state-owned enterprises in Poland after the reforms, Schaffer (1992) examines aggregate trends in markup

over cost for Polish state-owned enterprises and concludes that there is no evidence to support the notion that state enterprises restricted output in order to exercise monopoly power. It is not clear, however, that such general conclusions about the exercise of monopoly power in Poland follow from an analysis of aggregate data. Slay's (1992) study of industrial concentration in Poland suggests that firms in different industries would respond to price liberalization and market reforms in different ways. Frydman and Wellisz (1991) argue that this is exactly what happened. State enterprises in the consumer goods sector, which faced strong competition from both domestic private firms and foreign firms, reacted to the decline in consumer demand by reducing production as well as mark-ups. On the other hand, they note that, "the strongly monopolized producer goods industries, insulated to a large extent from market shocks, switched, under the impact of the stabilization measures, from a policy of below-market clearing to monopolistic pricing." (Frydman and Wellisz p.144) Kharas (1991) argues to the contrary that "at a broad sectoral level, output changes correspond to what neoclassical theory would predict, rising in response to higher prices, and falling in sectors faced with higher costs and taxes." (p.19). While noting that state-owned enterprises in Poland did not appear to be exercising monopoly power in 1990, Kharas stresses that there is a real danger of such power developing unless strong actions, in addition to trade liberalization, are taken to promote competition. "[A]lthough openness to international trade provides a considerable spur to competition, it is a blunt instrument whose effects are uneven across sectors... Consumer goods industries, especially food-based products and other light industry goods, may be made competitive through trade, but in consumer durables, pharmaceuticals, producer goods and of course nontradables, international trade is less significant" (Kharas pp 30-31). Kharas goes on to suggest that trade liberalization policies should be supplemented with an active antimonopoly policy which looks at each firm on an individual basis, considering the potential economies of scale in the industry and the

influence of foreign competition in the sector, and the potential for abuse of monopoly power. In Kharas' view, trade liberalization and competitiveness policies are substitutes, but the relative impact of each policy varies across sectors of the economy.

Whatever the actions of large state Polish firms in the immediate post-reform period, the exercise of some degree of monopoly power was of significant concern to the government, which responded with both trade liberalization and competitiveness policies. Trade liberalization was a central feature of the Polish "big bang." In addition to lifting the quantity restrictions and the restrictions on economic entities allowed to engage in foreign trade which existed in the communist era, the government also lowered tariff rates on most products.³ Trade liberalization was accompanied by the establishment of full internal currency convertibility at a fixed rate. Given the hyperinflation that was plaguing Poland in 1989, the monetary stabilization program was naturally fraught with uncertainty. In hindsight, it appears that the fixed exchange rate, set in January 1990 and maintained until May of 1991, undervalued the Polish currency. This undervaluation served to dampen the competitive pressures of trade liberalization in 1990.

The Polish government has also focused attention on industrial concentration and monopoly in domestic production. Apparently, there is good reason for such concern as 80 percent of goods markets at a detailed product level are dominated by producers whose market share exceeds 30 percent. (OECD *Report on Poland*, p.60) (For detailed information on industrial concentration, see OECD *Industry in Poland*.) The Antimonopoly Law of February 1990 renders various monopolistic and anticompetitive acts illegal, and provides for the creation of the Antimonopoly Office. This office

³Whereas the average tariff rate in January of 1989 was 18.3%, the average tariff rate in 1990 fell to 5.5%. In August of 1991, the Polish government raised tariffs once again, especially on agricultural goods and animal products, so that the average tariff rate on all goods rose to 18.4%, and the average tariff rate on non-agricultural good is 16.3% (OECD *Report on Poland* 1992, p.134).

is empowered break up monopolistic enterprises and intervene actively in the pricing decision of firms which have a dominant position in the market.⁴

Of course, the other aspect of competition policy, requiring little government intervention, is the development of the private sector. The Polish mass privatization program continues to suffer delays due to political crisis. Comprehensive mass privatization legislation finally passed the Sejm (parliament) in April of 1993 and was approved by President Walesa.⁵ The legislation calls for the rapid commercialization and subsequent privatization of 400 large firms, including 170 manufacturing firms which account for 13.8% of manufacturing production. Meanwhile, the privatization of small shops and businesses proceeded rather rapidly. By September 1991, 75% of trading firms, 45% of construction firms and 80% of the trucking industry were under private ownership. (OECD *Industry in Poland*, p.38). Even in the area of industrial production, where privatization has not proceeded as rapidly as expected, the private sector accounted for 24.1% of total industrial production in 1991, up from 16.2% in 1989.

