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Optimal Voucher Privatization Fund Bids When Bidding Affects Firm Performance[1]

BARBARA G. KATZ AND JOEL OWEN

Stern School of Business, New York University; and ESSEC, France

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The voucher portfolio problem (VPP) is distinctive because the proportion of ownership resulting from a voucher bid is unknown, and the performance of a privatized firm depends on its ownership composition. We investigate the VPP when bidders have various skills in restructuring the firms in which they acquire ownership. We explore the impact of bidding on performance and derive the optimal ownership pattern. We show how ownership by voucher funds depends on their skills and voucher endowments and study conditions under which the most skilled acquire the most ownership. Finally, we assess the mass privatization plans of the Czech Republic, Russia, and Poland. *J. Comp. Econom.*, February 1997, **24**(1), pp. 25–43. Stern School of Business, New York University; and ESSEC, France. © 1997 Academic Press

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1. INTRODUCTION

Voucher privatization has emerged as a common feature of the transition in post-communist economies. Achieving a predominantly private ownership structure is seen as essential to successful economic transition in the formerly centrally planned economies. The magnitude of the task, however, mitigated against the case-by-case approach used when market economies privatized a limited number of firms. Instead, an economy-wide solution was sought to achieve a rapid privatization of productive assets. This wholesale approach to privatization has come to be called mass privatization.

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Although an objective of mass privatization is the transfer of assets from public to private ownership, this transfer is not in itself the sole concern of the government. Indeed, if a government were intent only on implementing the transfer of ownership, it would be indifferent as to which groups in society became the new private owners, and the choice of mass privatization strategy would be moot. Clearly, as current discussions make evident, it is the resulting pattern of private ownership that is of great concern, for it is this pattern of ownership that will determine the ultimate efficiency of the firms and their responsiveness to market phenomena. However, efficiency is not the only desirable outcome of the new ownership pattern; equity in the distribution of assets is also desired. Since considerations of equity suggest distributing ownership widely and arguments for effective corporate governance and thereby improved economic performance suggest distributing ownership more narrowly, a government wishing to engage in mass privatization needs to craft a plan that can incorporate elements of both of these goals.

The ability of the government to formulate a strategy to implement both of these goals is, of course, further complicated by political realities. Depending on the specifics of the situation, more or less appeasement of the entrenched political power-holders, and the workers and managers who might benefit more in the short run from various buy-out arrangements, will be required if any mass privatization plan is to succeed at all. As a result, different governments have chosen different approaches in dealing with these goals.

The best-known mass privatizations to make use of vouchers occurred in the Czech Republic and Russia. The stylized attributes of voucher privatization are as follows. Vouchers, denominated either in points or in currency, are offered to the population at a nominal cost. For purposes of fairness, an equal number of vouchers is offered to each participant. The vouchers are exchangeable for shares in firms being privatized; they may or may not be tradeable.[2] Individual voucher holders are permitted either to make voucher

[2] In the Czech case, the original intention was to offer 97% of the shares of the companies being privatized at voucher auctions. See Coffee (1994, p. 7 and note 13) for a discussion of why the actual percentage distributed via vouchers was less—approximately 81% of the shares in the first wave and 70% in the second. In Russia, the intention was to exchange 29% of the shares of all but the largest firms for vouchers. In these largest firms, the percentage offered by vouchers was to be smaller. The difference in the percentage of shares offered at voucher privatization auctions in the Czech Republic and Russia stems from the philosophic and pragmatic differences in the approaches to mass privatization in the two countries. In particular, in Russia, it was deemed necessary to give control to insiders to allow mass privatization to proceed. Note that trading in vouchers was permitted in the Russian privatization but not in the Czech. The Russian decision to permit trading in the vouchers seems to have been made both to avert the formation of a black market in vouchers, and in a limited way to improve corporate governance. Nevertheless, it had the effect of diluting one of the original reasons for which vouchers, rather than cash, were introduced: to prevent those who may have accumulated funds illegally under the old regime from profiting from those actions in the new regime.

bids on their own behalf in privatization auctions or to exchange their vouchers for shares in voucher privatization funds (VPFs) that will, in turn, submit voucher bids in privatization auctions. Entry into the VPF market is relatively unimpeded but, due to the short duration of voucher viability, can be taken to be limited. Once established, the VPFs compete for vouchers held by the public. Privatization auctions may be held simultaneously or sequentially. Regardless, the share of ownership corresponding to a particular voucher bid is, in general, proportional to the total number of voucher bids accepted for the fraction of the firm being offered at auction.[3] The financial intermediaries, or VPFs, are similar to mutual funds except that they are permitted and, indeed, expected to take an active role in firms in which they have acquired sufficient ownership.[4] Although restrictions on the percentage of ownership permitted to individual VPFs applied, it was anticipated that partial ownership by VPFs would improve corporate monitoring and performance.[5] Joint ownership by competing VPFs was recognized as a likely outcome. VPFs in both the Czech Republic and Russia received substantial fractions of the vouchers issued, and hence their portfolio choices are a matter of particular interest.[6]

Another type of mass privatization, which does not make use of vouchers, was introduced in Poland in the Fall of 1995, after a lengthy delay. In this

[3] The Russian voucher privatization program also permitted a bid specifying a reservation price. This type of bid was used by less than 2% of the bidders. See Boycko et al. (1994, 1995).

[4] More than 420 (that is, between 423 and 429) VPFs participated in the first wave of Czech privatization and 349 VPFs participated in the second wave. (See Coffee, 1994, p. 12, note 29, and p. 18.) In each wave, the 15 largest VPFs controlled approximately 40% of the total number of voucher points. (Coffee, 1994, p. 18.) In Russia, more than 600 VPFs were begun and, according to the Vouchers Fund Monitoring Group, Moscow, cited in Frydman et al. (1995, p. 12), 516 were minimally operational. In the sample of VPFs surveyed in Frydman et al. (1995), the largest 5 VPFs obtained 27% of all the vouchers collected by the VPFs. The FPR sample was taken somewhat prior to the close of voucher privatization in Russia.

