Information Technology and Organization Design: Locating Decisions and Information

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We study the impact of information technology (IT) on the profitability of individual organization designs and on the relative profitability of different organization designs. We develop models where organization design is defined by the location of investment decision authority. We consider global and local investment when there is an information asymmetry between a central authority and decentralized nodes—decentralized nodes make better local investment decisions because of their local knowledge. We define three separate organization designs: a hierarchy where all investments are made by a central authority, a market where all investments are made by the decentralized nodes, and a mixed mode where global investments are made by a central authority and local investments are made by decentralized nodes. Because of complementarities between global and local investment, we show that there is underinvestment relative to first-best in all three organization designs. We also find that IT can be used to mitigate that underinvestment, either by bringing information to the decision maker or by redesigning the monitoring and incentive structure. We demonstrate that IT does not necessarily favor decentralized organization designs, and we show how the costs of coordination may result in the mixed mode being dominated by one or both of the alternative organization designs. Thus, collocation of investment decision rights and information that results in decisions that require coordination might not be optimal when the costs of not synchronizing global and local investment are high.
(*Centralization/Decentralization*; *Collocation*; *Decision Rights*; *Information Asymmetry*; *Network Externalities*; *Organizational Form*)

1. Introduction

One of the most important frontiers of current research is how information technology (IT) affects organization design. Understanding the effects that IT has on individual organization designs and the potential relative advantages IT brings to different organization designs is crucial to making progress on this frontier. A critical feature that distinguishes between organization designs is the location of decision rights, that is, what part of the organization is responsible for making particular decisions. If decision rights are centralized, then the organization operates as a hierarchy—if they are decentralized, then the organization operates as a market. IT makes it possible to choose where decision-relevant information is located in the organization structure. IT can also improve the performance of a given organization design.

Hayek (1945) argued that an organization's performance results from making its best use of resources, which in turn requires that information (knowledge) and decision rights be located together. Jensen and Meckling (1992) stated two ways to collocate information and decision rights: first, to move the information closer to the decision maker; and second, to move the decision rights closer to those with the information. These have been referred to as the *MIS solution* and the *organization redesign solution*, respectively.[1] The MIS

[1] Brynjolfsson and Mendelson (1993).

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solution—the traditional view of IT used to support decision making that can be analyzed with information economics—is usually associated with centralization. The organizational redesign solution has earlier roots (pre-MIS) and usually favors some form of decentralization. Using Williamson's transaction cost theory as a referent, Gurbaxani and Whang (1991) examined whether IT induces centralization or decentralization of decision making in organizations and suggested that decision rights should be pushed down to where costs of communicating information up the organization are equal to the costs of goal divergence. Because IT can improve each cost, there is no reason to believe that one will dominate.

A complementary framing of the decision rights allocation problem was explored by King (1983) in the context of centralized versus decentralized computing. He argued that centralization of these rights promotes continuity in organizational operations because decisions are made at a single level, but separates the making of decisions from their environment. On the other hand, decentralization forces decision rights down to lower levels, possibly improving performance and encouraging innovation. Problems arise, however, if the lower levels are incompetent or unaccountable for their decisions. The key insight is that decision rights must reside at a single location rather than being shared.

We study the effects of IT—particularly those effects made up of knowledge, monitoring, and incentives—on the profitability of individual organization designs and on the relative profitability of different organization designs. We formulate the problem in terms of a central authority and a network of nodes making two types of complementary investments: one centralized (*global*) investment and many decentralized (*local*) investments. Thus, the decision rights in our model are rights to decide the levels of global and local investments. Our model focuses on a critical information asymmetry between the central authority and decentralized nodes—decentralized nodes make better local investments because of their local knowledge. We define three separate organization designs: (1) hierarchy, where all investments are made by the central authority; (2) market, where all investments are made by the decentralized nodes; and (3) mixed mode, where global investments are made by the central authority and local investments are made by decentralized nodes.