In the model below, we explore the interaction between three basic aspects of reform: current privatization, future privatization and price rationalization. We will then expand the model in order to study the impact of trade liberalization and competitiveness policies.

⁴The Antimonopoly Office appears to be taking its mandate quite seriously. In 1990 alone, 188 enterprises were broken up into 771 individual units. Most of these divisions occurred among enterprises under the control of the Ministries of Industry, Transportation and Agriculture. (Kharas, p.8). In the first half of 1991, 84 firms were broken up into 190 units. In addition, the Antimonopoly Office blocked about 10% of the 1100 proposals submitted by state enterprise attempting transformation (incorporation or liquidation). "In particular, 60 out of 200 requests for change of status to joint stock company were delayed in 1991 pending divestiture or reorganisation of the company concerned." (OECD *Report on Poland*, p.60)

⁵The implementation of this program has been delayed due to the collapse of the parliamentary government in May. Further delays are expected under the new left-leaning governing parliamentary coalition, which took over in October, 1993.

3. THE MODEL

We consider a model in which the firm transforms a single marketed input and employee efforts into a single output, using a variety of production processes. For concreteness and simplicity, we represent all employees involved in running the firm by a single agent whom we call “the manager.”⁶ The manager makes four choices in running the firm. He selects the levels x_1 and x_2 of the input to use in the firm’s two production processes and supplies two kinds of efforts e_1 and e_2 . The first kind of effort is used with the marketed input x_1 to produce current output according to the “effort intensive” production function $\text{Min}(e_1, x_1)$. The second kind of effort may represent an investment in intangibles or other assets that are not currently easily measured but that add output of value e_2 in a future period. Alternatively, e_2 can be used to represent effort expended in another sector of the economy, though we shall suppress that interpretation during the analysis of the model. In addition, there is a second production process using the marketed input that produces $g(x_2)$ units of output and that requires no managerial effort. Output of the two processes are indistinguishable. For compactness of notation, we sometimes represent output as a function of the effort e_1 and the total input purchases $x = x_1 + x_2$ as $f(e_1, x) = e_1 + g(x - e_1)$, with the convention that $g(z) = z$ for $z \leq 0$.

The motivation of this formulation is as follows. As we shall see, including output which is a joint function of effort and marketed inputs, where the two kinds of inputs are complementary, allows the state to use a low input price to promote managerial effort.⁷ The Min operator creates an especially tractable complementarity (between x_1 and e_1) when managerial effort is used in

⁶This reduced form approach is fully justified if the inside agents can monitor one another and contract perfectly among themselves (Holmstrom and Milgrom (1990)).

⁷Litwack and Qian (1993) have similarly observed that subsidizing complementary inputs — in their case public inputs — can supply an incentive for increased effort by a firm’s managers.

production. It is also reasonable to suppose that a manipulating the input price p_x will affect the firm's input mix; including the $g(x_2)$ term accomplishes that. The two kinds of effort allow the possibility of a similar distortion in effort provision. For example, an increase in the incentive for current output may cause effort to be shifted away from its other valuable use, namely, investing in intangibles that create future output.

The central planner is assumed to provide incentives to managers for current output by sharing a fraction α_1 of current net earnings with the manager.⁶ This may be done through an explicit performance contract, or the planner might blink when some fraction of the firm's net resources is diverted by managers to their personal use. Sharing profits is an alternative to privatization, but not a perfect substitute. One possible difference is political or ideological constraints that limit state managers' incomes more than those of private managers, making it easier to set α_1 higher in privately owned firms than in state-owned ones. A second difference lies in the possibilities for opportunistic behavior. Even a planner that can commit to sharing current income in excess of some target may still be unable to commit to future targets, and that makes sharing the future returns arising from current effort investments problematical. We suppose that there is a separate constant α_2 reflecting the share of returns on such investments that accrue to the firm's manager. We allow that α_2 may be zero.