[5] In the Czech voucher privatization VPFs could not invest more than 10% of their capital in any one firm and could not own more than 20% of the nominal value of the securities of any one issuer. But banks, which owned most VPFs, could set up a number of VPFs, and thus effectively control more than 10% of a firm. See Coffee (1994, p. 11). In the Russian voucher privatization VPFs were restricted from holding more than 10% of the shares in any one enterprise and were required to invest in no less than 10 enterprises. See Frydman et al. (1993b) and Frydman et al. (1995, p. 11). The latter reference discusses the nonenforceability of the 10% restriction and its subsequent replacement by a 25% limit (also nonenforceable) on the shares on any one enterprise that could be held by a single VPF.

[6] In the first wave of Czech privatization the VPFs acquired 72% of all the voucher points, while in the second wave the VPFs acquired 64% of all the voucher points. See Coffee (1994, p. 15). In Russia, 46% of the vouchers accepted in privatization auctions were tendered by VPFs. This percentage is based on results of the Russian privatization reported in Boycko et al. (1995, pp. 97–123). They state that VPFs acquired 45 million vouchers (p. 100) and that 97 million vouchers (of a total of 144 million vouchers) were accepted in privatization auctions (p. 105). The other 47 million vouchers, they state, were practically all used in closed subscriptions and small scale privatizations (p. 105).

plan, the government choses both the number of national investment funds as well as the funds themselves. These funds were intended to play a dominant role in corporate governance. Specifically, the government selected 512 enterprises whose shares were distributed among the 15 chosen funds in the following manner. In random order, each fund, usually managed jointly by foreign and domestic securities consortia, was given the right to choose an enterprise in which to become the lead fund. The government accorded the lead fund 33% of the shares of that firm. Of the remaining shares, 27% were distributed equally among the other funds, 15% were distributed to the employees, and 25% were reserved for the government. This process was repeated until all enterprises were assigned lead funds.[7] The intention of this process was to enable the lead funds to monitor and restructure the firms in which they held the 33% block. Individuals, for a nominal fee, received certificates representing equal holdings in all the 15 funds. The intention is to permit the conversion of these certificates into the shares of the individual funds, or the underlying firms in the funds' portfolios, in the future. The funds are to have a 10-year life span, after which time a decision will be made to have them become either industrial conglomerates or mutual funds, or to dissolve them.[8] Thus, in the Polish plan, the government limited the number of funds, gave a larger percentage of ownership in each firm to one of the funds, and bypassed the decision making role of individuals. However, since the consequences on firm performance of the skill levels of the funds remain, we will later find it instructive to compare this plan with voucher plans.

Detailed descriptions of the voucher privatization schemes and mechanisms can be found in many sources including Coffee (1994) and Boycko et al. (1994) for the Czech Republic, and Boycko et al. (1993, 1994, 1995), Frydman et al. (1993b) and Frydman et al. (1995) for Russia. Details of the Polish mass privatization plan without vouchers can be found in Grosfeld (1996), Sachs (1994), and Frydman et al. (1993a). An optimal privatization plan without vouchers but permitting joint ownership can be found in Katz and Owen (1995). Models addressing the speed and sequencing of privatization include Aghion and Blanchard (1994), Besancenot and Vranceanu (1995), Katz and Owen (1993), Laban and Wolf (1993), and Roland and Verdier (1994). So far, however, there has been no theoretical analysis of the voucher portfolio problem and thus no basis on which to evaluate different voucher privatization schemes. The present paper is an initial attempt to provide such an analysis.

We show that while the choice problem facing voucher holders is strikingly similar to the conventional portfolio choice problem, the voucher portfolio

[7] For a description of the Polish plan enacted in the fall, 1995, see Grosfeld (1996). See also Sachs (1993, p. 90) and Thieme (1993).

[8] See Frydman et al. (1993a, p. 197).

problem (VPP) has two important distinguishing characteristics. First, the proportion of ownership that will result from a given voucher bid for the shares of a firm offered for privatization is unknown. This follows since a pre-auction share price is lacking and knowledge of other competing voucher bids is not available. Second, the performance of the privatized firm will depend on the composition of ownership, and, as a consequence of the first characteristic, cannot be known at the time a voucher bid is submitted. In this paper we investigate the VPP when these characteristics prevail and when the bidders have various skills in managing and restructuring the firms in which they have acquired ownership shares. Our model enables us to explore the impact of the bidding process on economic performance. We first derive the optimal pattern of ownership that would result from a bidding process. We show how the proportion of ownership of each VPF depends on both the relative skill of a fund as well as the initial endowment of vouchers available to that fund. We then investigate the conditions under which the most skilled acquire the highest proportion of ownership. The impact of the bidding process on total profit achieved when some VPFs are more skilled than others is investigated next. Finally, we use these results to assess three mass privatization plans, specifically, those of the Czech Republic, Russia, and Poland.

The plan of the paper is as follows. In Section 2 we present our model and conditions for its solution. In Section 3 we derive the optimum bids for each VPF when the VPFs have different skill levels managing the enterprises in which they have acquired ownership. Further implications concerning the resulting ownership of the enterprises are also explored in this section. We use these results in Section 4 to evaluate the recent voucher privatizations in the Czech Republic and Russia, as well as the mass privatization plan in Poland.

2. THE MODEL AND CONDITIONS FOR ITS SOLUTION

We assume that there are F_j, $j = 1, \ldots, m$, voucher privatization funds. Out of a total of N vouchers, fund F_j has acquired N_j, $\Sigma_{i=1}^{m} N_j = N$, vouchers and, conditional on these N_j, the F_j face an m-player noncooperative game in which they bid to acquire ownership shares in the n enterprises being privatized. Each F_j chooses a vector of bids $\mathbf{a}_j = (a_{1j}, \ldots, a_{nj})$, where $a_{ij} \geqslant 0$ and $\Sigma_{i=1}^{n} a_{ij} = N_j$. Having chosen its bids, each risk-neutral F_j receives the proportion $p_{ij} = a_{ij}/\Sigma_{j=1}^{m} a_{ij}$ of g_i, the profit of firm i, $i = 1, \ldots, n$. In keeping with the voucher schemes outlined above, this profit g_i is shown below to depend on the p_{ij} as well as a random element, ϵ_i. Each F_j seeks an optimal $\mathbf{a}_j$ which maximizes, in a Nash sense, the expected sum of its earnings from all firms, i.e.,

$$\max_{\mathbf{a}_j \geqslant 0} E \sum_i p_{ij} g_i \qquad \text{subject to} \sum_{i=1}^{n} a_{ij} = N_j. \tag{1}$$

A feature that we incorporate is that each F_j has a particular level of expertise that varies over the firms being privatized. That is, funds differ in the degree to which they can affect the performance and profitability of those firms in which they have acquired some ownership. For expositional purposes, we think of the managerial involvement of F_j in firm i as being performed within F_j by individual i, and we refer to that individual as manager ij.