To make the model concrete, we consider a market for a good or service that is supplied by the organization. Nodes have well-defined locations, and customers are partitioned by location. Customers have demands inside and outside their location. Using the commercial fueling industry as an example, a given geographic area contains the main office of trucking firms whose vehicles require fuel in various locations outside that geographic area. We concentrate on particular types of global and local investment—local investment is investment that affects demands from local customers whether the demand is local or not. Therefore, investment by one node affects demands at other nodes, creating an interdependence between them. Thompson (1967) would refer to this as *pooled interdependence*, recognizing that nodes have a measure of power over one another. Global investment affects all the demands. The key assumption in the model that drives our main result comparing organization designs is the information asymmetry about local investment. The key restriction we use in the model that determines where the model can be applied concerns the effects of local investment on demands. Using our example from commercial fueling, local investments can be thought of as recruiting and promotional visits to local trucking firms rather than investments at the point of sale. Global investments could be national advertising in the road transport trade press that affects both recruitment and sales. Therefore, it is inappropriate to apply our analysis to contexts where local information about point of sale investments is both important and private. It is worth noting that if local information about point of sale investments is important but known to the central authority, these investments can be contracted, and the results of our analysis whould still hold.[2]

We model the effects of IT in two ways. First, in previous work we proposed *ownership of customers* as an IT-based mechanism to improve local investment incentives when local investment rights are decentralized (Nault and Dexter 1994, Nault 1997). Ownership of customers has three features: (1) unique identification of

[2] Assuming, of course, that contract completeness is not an issue.

individual customers with individual nodes, (2) perfect monitoring of customer purchases across nodes, and (3) transfers of profits between nodes based on internode customer purchases. That is, each customer is owned by one node, all purchases by those owned customers are tracked perfectly across the network of nodes by the central authority, and profits from internode purchases are transferred between nodes. The IT-basis for ownership of customers is both simple and crucial: (a) unique identification is handled with database matching, (b) monitoring takes place through network transaction processing, and (c) the transfer of profits is accomplished through electronic funds transfer. Second, we capture the effects of IT through a lessening of the impact of the information asymmetry, consistent with the information economic approach of concentrating on information characteristics such as timeliness, accuracy, and fineness (Ahituv 1980, Feltham 1968, Hilton 1981, Marschack and Radner 1972). Thus, our modeling of the effects of IT is not inconsistent with the MIS and organization redesign solutions. We adopt the MIS solution in the hierarchy and mixed mode forms where we model the MIS solution as a lessening of the information asymmetry through the use of IT. We also adopt the organizational redesign solution that we model as moving decision rights for local investment to nodes and as our ownership of customers structure in the market and mixed mode forms. Thus, the mixed mode is a blend of both solutions.

Our models yield three main results. First, we show that because of investment complementarities, there is both global and local underinvestment relative to first-best in all three organization designs. Second, we show that IT mitigates both global and local underinvestment in each of the organization designs. Therefore, as long as the IT costs are not excessive, the joint profitability of each organization design is increased by IT. Third, we demonstrate that the effects of IT do not necessarily favor decentralized organization designs and, most importantly, show how the costs of coordination may result in the mixed mode being an organization design that is dominated by one or both alternative organization designs. Thus, the collocation of information and decision rights—our mixed mode—suffers from coordination problems that are not encountered when decision rights are fully centralized or decentralized.

There are two agency aspects to our formulation. There is a vertical agency problem in that the central authority cannot determine the correct (first-best) levels of local investment. Because of investment complementarities, this lack of information about local investment is also reflected in global investment. The horizontal agency problem is that each node ignores the effects of its investment on other nodes (Katz 1989). Thus, unless the incentives reward nodes based on nonlocal (external) as well as local effects of their investments, external effects will not be accounted for in local investment decision making. Investment complementarities again extend those effects to global investment.

The structure of our model is similar to the one used in Nault and Dexter (1994). That article examines the impact of IT on a franchise organization where local investments were made by franchises and franchises could decide individually whether to adopt the IT. The results from that work show that IT could increase the levels of local investment chosen by the franchises, but not all franchises choose to adopt the IT. Studying only the local investment decision, Nault (1997) extends that analysis to determine when the franchisor, the franchisees, or both are more profitable. Juxtaposing those articles with this one, local investment in those models is akin to local investment in our market organization design. However, here we add global investment to the decisions made by nodes in the market organization design. Moreover, consolidated global and local investments by the central authority (our hierarchy) and partitioned global and local investments (our mixed mode) are not part of the prior formulation. Our comparison of organization designs and implications for the allocation of decision rights—the most important contribution of this article—is novel as well.