The manager has quasi-linear preferences and constant absolute risk aversion, that is, utility is given by $U(w, e) = -\exp[-r(w - C(e))]$. In this expression, $C(e)$ is the "cost of effort," w is the manager's "wage," and r is the coefficient of absolute risk aversion. This utility specification has two main advantages. First, it implies that transfers made to or from the manager affect neither his

⁶In this reduced form model, we simply assume that the compensation contract is linear in form. This linearity can be justified as the form of the optimal contract in a certain fully specified dynamic model. See Holmstrom and Milgrom (1987).

willingness to bear a given risk nor his willingness to expend a given level of effort for a given level of pay. These properties add tractability to the analysis of incentives. Equally importantly, when combined with a similar assumption about other agents in the economy, the specification means that cash transfers among agents do not affect the total certainty equivalent of the parties. This achieves a complete separation of distributional issues from efficiency issues within the model. The total certainty equivalent in this context is an unambiguous neoclassical index of efficiency: Given any two productive arrangements with different values of this index, there is a potential Pareto improvement to be achieved by moving from the low index arrangement to the higher index arrangement and making appropriate transfers, but no potential Pareto improvement by moving in the other direction. The index for the overall economy is the sum of the firm-level efficiency indexes. This separation of distributional from efficiency issues is very useful analytically: it allows us to isolate and study the issues of how various reform policies combine to affect the efficiency of firms' operations. At the same time, one must remember that what is being analyzed is just one important aspect of the actual reform problem.

We also assume that the cost of effort function is convex quadratic, as follows: $C(e_1, e_2) = \frac{1}{2}c_1e_1^2 + \frac{1}{2}c_2e_2^2 + c_{12}e_1e_2$. The significance of the quadratic form has been discussed at length by Holmstrom and Milgrom (1993). Essentially, the linearity of production in effort combined with the quadratic effort-cost function results in a separable effort supply function, so that the level of incentives for one activity does not affect the slope of effort supply for the other activity. This simplifies the analysis by eliminating an effect of ambiguous sign, and thus also limits the generality of the conclusions we obtain. We further assume that $c_1, c_2, c_{12}, \Delta > 0$, where $\Delta = c_1c_2 - c_{12}^2$. That c_{12} is positive means that the two kinds of efforts are substitutes in cost for the agent: a higher level of effort in one activity raises the marginal cost of effort in the other. That the determinant Δ is

positive means that the cost function is convex.

The firm's profits are $\pi = p_y f(e_1, x) - p_x x + \epsilon$, where p_y is the output price, $p_x < p_y$ is the input price, and ϵ is a normally distributed error term with variance σ^2 . That requirement that $p_x < p_y$ means that the production process requiring managerial inputs is potentially viable. The manager thus chooses x , e_1 and e_2 to maximize his certainty equivalent, which is:

$$\alpha_1 [p_y f(e_1, x) - p_x x] + \alpha_2 e_2 - C(e_1, e_2) - \frac{1}{2} r \alpha_1^2 \sigma^2.$$

If we further specify that the function g is smooth and concave on \mathbb{R}_+ and satisfies $\lim_{z \rightarrow 0} g'(z) \geq 1$ and $\lim_{z \rightarrow \infty} g'(z) \rightarrow 0$, then clearly x will be chosen to be strictly larger than e_1 . The firm's demand for the input is then $e_1 + x_2$, where x_2 is determined by:

$$g'(x_2) = p_x / p_y. \quad (1)$$

It is not difficult to show that the effort supply functions are then:

$$e_1 = e_1(\alpha_1(p_y - p_x), \alpha_2) = c_2 \Delta^{-1}(p_y - p_x) \alpha_1 - c_{12} \Delta^{-1} \alpha_2 \quad (2)$$

$$e_2 = e_2(\alpha_1(p_y - p_x), \alpha_2) = -c_{12} \Delta^{-1}(p_y - p_x) \alpha_1 + c_1 \Delta^{-1} \alpha_2. \quad (3)$$

Notice from (2) that incentives for current effort can be provided either by increasing α_1 or by increasing the spread between input and output prices, $p_y - p_x$. Since we are not modeling the uses of output, the distortions from manipulating p_y are omitted from our model. For that reason, we shall regard p_x but not p_y as incentive instrument for the planner and assume that $p_y = p_y^*$.