Each manager ij must choose an effort level e_{ij} to expend on the task of monitoring and restructuring firm i for F_j. We denote by k_{ij} the incremental impact on profit by manager ij for each unit of effort expended. Letting $\mathbf{e}_i = (e_{i1}, \ldots, e_{im})$ and $\mathbf{k}_i = (k_{i1}, \ldots, k_{im})$, we assume that profit for firm i, g_i, can be written as $g_i(\mathbf{e}_i, \mathbf{k}_i) = k_{i0} + \Sigma_j k_{ij}e_{ij} + \epsilon_i$, where ϵ_i is a random variable with $E\epsilon_i = 0$ and k_{i0} is the level of profit prior to the bidding process. Thus, g_i depends on the effort selections, the expertise levels of all the F_js that have obtained ownership shares, and a random element. Let $E(g_i) = \pi_i(\mathbf{e}_i, \mathbf{k}_i) = k_{i0} + \Sigma_j k_{ij}e_{ij}$.

Given the $\mathbf{a}_j$, we assume that the utility of manager ij depends on the expected profit of firm i as well as the particular manager's cost of effort. We assume that manager ij chooses to $\max_{e_{ij}\geqslant 0} [\gamma p_{ij}\pi_i - (\hat{c}_{ij}/2)e_{ij}^2]$ where $(\hat{c}_{ij}/2)e_{ij}^2$ represents the cost per unit of effort. The factor γ represents the manager's fee as a proportion of profit, is exogenously given, and is assumed to be independent of e_{ij}. We can write the manager's problem as follows: find e_{ij}^* that satisfies $e_{ij}^* = \operatorname{argmax}[p_{ij}\pi_i - (c_{ij}/2)e_{ij}^2]$ where $c_{ij} = \hat{c}_{ij}/\gamma$. Given the solutions to the managers' problems, F_j seeks $\mathbf{a}_j^*$ which satisfies $\max_{\mathbf{a}_j\geqslant 0} \Sigma_i p_{ij}\pi_i(\mathbf{e}_i^*, \mathbf{k}_i)$ s.t. $\Sigma_{i=1}^n a_{ij} = N_j$.

The first order conditions for manager ij are $(\partial/\partial e_{ij})[p_{ij}\pi_i - (c_{ij}/2)e_{ij}^2] = 0 = p_{ij}k_{ij} - c_{ij}e_{ij}$, yielding $e_{ij}^* = (p_{ij}k_{ij})/c_{ij}$. Then, $\pi_i(\mathbf{e}_i^*, \mathbf{k}_i) = k_{i0} + \Sigma_j p_{ij}(k_{ij}^2/c_{ij})$. We reparameterize the last expression as

$$\pi_i = k_{i0} + \sum_j p_{ij}d_{ij} \tag{2}$$

which we think of as a function of $\mathbf{p}_i = (p_{i1}, \ldots, p_{im})$ for the next stage of the optimization, i.e., $\pi_i = \pi_i(\mathbf{p}_i)$. In what follows, we refer to the expertise-adjusted parameter d_{ij} as the skill of manager ij. We assume that the parameters of the model, k_{i0} and d_{ij} are known to all participants before the bidding. We note that the dependency of π_i on $\mathbf{p}_i$, given in Eq. (2), could have been assumed directly in the optimization problem of Eq. (1) thereby bypassing manager ij completely. We chose our development to motivate this assumption. Either way, we have implicitly assumed (i) a divisibility of managerial control among bidders, (ii) a proportional relationship between managerial control and the degree of ownership, and (iii) an additive linear relationship between profit and skills, or equivalently, no interdependence among owners. These assumptions permit us to model corporate governance in a tractable manner.

We now can restate the optimization problem in Eq. (1) faced by each F_j. Subject to the $F_{j'}$, $j' \neq j$, having chosen their bids, F_j must choose its bids $\mathbf{a}_j$, in a Nash sense, to satisfy

$$\max_{\mathbf{a}_j} \sum_i p_{ij}\pi_i(\mathbf{p}_i) \qquad \text{subject to} \sum_i a_{ij} = N_j. \tag{3}$$

We call this problem the voucher portfolio problem (VPP). The Lagrangians for this problem are

$$L_j = \sum_i p_{ij}\pi_i(\mathbf{p}_i) - \lambda_j\Big(\sum_i a_{ij} - N_j\Big), \qquad j = 1, \ldots, m.$$

The first order conditions for a_{ij} are

$$\frac{\partial L_j}{\partial a_{ij}} = \frac{\partial p_{ij}}{\partial a_{ij}}\pi_i + p_{ij}\frac{\partial \pi_i}{\partial a_{ij}} - \lambda_j = 0, \qquad i = 1, \ldots, n;\ j = 1, \ldots, m. \tag{4}$$

We next establish the existence of a unique solution to the optimization problem faced by each F_j under the condition that one voucher fund has more skill than the others.