Aspects of our work are related to research on divisionalization. Veendorp (1991) examined the effect of the location of capacity investment rights and the reversibility of that investment on a firm's ability to forestall entry. He found that centralizing the irreversible investment decision mitigates the negative effect of independent division decisions accounting only for divisional profits, similar to our horizontal agency problem.

There are also connections between our work and research in organization theory, some of which incorporates additional features such as heterogeneous technologies, turnover, and reliability. Cohen et al. (1972) hypothesize that heterogeneous technology and high interrelation of problems (our horizontal externalities and complementarity between local and global investment) lead to hierarchical decision structures, where hierarchical decision structures are defined as structures that locate more important problems where there is wider access to choices. Simulating a series of decision problems with learning, Carley (1992) finds that hierarchies—modelled as lower levels making recommendations to higher levels—can be outperformed by teams (e.g., democracies) but are less affected by turnover because superior organizational memory is maintained. Using nuclear powered aircraft carriers as the subject of a study of high reliability organizations (HROs), Roberts (1990) found that tasks in HROs are highly interdependent. To manage such an environment, this particular HRO employs extreme hierarchical differentiation—providing explicit roles to individuals and sequences of tasks. Behavior is reinforced by goal congruence within the organization—keeping aircraft flying and safety (e.g., reliability).

Our approach differs from the mechanism design approach to resolving an information asymmetry. In that approach a principal designs an incentive mechanism that forces agents to reveal their types by the incentives they choose. In our problem the mechanism design approach is infeasible because we imagine an environment where individual nodes have access to continuously changing information (Hayek 1945). Therefore, revelation at one point would provide the principal with little value because the information changes continuously.

The remainder of the paper proceeds as follows. In §2 we detail the assumptions underlying our models. In §3 we analyze the different organization designs. We determine the first-best solution and then successively examine investments in the hierarchy, the market, and the mixed mode designs. We then compare the three organization designs. Section 4 contains our concluding remarks.

2. Organization Structure: Our Assumptions

The organization structure we model has one central authority and many decentralized nodes. We consider nodes to be analogous to branches, outlets, affiliates or franchises. It is useful for our exposition to associate nodes with locations.

ASSUMPTION 1. *Decentralized nodes differ. A node is responsible for a single location, and customers are partitioned by location of residence.*

Individual nodes are identified by x, and x is distributed $f(x) > 0$ over $x \epsilon [\underline{x}, \overline{x}]$ and the density is zero elsewhere. x could represent, for example, the size of the local market. The partitioning of customers by location of residence captures locational inelasticities or exclusive rights to customers.

ASSUMPTION 2. *There are two types of investment: global and local.*

Global investment is represented by a and can be thought of as organization-wide investment. When nodes choose their individual contribution to global investment this contribution is denoted by a_x and total global investment is $a = \int_{\underline{x}}^{\overline{x}} a_x f(x) dx$. Local investment is location specific and is represented by e_x. Investment possibilities range over the compact and convex intervals $[\underline{a}, \overline{a}]$, $[\underline{a_x}, \overline{a_x}]$ and $[\underline{e_x}, \overline{e_x}]$. We treat a, a_x and e_x generically where, for example, global investment could represent national advertising and local investment could represent effort in new customer recruitment. The vector of local investment over $x \epsilon [\underline{x}, \overline{x}]$ is $\mathbf{e} = (e_x, e_{\setminus x})$, where e_x is the local investment made in location x and $e_{\setminus x}$ is the vector of local investments made by nodes other than x.

ASSUMPTION 3. *Marginal costs of investment are positive and constant across investment locations.*

We use the function $C(a, \mathbf{e})$ to represent total investment costs and $c_a, c_{\mathbf{e}} > 0$ to represent the constant marginal cost of global and local investment, respectively. That notation is sufficient for individual and total global investment because a is increasing in any a_x. Because investment costs are not the focus of our analysis, Assumption 3 removes any investment cost effects and clarifies the exposition. Our results hold under convex cost assumptions. Details can be provided upon request.

For a given node, we use the term *own customers* to refer to those customers based in the node's location and *foreign customers* to refer to customers based outside the node's location. Each node faces three positive demands that we assume are twice continuously differentiable:

1. $D_D(x, a, \mathbf{e})$ = Domestic demand: demand from own customers at own node.
2. $D_I(x, a, \mathbf{e})$ = Imported demand: demand from foreign customers at own node.
3. $D_E(x, a, \mathbf{e})$ = Exported demand: demand from own customers at foreign nodes.