Although reducing p_x is a substitute for increasing α_1 in providing incentives, it can be an inferior substitute. For suppose the actual shadow price of the input in the economy is p_x^* . Then providing incentives by setting $p_x < p_x^*$ does tend to encourage more use of effort e_1 and a correspondingly higher level of input x_1 in the first production process, but it also leads the firm to use too much of the input x_2 in the second production process. In mathematical terms, for any fixed level of e_1 , the firm chooses x to maximize $p_y^* g(x - e_1) - p_x x$, but the social optimum involves

choosing x to maximize $p_y^*g(x - e_1) - p_x^*x$. With $p_x < p_x^*$, the optimal level of x is no smaller in the second problem, and is strictly larger whenever equation (3) applies. Thus, manipulating incentives using input prices induces an extra distortion in the economy. (Notice, though, that we have not yet described the cost of using α_1).

The low price of certain basic inputs, such as energy, in the socialist economies is consistent with a policy of encouraging effort devoted to the production of final goods when those who control a firm are not residual claimants. Later, for our formal comparisons of policies, we will assume that pre-transition input prices were set optimally given the institutionally imposed restrictions on α_1 and α_2 . In particular, this implies that the actual input price is set below the corresponding economy-wide shadow price or the price at which the input might be sold in the world market, if that is the relevant opportunity cost: $p_x < p_x^*$.

The social objective in our model is to maximize the total certainty equivalent of the manager and the rest of society. This total consists of the social value of the present and future outputs produced, minus the value of inputs used, and minus the cost of managerial effort and any risk premium that the manager bears. Thus, the social objective is:

$$p_y^*f(e_1, x) - p_x^*x + e_2 - C(e_1, e_2) - \frac{1}{2}r\alpha_1^2\sigma^2. \quad (4)$$

This is to be controlled choosing the input price p_x and the incentive coefficients α_1 and α_2 , subject to the constraints that effort and inputs are chosen consistently with equations (1)-(3). Later, we shall also introduce competition policy, consisting of antitrust policy and trade policy, into the model.

4. COMPLEMENTARITY AMONG INCENTIVE INSTRUMENTS

The analysis of the model is conducted by substituting the constraints (1)-(3) into the objective function (4). We first consider complementarities among incentives for the two activities.

Let $a_1 = \alpha_1(p_y - p_x)$, $a_2 = \alpha_2$, and $a = (a_1, a_2)$. Obviously, the manager's optimum entails $x_1 = e_1$.

So, we may rewrite the social objective as:

$$\begin{aligned} \Omega = & (p_y^* - p_x^*)e_1(a) + p_y^*g(x_2(p_x/p_y)) - p_x^*x_2(p_x/p_y) + e_2(a) \\ & - C(e_1(a), e_2(a)) - \frac{1}{2}ra_1^2\sigma^2/(p_y^* - p_x^*)^2. \end{aligned} \quad (5)$$

Here, we regard Ω as $\Omega(a_1, a_2, p_x)$: performance depends on the control instruments.

Proposition 1. Incentives for current and future output are complementary, that is, $\partial^2\Omega/\partial a_1\partial a_2 > 0$.

Proof. The linearity of the effort supply functions, $e_i(a) = (c_1a_1 - c_2a_2)/\Delta$ implies that $\partial^2\Omega/\partial a_1\partial a_2 = -\partial^2C(e_1(a), e_2(a))/\partial a_1\partial a_2$. Substituting the effort supplies into the quadratic cost function and evaluating the cross partial yields $\partial^2\Omega/\partial a_1\partial a_2 = -\partial e_2/\partial a_1 = c_1/\Delta > 0$. \square

If we imagine that privatization amounts to increasing α_1 and α_2 toward unity (with unity representing the firm's manager and employees being full residual claimants), then the implication of this is that from the point of view of managerial incentives, announcing a privatization reform for the future makes it more worthwhile to take steps that increase current incentives. Such steps may include making privatization immediate. In the alternate interpretation, the proposition also implies that if there are no restrictions on the flow of resources (such as capital and effort) out of state firms, it is imperative to match increased incentives in the private sector with increased incentives in the state sector.