3. THE CASE OF SKILLED AND UNSKILLED FUNDS

We assume that F_1, through its managers, may have unique skills in managing at least one of the firms. Furthermore, we assume that all other F_j, $j > 1$, are no more skilled than F_1 in any firm. Specifically, we assume that $d_{ij} = d$, $j > 1$ and $\forall i$ and $d_{i1} \geqslant d\ \forall i$. Let $\Delta_i = (d_{i1} - d)$. Then by adding and subtracting the term $p_{i1}d$ in Eq. (2), noting that $\Sigma_{j=1}^m p_{ij} = 1$, we have

$$\pi_i = k_{i0} + d + p_{i1}\Delta_i. \tag{5}$$

Letting $a_{i\bullet} = \Sigma_{j=1}^m a_{ij}$, we have that

$$\frac{\partial p_{ij}}{\partial a_{ij}} = \frac{1 - p_{ij}}{a_{i\bullet}}, \quad \frac{\partial p_{ij}}{\partial a_{ik}} = \frac{-p_{ij}}{a_{i\bullet}}, \qquad k \neq j,$$

and from Eq. (5),

$$\frac{\partial \pi_1}{\partial a_{i1}} = \frac{1 - p_{i1}}{a_{i\bullet}}\Delta_i \text{ and } \frac{\partial \pi_i}{\partial a_{ij}} = \frac{-p_{ij}}{a_{i\bullet}}\Delta_i \text{ for } j > 1.$$

The VPP under these conditions leads to the following FOCs (Eqs. (4)):

$$\lambda_1 = \frac{1}{a_{i\bullet}}[\pi_i - p_{i1}(\pi_i + p_{i1}\Delta_i - \Delta_i)] \tag{6}$$

and

$$\lambda_j = \frac{1}{a_{i\bullet}}[\pi_i - p_{ij}(\pi_i + p_{i1}\Delta_i)], \qquad j > 1. \tag{7}$$

Before presenting a solution we need the following lemmas.

LEMMA 1. *The equation*

$$(1 - x) = f \frac{a + bx}{a + 2bx}$$

for $0 \leqslant f \leqslant 1$ *and* $a > b \geqslant 0$ *has a unique solution* $x \in [0, 1]$.

Proof. See Appendix A.

LEMMA 2. *Let* $a_i > b_i \geqslant 0$, *for* $i = 1, \ldots, n$. *For every* $\alpha \in [0, 1]$ *there exists a unique* $f^*(\alpha) \in [0, 1]$ *such that*

$$\frac{\Sigma_i \, x_i(f^*)w_i(f^*)}{\Sigma_i \, w_i(f^*)} = \alpha,$$

where for $i = 1, \ldots, n$, $x_i(f^*)$ *are the solutions to the equations*

$$1 - x = f^* \frac{a_i + b_i x}{a_i + 2b_i x}$$

and $w_i(f^*) = a_i + b_i x_i(f^*)$.

Proof. See Appendix B.

THEOREM 1. *Let* $d_{ij} = d$ *for* $j > 1$ *and* $\forall i$ *and let* $\Delta_1 = d_{i1} - d \geqslant 0 \; \forall \; i$. *Let* $k_{i0} + d > \Delta_i \; \forall i$. *Let* p_{i1} *be the nonnegative solution to the equation*

$$1 - p = \ominus \frac{\pi_i}{\pi_i + \Delta_i p} \qquad \forall i,$$

where $\ominus$ *is the solution to the equation*

$$\frac{N_1}{N} = \frac{\Sigma_i \, p_{i1}\pi_i}{\Sigma_i \, \pi_i}$$

when the π_i *are evaluated at* p_{i1}. *Then the unique Nash solution to the VPP given by Eq. (3) is*

$$a_{i1} = Kp_{i1}\pi_i \qquad \forall i$$

$$a_{ij} = K(1 - p_{i1}) \frac{\pi_i N_j}{N - N_1} \qquad \forall i, \quad j > 1$$

$$\lambda_1 = \frac{\ominus}{K}$$

$$\lambda_j = \frac{1}{K}\left(1 - \frac{\ominus N_j}{N - N_1}\right) \qquad j > 1$$

$$K^{-1} = \frac{1}{N} \sum_i \pi_i \, ,$$

where all the π_i *are evaluated at* p_{i1}.

Proof. See Appendix C.

The solution to the VPP that we present in Theorem 1 establishes the bids of all the F_j. We note that $a_{i1} = (N\pi_i/\Sigma_i \pi_i)p_{i1}$ and $\Sigma_{j>1} a_{ij} = (N\pi_i/\Sigma_i \pi_i)$ (1 − p_{i1}). Therefore, at equilibrium, the total number of vouchers bid for firm *i* is $N\pi_i/\Sigma_i \pi_i$ with F_1 contributing the proportion p_{i1} of this amount and F_j, $j > 1$, contributing N_j/N of the remaining amount $(N\pi_i/\Sigma_i \pi_i)$ $(1 - p_{i1})$. The total number of vouchers bid for firm *i* is thus proportional to π_i even though π_i itself depends on the distribution of ownership determined by the bidding process. Because of this dependence, the π_i cannot be known in advance of the bidding process. It also follows from these remarks that the solution yields to F_1 the proportion of ownership p_{i1} of firm *i* and to F_j, $j > 1$, the proportion of ownership (N_j/N) $(1 - p_{i1})$.

The factor K^{-1} can be interpreted as the value per voucher determined by the bidding process. Then $\lambda_1 = K^{-1}\ominus$ can be interpreted as the percentage of this value that F_1 can be expected to gain if it acquired an additional voucher. A similar interpretation holds for λ_j, $j > 1$. We defer until later comments on the relative sizes of the λ_j.

As we have seen, the *n* values of p_{i1} and the value of $\ominus$ found in the shadow prices are jointly determined. To further interpret the p_{i1} and $\ominus$, it is necessary to have a benchmark against which to compare them. A natural benchmark case is the one in which all Δ_i equal zero. We begin by establishing this benchmark.

COROLLARY 1. *$\ominus \geqslant 1 - N_1/N$ and $\ominus = 1 - N_1/N$ iff $\Delta_i = 0 \ \forall \ i$.*

Proof. See Appendix D.

We now establish the pattern of ownership in the benchmark case where $\Delta_i = 0 \ \forall \ i$.