ASSUMPTION 4. *Demands are increasing and concave in global investment.*

Each of the demands is characterized by diminishing returns to global investment,

$$\frac{\partial D_j(x, a, \mathbf{e})}{\partial a} > 0 \quad \text{and} \quad \frac{\partial^2 D_j(x, a, \mathbf{e})}{\partial a^2} < 0, j = \{D, I, E\}.$$

ASSUMPTION 5. *Domestic and exported demands are increasing and concave in own local investment and are unaffected by other nodes' own local investment.*

Demands from own customers exhibit diminishing returns to local investment, and there are no spillovers from others' local investment.

$$\frac{\partial D_D(x, a, \mathbf{e})}{\partial e_x} > 0, \quad \frac{\partial^2 D_D(x, a, \mathbf{e})}{\partial e_x^2} < 0,$$

$$\frac{\partial D_D(x, a, \mathbf{e})}{\partial e_{\setminus x}} = 0,$$

$$\frac{\partial D_E(x, a, \mathbf{e})}{\partial e_x} > 0, \quad \frac{\partial^2 D_E(x, a, \mathbf{e})}{\partial e_x^2} < 0$$

$$\text{and } \frac{\partial D_E(x, a, \mathbf{e})}{\partial e_{\setminus x}} = 0.$$

ASSUMPTION 6. *Imported demand is unaffected by own local investment and is increasing in other nodes' own local investment.*

Because one node's imported demand is another node's exported demand, this is the counterpart to the assumptions about exported demand,

$$\frac{\partial D_I(x, a, \mathbf{e})}{\partial e_x} = 0 \quad \text{and} \quad \frac{\partial D_I(x, a, \mathbf{e})}{\partial e_{\setminus x}} > 0.$$

Demands that depend on own customers, domestic and exported demands, increase at a decreasing rate in own local investment. For example, customer recruitment visits generate additional customers, but at a decreasing rate because one would visit those customers with largest potential first. Domestic and exported demands are not directly affected by other nodes' own local investments because those investments do not directly affect customers in own location. That is, we are assuming that, for example, investments in customer recruitment visits in one node does not directly affect customer recruitment in another location. Demand that depends on foreign customers, imported demand, is not affected by own investment because own investment only directly affects own customers. However, imported demand is increasing in other nodes' own local investment because those investments increase the number of foreign customers. Essentially, that structure admits demand spillovers from customers that generate demands across locations, but it does not admit local investment spillovers where investments in one location affects demands from customers that reside in other locations. Nonetheless, that latter kind of demand spillover is usually a result of global investment, and our model does allow for global investment spillovers of that kind.

ASSUMPTION 7. *The central authority and nodes have perfect information about the relationship between global investment and demands. Nodes have perfect information about the relationship between local investment and demands. The central authority has incomplete information about the relationship between local investment and demands.*

Assumption 7 defines an information asymmetry between the central authority and nodes concerning local investment. There is another information asymmetry that is not critical because it does not affect our results. In the appendix we show that if there is an information asymmetry between the central authority and nodes concerning global investment, then it is in the interest of the central authority to inform the nodes about the relationship between global investment and demands.

ASSUMPTION 8. *Without information from nodes, the effectiveness of local investment by the central authority is a fraction of the effectiveness of local investments by nodes.*

We represent the efficiency of central authority local investment relative to node local investment by a multiplicative constant, $\alpha \in (0, 1)$, where the demands are linearly homogeneous in local investment, $D_j(x, a, \alpha\mathbf{e}) = \alpha D_j(x, a, \mathbf{e})$, $j = \{D, I, E\}$. Thus, in our analysis the efficiency of central authority local investment is constant across nodes. α as a constant, linearly homogeneous demands, and identical effectiveness across nodes entails no loss of generality in qualitative nature of our results. When the central authority makes local investments $\mathbf{e}$, the effectiveness of those investments is $\alpha\mathbf{e}$. If the information asymmetry did not exist, then the central authority's local investments would be as efficient as the nodes' local investments, $\alpha = 1$. Our modeling of IT with respect to the information asymmetry is blunt: IT increases α. One can easily think of many forms of IT that would have that effect: decision support systems, group decision support systems, executive information systems and expert systems. The intuition behind Assumption 8 is straightforward. If the central authority has less information than the nodes, then it cannot make as effective local investments. For example, with better knowledge of customer potential, nodes can target customer recruiting visits more effectively than the central authority, thereby gaining higher return on local investment. Higher payoffs from having superior information is consistent with virtually all the literature in information economics.