The intuitive explanation for this result is as follows. If the two different kinds of agent efforts are substitutes in the agent's cost function, as we have assumed, then increases in the incentive a_2 for investment tend to divert effort away from current production. The marginal opportunity cost of this diversion is zero if the effort devoted to current output is efficient (that is, if the marginal value of additional effort in producing current output equals the marginal cost), but

is positive if the efforts devoted to current output are inefficiently low. The stronger the incentives for current output, the less is the opportunity cost of the diverted effort. Notice that the magnitude of this effect hinges on the strength of the substitution effect, for $\partial^2\Omega/\partial a_1\partial a_2 = -\partial e_2/\partial a_1$.

Proposition 2. Starting from a "socialist equilibrium" defined by the condition that the current input price, p_x , is already optimized for the pre-transition values of $\alpha_1 < 1$ and $\alpha_2 \leq 1$, privatization (setting $\alpha_1 = 1$) and price rationalization (setting $p_x = p_x^*$) are complementary reforms.

Proof. By definition, at the socialist equilibrium, increasing p_x to p_x^* has a negative payoff. However, if privatization has occurred in the current period, so that $\alpha_1 = 1$ while $\alpha_2 \leq 1$, then the three effects of increasing p_x to p_x^* in (5) are all positive. The increase both eliminates excess use of the marketed input (reduces x_2), reduces a_1 to its optimal value $p_y^* - p_x^*$ leading to value increasing changes in both e_1 (which is reduced) and e_2 which is increased, and reduces the risk premium (which is proportional to a_1^2). \square

Proposition 3. It is possible in this formulation for there to be a policy-by-policy optimum at the socialist equilibrium. In that case, changes in any *one* of the policy instruments α_1 , α_2 or p_x can only reduce value, yet simultaneous increases in all three instruments would increase value.

Proof. Possibility is proved by giving an example. Let $c_1 = 1/5$, $c_2 = 1/6$, and $c_{12} = 1/6$. Let the social values of the input and output be $p_y^* = 10$ and $p_x^* = 8.5$, the coefficient of absolute risk aversion $r = 1/2$ and the variance $\sigma^2 = 1/16$. Finally, let $g(\cdot)$ be a piecewise linear concave production function with slope 1 on $[0,3]$, $3/4$ on $[3,5]$, $1/4$ on $[5,7]$, and 0 for $x_2 \geq 7$. In that case, one can show that $(\alpha_1, \alpha_2, p_x) = (.106, 0, 2.5)$ is a policy-by-policy optimum, leading to choices $(e_1, e_2, x_1, x_2) = (7.5, 0, 7.5, 5)$ and social payoff $\Omega = 8.125$. In contrast, setting $p_x = p_x^* = 8.5$ and $\alpha_1 = \alpha_2 = 1$, leading to $(e_1, e_2, x_1, x_2) = (7.06, .71, 7.06, 3)$ and $\Omega = 10.13$. \square

Notice, first, that the existence of an interior policy-by-policy optimum requires that the

social welfare maximization problem be nonconvex. For otherwise, the first order conditions of policy-by-policy optimization would also entail global maximization. This means that although C is quadratic and g is concave, the principal-agent incentive problem is not concave. Indeed, in our example, the agent's choice of x_2 is actually a discontinuous function of the price p_x , so the objective function is not even continuous in the policy variables. There is nothing unusual or strange about this. Nonconvexities of this sort are quite normal in principal-agent problems in general and in this sort of model in particular (Holmstrom and Milgrom, 1991). There is no plausible reason to rule out, *a priori*, the possibility of such policy-by-policy optima.

5. COMPETITION POLICY

Thus far, we have assumed that firms operate in perfectly competitive markets, so that the marginal return (MR) to output from the point of view of the firm coincides with both the output price and marginal social value of that output ($MR = p_y = p_y^*$) both before and after price liberalization. However, our discussion of trade and competitiveness policy in Poland (section 2) suggests that price liberalization can create opportunities for the exercise of monopoly power by domestic enterprises. Before price liberalization occurs, the government controls the price of output as well as the price of input, and sets the price of output so that it is equal to the marginal social value of that output. After price liberalization, the government no longer sets the price of output; instead, price is determined by what are usually imperfectly competitive market forces. To the extent that firms in a given industry are able to exercise such monopoly power, our assumption that $MR = p_y^*$ no longer holds. The purpose of this section is to examine the implications of monopoly power for our model, and to study the role of competitiveness policies in the overall reform package.