COROLLARY 2. *If $\Delta_i = 0 \ \forall \ i$, then $p_{ij} = N_j/N \ \forall \ i, j$.*

Proof. Given that $\Delta_i = 0 \ \forall \ i$, $\ominus = 1 - N_1/N$ by Corollary 1 and we have that $(1 - p_{i1}) = (1 - N_1/N)$, or $p_{i1} = N_1/N$. Recalling that

$$p_{ij} = (1 - p_{i1}) \frac{N_j}{N - N_1}, \qquad j > 1,$$

we see immediately that $p_{ij} = N_j/N$. Thus $p_{ij} = N_j/N \ \forall i, j$. ∎

When no differential skill exists among the F_j, then each F_j acquires, as a consequence of all the bids, the same proportion of ownership N_j/N in all firms. Thus the initial voucher holdings, which we have taken to be given, play an important role even in the benchmark case. Nonetheless, it is instructive to consider the special case in which all N_j are equal. In this case, the benchmark solution gives to each F_j the same proportion of ownership $1/m$.

The bound established in Corollary 1 permits us to explore the relative sizes of the shadow prices, which we do next.

COROLLARY 3.

$$\lambda_1 \geqslant \left(1 - \frac{N_1}{N}\right) \frac{\Sigma_i \pi_i}{N}$$

and

$$\lambda_j \leqslant \left(1 - \frac{N_j}{N}\right) \frac{\Sigma_i \pi_i}{N}, \qquad j > 1$$

with equalities holding iff $\Delta_i = 0 \ \forall \ i$.

Proof. From Corollary 1,

$$\lambda_1 = \frac{\ominus}{K} \geqslant \frac{1}{K}\left(1 - \frac{N_1}{N}\right).$$

Substituting the value for K, the result follows. Similarly,

$$\lambda_j = \frac{1}{K}\left(1 - \frac{\ominus N_j}{N - N_j}\right) \leqslant \frac{1}{K}\left(1 - \frac{(1 - N_1/N)\, N_j}{N - N_1}\right) = \frac{1}{K}\left(1 - \frac{N_j}{N}\right).$$

Since $\ominus = 1 - N_1/N$ iff $\Delta_i = 0 \ \forall \ i$, the inequalities become equalities in this case. ■

The shadow price for each F_j in the benchmark case is equal to

$$\left(1 - \frac{N_j}{N}\right) \frac{\Sigma_i \pi_i}{N},$$

where the $\Sigma_i \pi_i$ is the total profit achieved in the absence of any differential skill. Under these conditions, we denote $\Sigma_i \pi_i$ by Π^u. Thus Π^u/N represents the value per voucher and the shadow price is this value multiplied by the proportion of the firm not owned by F_j. When F_1 has unique skills in managing at least one firm, then the shadow price for a voucher increases, compared with its benchmark value, from two sources. First, the total profit, $\Sigma_i \pi_i$, is evaluated incorporating these different skills and is hence larger. We denote total profit in the presence of these skills by Π^s. Since $\Pi^s > \Pi^u$, the voucher value increases, as does the shadow price. Second, by Corollary 1, $\ominus > 1 - N_1/N$, providing an additional source of increase for the shadow price. Finally, if all the N_j are equal, then $\lambda_1 > \lambda_j$, $j > 1$.

We next show that the VPP yields greater ownership to F_1 in those firms in which F_1 can provide greater returns. In what follows, we let

$$r_i = \frac{\Delta_i}{k_{i0} + d} \qquad \forall i.$$

This represents the return of firm i if F_1 were to acquire complete ownership of firm i. By earlier assumptions, $0 \leqslant r_i \leqslant 1$.

COROLLARY 4. *If $r_i > r_{i'}$, then $p_{i1} > p_{i'1}$ and $p_{ij} < p_{i'j}$, $j < 1$. If $r_i = r_{i'}$, then $p_{i1} = p_{i'1}$ and $p_{ij} = p_{i'j}$, $j > 1$.*

Proof. Since the value of p_{i1} is explicitly given by $(1/4r_i)[r_i(2 - \ominus) - 1 + ((r_i(2 - \ominus) - 1)^2 + 8r_i(1 - \ominus))^{1/2}]$ it follows that $r_i p_{i1}$ is a strictly increasing function of r_i. Therefore, as r_i increases, the right-hand side of

$$1 - p_{i1} = \ominus \frac{1 + r_i p_{i1}}{1 + 2r_i p_{i1}}$$

decreases and p_{i1} strictly increases. Since

$$p_{ij} = (1 - p_{i1}) \frac{N_j}{N - N_1},$$

by the argument just given, it follows that $p_{ij} < p_{i'j}$, $j > 1$. The second half of the corollary follows from the fact that p_{i1} is uniquely determined by r_i. ■

This corollary shows that as a result of the bids, the VPP ranks the ownership of firms consistent with the ability of F_1 to affect returns. At the same time, it inversely ranks the ownership of F_j, $j > 1$. The ceding of ownership to F_1 is the result of its positive impact on profit and thus F_j receives greater profit while obtaining a smaller ownership share of these firms. Due to the fact that the N_j are not all the same, it is difficult to compare the size of p_{i1} to p_{ij}. The next corollary provides some clarification of this.

COROLLARY 5. *Let $r_1 = r_2 = \cdots = r_{n_1} = 0$ and let $0 < r_{n_1+1} \leqslant \cdots \leqslant r_n$. Then, there exists an n', $n_1 \leqslant n' \leqslant n$, such that $p_{i1} < N_1/N$ for $i < n'$ and $p_{i1} > N_1/N$ for $i \geqslant n'$.*

Proof. For $i \leqslant n_1$, $1 - p_{i1} = \ominus > 1 - N_1/N$ by Corollary 1. Therefore $p_{i1} < N_1/N$. Since $\ominus$ was determined so that

$$\frac{\Sigma_i\, p_{i1}\pi_i}{\Sigma_i\, \pi_i} = \frac{N_1}{N},$$

there must be some p_{i1}, $i > n_1$, with values greater than N_1/N. By Corollary 4 the p_{i1} are ordered according to the r_i and thus there must exist an $n_1 < n' \leqslant n$ such that $p_{i1} > N_1/N$ for $i \geqslant n'$. ■

The solution to the VPP does not necessarily yield to F_1 a larger proportion of ownership in all firms in which F_1 has differential skills; however, for a subset of these firms, a subset in which F_1 is most skilled, the solution yields a greater proportion of ownership to F_1 compared to the benchmark case, i.e., $p_{i1} > N_1/N$ for $i \geqslant n'$. Also, since

$$p_{ij} = (1 - p_{i1}) \frac{N_j}{N - N_1},$$

it follows that $p_{ij} < N_j/N$ for $i \geqslant n'$. If all the N_j were equal, then a comparison between p_{i1} and p_{ij} could be made, and we present this in the next corollary.