ASSUMPTION 9. *There are investment complementarities between global and local investment*.

The complementarities are represented by cross partial derivatives of investments on demands,

$$\frac{\partial^2 D_D(x, a, \mathbf{e})}{\partial a \partial e_x}, \quad \frac{\partial^2 D_E(x, a, \mathbf{e})}{\partial a \partial e_x} \quad \text{and} \quad \frac{\partial^2 D_I(x, a, \mathbf{e})}{\partial a \partial e_{\setminus x}} > 0.$$

Investment complementarities are at the center of the decision allocation problem because they compound the effects of the asymmetry in local investment to global investment. Considering our example of national advertising as global investment and customer recruiting visits as local investment, synergies between those types of investments would seem to be a natural feature of the environment.

As an example, consider commercial real estate firms. These firms often have local affiliates that serve clients with real estate needs in many locations. The affiliate that serves the client's head office owns the client, and affiliates in other locations serve the client with their local expertise. Each affiliate invests in recruiting clients locally through local advertising and client visits. The head office invests in name recognition through national promotion. The affiliates know better how to invest locally—such as which newspaper to advertise in and which potential clients to visit—and if the head office directed that local investment it would be less effective. Finally, with higher investments in national promotion, each dollar spent locally is more effective, and vice versa.

The partition of demands, the effects of local investment on those demands in Assumptions 5 and 6, and the information asymmetry about local investment and demands in the second part of Assumption 7 mirror the structure taken from a case example of commercial fueling and used in Nault and Dexter (1994) and Nault (1997). The novel assumptions we use here are the different types of investment in Assumption 2, the effects of global investment on the demands in Assumption 4, the information symmetry about global investment in first part of Assumption 7, the reduced effectiveness of local investment by the central authority in Assumption 8, and the investment complementarities in Assumption 9.

3. Models of Organization Designs

We begin our analysis by establishing conditions for first-best global and local investments. That allows us to compare investments in other organization designs to the standard of first-best. We then model each of the three organization designs: hierarchy, market, and mixed mode. For each of the market and mixed mode organization designs we examine investments in absence of, and in the presence of, ownership of customers. In the absence of ownership of customers, nodes make profits based on domestic and imported demands. With ownership of customers, nodes can make profits on domestic, exported, and imported demands. The division between the latter two is based on a transfer from the owning node to the serving node.

3.1. First-Best Investments

First-best global and local investments can be represented by investment levels selected by a perfectly informed central authority. Let p be the full price premium on demands, where the premium is exogenously determined.[3] Thus, p represents the return to the organization from satisfying one unit of demand. Nodes are paid a lump-sum amount, $L(x)$, to cover their reservation utility. Using exported demands to account for spillovers between nodes, the profit maximization for first-best is

$$\max_{a,\mathbf{e}} \left\{ p \int_{\underline{x}}^{\bar{x}} [D_D(x, a, \mathbf{e}) + D_E(x, a, \mathbf{e})] f(x) dx - C(a, \mathbf{e}) - \int_{\underline{x}}^{\bar{x}} L(x) f(x) dx \right\}.$$

The necessary first-order conditions are

$$p \int_{\underline{x}}^{\bar{x}} \left[\frac{\partial D_D(x, a, \mathbf{e})}{\partial a} + \frac{\partial D_E(x, a, \mathbf{e})}{\partial a} \right] f(x) dx - c_a = 0, \quad (1)$$

and

$$p \left[\frac{\partial D_D(x, a, \mathbf{e})}{\partial e_x} + \frac{\partial D_E(x, a, \mathbf{e})}{\partial e_x} \right] - c_e = 0 \quad \forall x, \quad (2)$$

where from Assumption 5 the demand derivatives of local investment from other nodes are zero, and the lump-sum term disappears.