As the discussion in section 2 indicates, there may be some sectors of the economy that are

made effectively competitive by import competition, others that already consist of many small firms, others where the break-up of large firms to reduce market power is desirable, and still others where the emergence of new domestic competitors makes any government policy intervention unnecessary. There is little to be gained for our purposes by modeling all these possibilities in detail. Instead, we make a simple extension of our model, allowing that there may be a difference between the marginal return MR_y received by a firm for units of output and the social value of output, which is p_y^* . A firm with market power has a tendency to restrict output, which we may represent by the condition that $MR_y < p_y^*$. A small firm in an industry where other firms are restricting output may find its marginal revenue is $MR_y > p_y^*$. Competition policies are just policies to reduce or eliminate the difference between MR_y and p_y^* . In terms of the mathematical model, these possibilities are modeled by replacing p_y^* by MR_y in the manager's first-order condition.

Within the formal model, competition policy is just an element of price rationalization. In the previous section, where we assume that firms operate in perfectly competitive markets, *price liberalization* (freeing prices to be set by the firms in the market) is the same as *price rationalization*. When firms exercise market power, this is no longer the case. Proposition 2 states that price rationalization and privatization are complementary policies. When markets are perfectly competitive, this is the same as saying that price liberalization and privatization are complementary. If, however, market power exists, the direct effect of price liberalization can be ambiguous. On the one hand, it allows p_x to move to the optimal level p_x^* ; at the same time, it causes MR_y to deviate from p_y^* . Price liberalization may still be complementary with privatization; but, it may not be. The relationship will ultimately depend on the nature and extent of market power in a given industry (that is on the magnitude of the difference $p_y^* - MR_y$). When market power is strong, an effective competition policy may be necessary to obtain any beneficial effects from price liberalization regardless of the

ownership arrangements. What Proposition 2 tells us is that price liberalization combined with competition policy is complementary with privatization.

6. CONCLUSION

The main thrust of this paper has been to examine how certain reforms that have been proposed and implemented in the transition from socialism interact, whether complementarities among policy instruments can be found at the level of the firm, and what the implications of those complementarities may be. Our analysis does indeed find likely complementarities at work between price rationalization and ownership reforms (privatization), a temporal complementarity that makes speed-up of reforms desirable, and a complementarity between the package of ownership and price reforms and competitiveness policies of various kinds.

As its very definition indicates, complementarity is an attribute of the *interaction* among different policy instruments. Our conclusions about complementarities remain unchanged if one were to enrich the analysis by introduces extra effects that alter the *separate* benefits or costs of using price controls, privatization, or competitiveness policy. This lends some robustness to our analysis, since quite large alterations of the model could be made without affecting the complementarity conclusion. This observation, however, is a two-sided coin. The fact that complementarity continues to hold even when one makes large changes in the costs and benefits of a certain policy implies that arguments about complementarity cannot alone determine the form of the optimal policy.

As we emphasized in the introduction, when reform is desirable, complementarity over time tend to reinforce the argument in favor of fast, comprehensive reform. But this is only a tendency. Contrary to the arguments sometimes made, complementarity among instruments does not by itself imply that fast, comprehensive reform—the “big bang”—is necessary or desirable, because there are

also costs to implementing such a strategy.⁹ Contrary to arguments that are sometimes made in favor of a more gradual approach to implementing reforms, we have shown that a policy-by-policy socialist equilibrium is possible. That is, regardless of scale economies, there may not exist any gradual reform path from the socialist equilibrium to the first best policy that involves improved performance at each step of the way. Indeed, there may not even exist a first step involving a single policy that does not involve some temporary loss of output. The presence of complementarities alone does not determine the optimal path of reform.

⁹For example, Dewatripont and Roland (1992) emphasize that political constraints can cause a too rapid reform to fail. McKinnon (1991) cites financial constraints on firms needing to upgrade their technologies as a reason to go slow. Blanchard, Dornbusch, Krugman, Layard and Summers (1991) cite both financial and labor market imperfections as raising the costs of rapid transition.

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