COROLLARY 6. *If $N_j/N = 1/m \ \forall\ j$, then $p_{i1} > p_{ij}$ for $i \geqslant n'$ where n' is defined as in Corollary 5.*

Proof. The proof follows directly from the preceding remarks. ■

We next evaluate the profit that the VPP yields to each F_j. Recall that $\Pi^s = \Sigma_i\ \pi_i$ evaluated at p_{i1} when not all the Δ_i are equal to zero.

COROLLARY 7. *The solution to the VPP yields to F_j the profit $(N_j/N)\Pi^s\ \forall\ j$.*

Proof. The profit F_1 receives is $\Sigma_i\ p_{i1}\pi_i$. Since $\ominus$ was determined so that

$$\frac{\Sigma_i\ p_{i1}\pi_i}{\Sigma_i\ \pi_i} = \frac{N_1}{N},$$

we have that the profit for F_1 is $(N_1/N)\Pi^s$. The profit F_j receives is

$$\sum_i p_{ij}\pi_i = \frac{N_j}{N - N_1} \sum_i (1 - p_{i1})\pi_i = \frac{N_j}{N - N_1} (\Sigma_i\ \pi_i - \frac{N_1}{N} \sum_i \pi_i) = \frac{N_j}{N} \Pi^s. \quad ■$$

In the solution to the VPP each F_j receives a proportional share of Π^s. It is worth emphasizing that Π^s is monotonic increasing in $\Sigma_i p_{i1} \Delta_i$ and thus its size depends critically on the ownership pattern of F_1. Therefore, if F_j, $j > 1$, had more vouchers while F_1 had fewer, it would not necessarily follow that the profit of F_j would have increased since the magnitude of p_{i1} depends on N_1 through $\ominus$. We next explore this idea.

When $\Delta_i > 0$ and $\Delta_{i'} = 0$ for $i' \neq i$, $\Pi^s = \Pi^u + p_{i1}\Delta_i$. Therefore, to investigate changes in Π^s when parameters change, under these conditions we need only look at changes in p_{i1}.

COROLLARY 8. *Let $\Delta_i > 0$ and $\Delta_{i'} = 0$ for $i' \neq i$, and let $\alpha = N_1/N$. Then, $d\Pi^s/d\alpha > 0$.*

Proof. See Appendix E.

This supports the idea expressed above in the following way. Suppose a voucher is taken from F_1 and given to F_j. Then N_j/N increases and N_1/N decreases which, by Corollary 8, implies that Π^s decreases. This leaves open the question as to whether the product of these two changes benefits F_j; however, it is clear that the profit to F_1 falls.

4. DISCUSSION

In the Introduction, we described the somewhat conflicting goals facing a government wishing to transfer assets from public to private ownership. With regard to the goal of equity, the Czech, Russian, and Polish plans adopted a similar stance toward the individual. That is, each citizen was given an equal opportunity to become a shareholder in firms being privatized. However, these plans differed in the degree to which they permitted the marketplace to participate in the privatization process. The Czech Republic offered for sale at voucher auction 97% of the shares of each firm being privatized, and 3% of the shares were reserved by the state; Russia offered 29% of the shares at voucher auction, and for the remainder of the shares the government created three options, with most firms choosing the option that left insiders with majority control;[9] and Poland offered no shares at voucher auction. We thus think of the three strategies as points along a continuum according to the degree to which they permitted the marketplace to participate in the privatization process. In this sense, the three plans can be thought of as representing the spectrum of existing plans.

Although all three strategies enable a government to effect the transfer of ownership, the implications for corporate governance, and hence the goal of improved economic performance, differ. All these strategies led to multiple ownership of the firms and therefore a sharing of corporate governance. This sharing of responsibility, and its impact on firm profits, is what we attempted to capture with the assumptions of a proportional and additive impact of ownership on profit. While being simplistic, these assumptions permitted us to incorporate the idea of shared responsibility in our voucher privatization model. In our model, we combine the unique features of voucher privatization, specifically that there is a bidding process and that the set of voucher bids affects the profits of the firms offered for voucher auction, the idea of shared responsibility, to yield normative investment behavior. We now use the results of our model to shed light on the strategies used by the three countries and to compare the economic performance associated with these strategies.

As a result of the Nash solution obtained in Theorem 1, derived under the assumptions that the shares (N_j) acquired by the VPF (F_j) were given and that information was freely available, it followed that (1) an F_j would acquire more ownership in firms in which its relative skill was higher, and (2) at equilibrium each F_j would receive a share of total profit proportional to N_j where total profit is taken to mean the sum of all profit achieved at this Nash solution. We interpret this total profit as a measure of economic performance of the plan. Since, in the VPP, total profit depends on the given set of N_j, questions of different total profit levels involve alternate distributions of the

[9] For the specifics concerning the three options open to managers and workers, see, for example, Boycko et al. (1995).

vouchers to the F_j. Since we also showed that by increasing the number of vouchers to the more skilled funds total profit would be increased, it follows that we can evaluate voucher plans by their ability to induce voucher holders to give more vouchers to the more skilled F_j. For nonvoucher plans, as in the Polish case, the assessment of a plan's impact on total profit must be made directly. We now evaluate the Czech, Russian, and Polish plans from this perspective.