3.2. Hierarchy: Central Authority Selects Investments

In this setting the central authority selects both global and local investments. Under that centralized structure there is no decision making by nodes. In the hierarchy the central authority fully accounts for demand spillovers in its profit function. Nodes are paid $L(x)$, as before, and it costs the central authority $K(x)$ to monitor node investments. The central authority's profit function is

$$\Gamma(a, \mathbf{e}) = p \int_{\underline{x}}^{\bar{x}} [D_D(x, a, \alpha\mathbf{e}) + D_E(x, a, \alpha\mathbf{e})] f(x) dx - C(a, \mathbf{e}) - \int_{\underline{x}}^{\bar{x}} [L(x) + K(x)] f(x) dx,$$

which is similar to the profit function for first-best except for the reduced effectiveness of local investment and the additional costs of monitoring node investments. Maximizing profits by choice of a and the elements of $\mathbf{e}$ yields the first-order conditions

$$\frac{\partial \Gamma(a, \mathbf{e})}{\partial a} = p\alpha \int_{\underline{x}}^{\bar{x}} \left[\frac{\partial D_D(x, a, \mathbf{e})}{\partial a} + \frac{\partial D_E(x, a, \mathbf{e})}{\partial a} \right] f(x) dx - c_a = 0, \quad (3)$$

and

$$\frac{\partial \Gamma(a, \mathbf{e})}{\partial e_x} = p\alpha \left[\frac{\partial D_D(x, a, \mathbf{e})}{\partial e_x} + \frac{\partial D_E(x, a, \mathbf{e})}{\partial e_x} \right] - c_{\mathbf{e}} = 0 \quad \forall x. \quad (4)$$

It is obvious that because the full cost of local investment is incurred but the effectiveness of this investment is reduced by the information asymmetry, the central authority underinvests in global and local investment at each node relative to first-best. We state that result directly and without proof.

THEOREM 1. *In a hierarchy, there is both global and local underinvestment.*

The underinvestment is due to a lack of knowledge, a lack of knowledge that can be mitigated by the MIS solution of bringing more information to the central authority. Measured as the effects of implementation of different managerial support systems or as the effects of IT investments on characteristics such as timeliness, fineness, and accuracy, IT can increase global and local investments. Assuming IT costs are covered, the MIS solution can increase the value of the hierarchical organization design. It is simple to see that all investments increase with α both directly and indirectly through investment complementarities.

In the commercial real estate example, a hierarchy corresponds to the head office deciding on investments in national promotion, and directing investments in local activities such as local advertising and client visits. Being less effective in local investment than if affiliates directed local investment means that returns to this investment are lower, and the head office underinvests.

[3] In our model that is the same as assuming the premium is not determined by investment.

Because of complementarities, there is underinvestment in national promotion as well (Theorem 1). If the head office can obtain better information about how to invest locally, then both types of investment can be increased.

3.3. Market: Node Selects Investments

In the market organization design decisions are made in two stages. In the first stage the central authority sets the incentives for the nodes. In the second stage each node sets its individual levels of local investment and its contribution to global investment. Those investments depend on the incentive structure set by the central authority. We consider incentive structures with and without ownership of customers. As is standard in these types of problems, we work backwards, solving for investments as a function of the incentives and then determining the optimal level of incentives.

3.3.1. Global and Local Investments. To create an investment incentive for investments without ownership of customers, the central authority provides a margin to each node that depends on units of demand generated by the node's investments. Without loss of generality in our analysis, we specify a unit margin, m, as a fraction of the price premium, $m < p$. Without ownership of customers the profit function of node x is

$$\Pi(x, a, \mathbf{e}) = m[D_D(x, a, \mathbf{e}) + D_I(x, a, \mathbf{e})] - C(a, \mathbf{e}), \quad (5)$$

where each node is rewarded for demands at its own node and faces the same investment costs as the central authority. The two first-order conditions choosing a_x and e_x are

$$\frac{\partial \Pi(x, a, \mathbf{e})}{\partial a_x} = m\left[\frac{\partial D_D(x, a, \mathbf{e})}{\partial a_x} + \frac{\partial D_I(x, a, \mathbf{e})}{\partial a_x}\right] - c_a = 0, \quad (6)$$

and

$$\frac{\partial \Pi(x, a, \mathbf{e})}{\partial e_x} = m\,\frac{\partial D_D(x, a, \mathbf{e})}{\partial e_x} - c_{\mathbf{e}} = 0, \quad (7)$$

where the derivative of local investment on imported demand is zero from Assumption 6. Because the profit functions of the nodes are supermodular, the investments of all the nodes make up a supermodular game. That ensures existence of a pure Nash equilibrium defined by the collection of (6) and (7) for $x \epsilon [\underline{x}, \overline{x}]$ (Milgrom and Roberts 1990). Those conditions result in equilibrium investments as a function of the margin.

Under ownership of customers, on foreign transactions the owning node receives proceeds from the sale and then transfers part of the proceeds to the foreign node. That particular operationalization of ownership of customers is not critical. What is critical is that the owning node eventually receives all or part of the proceeds. The central authority sets both a margin and a transfer, where without loss of generality for our analysis t is a unit transfer and $t \in [0, m]$. A given node's profit function is the margin on domestic demand, the margin less the transfer on exported demand, and the transfer on imported demand, less investment costs:

$$\Pi^o(x, a, \mathbf{e}) = mD_D(x, a, \mathbf{e}) + [m - t]D_E(x, a, \mathbf{e}) + tD_I(x, a, \mathbf{e}) - C(a, \mathbf{e}),$$

where the superscript o is used to distinguish the node profit function under ownership of customers. The node's first-order conditions for profit maximization choosing investments are

$$\frac{\partial \Pi^o(x, a, \mathbf{e})}{\partial a_x} = m\,\frac{\partial D_D(x, a, \mathbf{e})}{\partial a_x} + [m - t]\,\frac{\partial D_E(x, a, \mathbf{e})}{\partial a_x} + t\,\frac{\partial D_I(x, a, \mathbf{e})}{\partial a_x} - c_a = 0, \quad (8)$$

and

$$\frac{\partial \Pi^o(x, a, \mathbf{e})}{\partial e_x} = m\,\frac{\partial D_D(x, a, \mathbf{e})}{\partial e_x} + [m - t]\,\frac{\partial D_E(x, a, \mathbf{e})}{\partial e_x} - c_{\mathbf{e}} = 0. \quad (9)$$

It is easy to check that supermodularity conditions are again satisfied so that (8) and (9) define Nash equilibria over the support of x. The following lemma summarizes the dominance of ownership of customers as an investment incentive. That is succeeded by a theorem that shows in the market, as compared to first-best, there is underinvestment in both global and local investment.

LEMMA 1. *In the market, ownership of customers yields no lesser global and local investment.*

PROOF. With an appropriate setting of t, (8) yields no less global investment than (6). Greater or equal local investment follows from (7) and (9), greater or equal global investment follows from investment complementarities. □

THEOREM 2. *In the market, there is both global and local underinvestment.*

PROOF. From Lemma 1 it is sufficient to show global and local underinvestment under ownership of customers. Starting with global investment, from (8) we get node contributions to global investment as a function of the margin and transfer, $a_x(m, t)$ over the nodes. Substituting the variable y for x in the node's contribution to global investment, we can integrate (8) with respect to $a_y(m, t)$ over $[\underline{y}, \bar{y}]$ giving the marginal effect of global investment. Integrating once more over x gives

$$\int_{\underline{x}}^{\bar{x}} \left[m \frac{\partial D_D(x, a(m, t), \mathbf{e})}{\partial a} + [m - t] \frac{\partial D_E(x, a(m, t), \mathbf{e})}{\partial a} + t \frac{\partial D_I(x, a(m, t), \mathbf{e})}{\partial a} \right] f(x)dx - c_a = 0. \quad (10)$$

Using condition (1) from first-best, recognizing that (1) could also be written in terms of imported demands,

$$\int_{\underline{x}}^{\bar{x}} \left[p \frac{\partial D_D(x, a, \mathbf{e})}{\partial a} + [p - t] \frac{\partial D_E(x, a, \mathbf{e})}{\partial a} + t \frac{\partial \mathrm{D}_I(x, a, \mathbf{e})}{\partial a} \right] f(x)dx - c_a = 0.$$

For given levels of local investment, with $p > m$, there is lower global investment in a market. A direct comparison of (2) and (9) indicates that, for a given level of global investment, there is lower local investment at each node. Those direct effects are reinforced by investment complementarities. □