We begin with the Czech strategy. In the Czech case, where almost all privatization was accomplished using vouchers, individuals could use their vouchers to bid directly for the shares offered for sale, or could exchange their vouchers for shares in the VPFs that would then bid for the shares. A vast majority of the vouchers, actually, in the Czech case, the voucher points, were given to the VPFs. Thus, each VPF (F_j) acquired a certain number of vouchers, N_j, $j = 1, \ldots, m$, and a bidding process for ownership followed. We now consider the conditions under which the resulting ownership pattern would lead to improved economic performance. As argued above, improved economic performance would prevail if, as a result of the bidding process, skilled managers acquired a larger share of ownership. From Theorem 1 and its corollaries, it follows that improved economic performance would occur if the pattern of vouchers N_j were highly correlated with the pattern of skills, d_{ij}, of the F_j. This would happen if the populace were sufficiently informed about the skills of the F_j. Under the assumption that this information were available to the population, the Czech strategy appears to be a realization of the optimal solution of our model. However, questions arise as to what sorts of information are available and how such information might be acquired by the population. If, for example, advertising by the F_j were permitted without a requirement of truth in advertising, then the pattern of N_j acquired by the F_j might be very unlike the pattern of their skills and thus economic performance might be impeded. In fact, since the F_j were newly formed at the time of voucher privatization, very little information could be known about them, or about the banks with which most F_j were associated since these banks themselves lacked track records, making the issue of advertising a problem.

In Russia, where insiders were permitted to maintain majority control, the possibility for improved corporate governance through the voucher bidding process was severely impaired. The only assumption that could be made which would make this strategy a realization of an optimal solution would be if the insiders represented highly skilled management. Still, of the 29% of the shares put up for voucher bids, an informed populace could result in skilled F_j acquiring larger ownership shares, as in the Czech case. But, as in the Czech case, should information about skills not be available or should advertising contort this information, then economic development would suffer.

Under the Polish plan, in random order, each F_j selected a firm in which to become the lead fund, with each F_j having the same number of choices. While there is neither a voucher acquisition stage for the F_j nor a bidding process among the F_j, we can nonetheless describe conditions under which the Polish strategy would yield improved economic performance. If the government chose equally skilled F_j, with their skills in different industries, and if these F_j chose to be lead funds for firms in those industries, then, since profit is assumed to be related to managerial skills, total profit and thereby economic performance would be improved. Thus this plan would automatically align skills with ownership. Unlike in the Czech and Russian cases, the information available to the populace is, in fact, not relevant to the implied optimality of the Polish plan. Rather, what is relevant is the ability of the government to assess the capabilities of the F_j better than the populace could have done and to pick the set of F_j with the above described characteristics.

Our model demonstrates that the results of a bidding process may not align skills with ownership. This possible contortion has been noted but not formalized in discussions of voucher privatization and its resultant implications for corporate governance and performance. Our analysis of the three points on the continuum suggests that the two extreme points, the Czech and Polish cases, represent realizations of situations which might lead to improved corporate governance and performance, although the level of marketplace participation markedly differs. This improvement in economic performance can, of course, be threatened by problems of information. In the Czech case, the populace needs the ability to evaluate newly formed VPFs, while in the Polish case the government must evaluate potential funds. It seems to us, in this startup situation, that the information requirements of the Polish strategy are less stringent.

Perhaps voucher privatization may come to be remembered better as a mechanism for mobilizing the necessary popular support to permit a timely transfer of ownership than as a mechanism whose implications for ownership, and consequently for economic performance, are optimal.

APPENDIX A: PROOF OF LEMMA 1

Multiplying through by $a + 2bx$ and collecting terms, x must satisfy $2bx^2 + x[a - b - b(1 - f)] - a(1 - f) = 0$. For $0 < f < 1$, this convex function is negative at $x = 0$ and positive at $x = 1$ and thus has a unique root in the open interval (0, 1). For $f = 1$, this is a monotonic convex function which is zero when $x = 0$ and positive when $x = 1$; thus, the unique root is zero. Finally, for $f = 0$, the unique root is one. ■

APPENDIX B: PROOF OF LEMMA 2

When $b_i > 0$, x_i is given by $4b_ix_i = b_i(1 - f) + b_i - a_i + [(b_i(1 - f) + b_i - a_i)^2 + 8a_ib_i(1 - f)]^{1/2}$ which is a continuous strictly decreasing function of f. (When $b_i = 0$, $x_i = 1 - f$ which has the same properties.) Thus, w_i is also a continuous strictly decreasing function of f. To prove the lemma, it then suffices to show that the difference $D(f) = \Sigma_i\, x_i(f)w_i(f) - \alpha\, \Sigma_i\, w_i(f)$

is strictly decreasing with $D(0) \geqslant 0$ and $D(1) < 0$. Since $D(f) = \Sigma_i\,[a_i x_i + b_i x_i^2 - \alpha a_i - \alpha b_i x_i]$ it follows that $D(0) = \Sigma_i\,(1 - \alpha)(a_i + b_i) \geqslant 0$. Also, $D(1) = -\alpha\,\Sigma_i\,a_i < 0$. Finally $dD/df = \Sigma_i\,[a_i - \alpha b_i + 2x_i b_i](dx_i/df)$. Since, by previous remarks, $dx_i/df < 0$, it follows that $dD/df < 0$. ■

APPENDIX C: PROOF OF THEOREM 1

We first show that p_{i1} and $\ominus$ are uniquely and jointly determined by their respective $n + 1$ equations. Setting $k_{i0} + d = a_i$ and $\Delta_i = b_i$ it follows that Eq. (5) becomes $\pi_i = a_i + b_i p_{i1}$ and therefore the defining equation for p_{i1} becomes

$$1 - p = \ominus\,\frac{a_i + b_i p}{a_i + 2b_i p}\,.$$

If $0 \leqslant \ominus \leqslant 1$, it follows from Lemma 1 that p_{i1} is unique in [0, 1]. We now show that $\ominus$ is, in fact, in that interval. Since $\pi_i = a_i + b_i p_{i1}$ all the assumptions of Lemma 2 are met and it follows that for $0 \leqslant N_j/N \leqslant 1$ there exists a unique $\ominus \in [0, 1]$ which makes

$$\frac{\Sigma_i\,p_{i1}(\ominus)\pi_i(\ominus)}{\Sigma_i\,\pi_i(\ominus)} = \frac{N_1}{N}\,.$$

We now show that the FOCs given in Eqs. (6) and (7) are met. First, $a_{i\bullet} = \Sigma_j\,a_{ij} = K\pi_i\ \forall i$. Since $p_{ij} = a_{ij}/a_{i\bullet}$ it follows that $p_{i1} \equiv p_{i1}$ and

$$p_{ij} = (1 - p_{i1})\,\frac{N_j}{N - N_1}\,, \qquad j > 1.$$

Evaluating the FOCs given in Eq. (6), we have that

$$\frac{1}{a_{i\bullet}}\,[\pi_i - p_{i1}(\pi_i + p_{i1}\Delta_i - \Delta_i)] = \frac{1}{a_{i\bullet}}\,(1 - p_{i1})(\pi_i + p_{i1}\Delta_i)$$

$$= \frac{\ominus\pi_i}{a_{i\bullet}} = \frac{\ominus}{K} = \lambda_1.$$

Evaluating the FOCs given in Eq. (7) we have that for $j > 1$,

$$\frac{1}{a_{i\bullet}}\,[\pi_i - p_{ij}(\pi_i + p_{i1}\Delta_i)] = \frac{1}{a_{i\bullet}}\left[\pi_i - (1 - p_{i1})\,\frac{N_j}{N - N_1}\,(\pi_i + p_{i1}\Delta_i)\right]$$

$$= \frac{1}{a_{i\bullet}}\left[\pi_i - \frac{N_j}{N - N_1}\,\ominus\,\pi_i\right]$$

$$= \frac{1}{K}\left(1 - \frac{\ominus N_j}{N - N_1}\right) = \lambda_j.$$

We next show the constraints are satisfied. Summing the elements of the first column we have $K \Sigma_i p_{i1}\pi_i$ which equals

$$\frac{N \Sigma_i p_{i1}\pi_i}{\Sigma_i \pi_i}$$

by substituting the K value given above. The value of $\ominus$ was chosen so that this last expression would equal $N(N_1/N) = N_1$. Summing the elements of the jth column we have

$$\frac{N_j K}{N - N_1} \sum_i (1 - p_{i1})\pi_i = \frac{N_j K}{N - N_1} [\sum_i \pi_i - \sum_i p_{i1}\pi_i]$$
$$= \frac{N_j K}{N - N_1} \sum_i \pi_i \left(1 - \frac{N_1}{N}\right) = N_j.$$

Since the objective function is separable in the a_{ij}, the strict concavity of the objective function follows by showing that each term is concave with at least one being strictly concave. Since $\partial^2 p_{ij}\pi_i/\partial a_{ij}^2 = -2(1 - p_{ij})(k_{i0} + d + 3p_{ij} - \Delta_i)/a_{i\cdot}^2$, the fact that p_{ij} cannot be unity for all i and the assumption that $k_{i0} + d > \Delta_i$ implies that at least one second derivative is strictly negative. Therefore, the objective function is strictly concave and the solution is then unique. ■

APPENDIX D: PROOF OF COROLLARY 1

Since

$$1 - p_{i1} = \ominus \frac{\pi_i}{\pi_i + \Delta_i p_{i1}},$$

it follows that $1 - p_{i1} \leqslant \ominus$ or $p_{i1} \geqslant 1 - \ominus$. Since $\ominus$ was chosen to make

$$\frac{N_1}{N} = \frac{\Sigma_i p_{i1}\pi_i}{\Sigma_i \pi_i},$$

it follows that $N_1/N \geqslant 1 - \ominus$ and therefore $\ominus \geqslant 1 - N_1/N$.

If $\Delta_i = 0 \ \forall \ i$, then $p_{i1} = 1 - \ominus$ and $N_1/N = 1 - \ominus$. Now assume that $\Delta_i > 0$ for $i = i'$. Then, $p_{i1} \geqslant 1 - \ominus$, $i \neq i'$ and $p_{i'1} > 1 - \ominus$. Thus

$$\frac{N_1}{N} = \frac{\Sigma_i p_{i1}\pi_i}{\Sigma_i \pi_i} > 1 - \ominus$$

and therefore $\ominus > 1 - N_1/N$.

APPENDIX E: PROOF OF COROLLARY 8

From the remarks above, it suffices to show that $dp_{i1}/d\alpha > 0$. Since p_{i1} depends on $\ominus$ which in turn is affected by α, we must examine the equation that relates these variables. The p_{i1} and $\ominus$ are connected by the equation $\Sigma_i\, p_{i1}\pi_i = \alpha\, \Sigma_i\, \pi_i$. Since $\Delta_{i'} = 0$ for $i' \neq i$, by Corollary 5 $p_{i'1} = 1 - \ominus$. Thus the last equation becomes $(1 - \ominus)\, \Sigma_{k\neq i}\, \pi_k + p_{i1}\pi_i - \alpha\Pi^s = 0$. Implicitly differentiating w.r.t. α, we have that

$$-\frac{d\ominus}{d\alpha}\sum_{k\neq i}\pi_k + \frac{dp_{i1}}{d\alpha}(\pi_i + p_{i1}\Delta_i) - \left(\Pi^s + \alpha\frac{dp_{i1}}{d\alpha}\Delta_i\right) = 0.$$

Notice also that

$$\frac{d\ominus}{d\alpha} = \left(\frac{dp_{i1}}{d\ominus}\right)^{-1}\frac{dp_{i1}}{d\alpha}.$$

Finally, we have

$$\frac{dp_{i1}}{d\alpha}\left[\pi_i + (p_{i1} - \alpha)\Delta_i - \left(\frac{dp_{i1}}{d\ominus}\right)^{-1}\sum_{k\neq i}\pi_k\right] - \Pi^s = 0.$$

From Corollary 5, $p_{i1} > \alpha$ and from the defining equation of p_{i1} (see proof of Corollary 4) p_{i1} is strictly decreasing in $\ominus$ so $dp_{i1}/d\ominus < 0$ and the coefficient of $dp_{i1}/d\alpha$ is then positive. Since $\Pi^s > 0$, the result follows. ■

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