3.3.2. Incentives. Because of global and local underinvestment, the central authority's setting of incentives concentrate on increasing the levels of investment. It is straightforward to show that with and without ownership of customers, both types of investment are increasing in the margin. The effect on investment of a change in the transfer is less clear. The central authority maximizes profits from selecting the margin and the transfer for the profit function

$$\Gamma(m, t) = [p - m] \int_{\underline{x}}^{\bar{x}} [D_D(x, a(m, t), \alpha\mathbf{e}(m, t)) + D_E(x, a(m, t), \alpha\mathbf{e}(m, t))] f(x)dx,$$

subject to the restrictions $p \geq m \geq t \geq 0$. The transfer appears only through investments and the effectiveness of local investment is tempered by α. Developing the necessary conditions for an interior solution is straightforward. However, one of the corner solutions is worth considering. In the next lemma we provide a sufficient condition for the optimal transfer to be zero. When that is the case, each node accounts for spillovers in its investment decisions exclusively through exported demand.

LEMMA 2. *In the market, if the marginal effect of the transfer on demands is larger through local investment than it is through global investment, then the optimal transfer is zero.*

PROOF. The transfer only affects the central authority's profits through investments. The first-order condition of $\Gamma(m, t)$ with respect to t can be written as

$$\frac{\partial \Gamma(m, t)}{\partial t} = [p - m]\alpha \int_{\underline{x}}^{\bar{x}} \left[\frac{\partial D_D(x, a(m, t), \mathbf{e}(m, t))}{\partial a} + \frac{\partial D_E(x, a(m, t), \mathbf{e}(m, t))}{\partial a} \right] \times \frac{\partial a(m, t)}{\partial t} f(x)dx + [p - m]\alpha \times \int_{\underline{x}}^{\bar{x}} \left[\frac{\partial D_D(x, a(m, t), \mathbf{e}(m, t))}{\partial \mathbf{e}} + \frac{\partial D_E(x, a(m, t), \mathbf{e}(m, t))}{\partial \mathbf{e}} \right] \times \frac{\partial \mathbf{e}(m, t)}{\partial t} f(x)dx = 0.$$

The terms under integration are the elements of the condition in the premise. With the condition in the premise, the first-order condition cannot be satisfied with $t > 0$. □

In the commercial real estate example, a market corresponds to each affiliate selecting its own level of local investment, and a contribution to national promotion. The head office sets the proportion of profit from each sale which the local affiliate that made the sale can keep. Under ownership of customers the head office sets the proportions of profits from each foreign sale (a sale to a client in a location away from its head office) that go to the affiliate that owns the client (location of client head office) and to the affiliate which made the sale. Because ownership of customers rewards affiliates that own clients on foreign sales, they make higher local investments and make correspondingly greater contributions to national promotion (Lemma 1). If investments at the margin in local activities yield more than those in national promotion, then profits from a foreign sale should be divided between the head office and the affiliate that owns the client, but not the affiliate that made the sale (Lemma 2). In the standard case and under ownership of customers, affiliates do not account for the full amount of spillover from their local investments in generating owned clients because they are not fully rewarded for foreign sales, and as a result they underinvest (Theorem 2).

3.4. Mixed Mode: Central Authority Selects Global and Nodes Select Local Investments

Similar to the market organization design, decisions in the mixed mode are made in two stages. In the first stage the central authority selects the level of incentives. In the second stage the central authority selects global investment, and the nodes select their individual levels of local investment simultaneously.

3.4.1. Global and Local Investments. The central authority expects each node to choose e_x to maximize profits, $\Pi(x, a, \mathbf{e})$, but with the efficiency of local investment tempered by α. The central authority knows each node can achieve at least α efficiency with local investment, but does not know how much more.[4] That is, the central authority does not know the rate of return each node makes on local investment. The node knows that and responds to the central authority's choice of global investment, a^α, with its best response.

[4] Because the central authority does not have an upper limit on which to base an expectation, it has an infinitely diffuse prior on α, and cannot apply a mixed strategy over the support of α.

Without ownership of customers, using the node profit function defined by (5), taking global investment as given and adjusting the benefits from local investment by α, the first-order condition the central authority expects each node to solve is

$$\frac{\partial \Pi(x, a, \alpha\mathbf{e})}{\partial e_x} = m\alpha \frac{\partial D_D(x, a, \mathbf{e})}{\partial e_x} - c_{\mathbf{e}} = 0. \quad (11)$$

The central authority's profit as a function of global investment is

$$\Omega(a, m) = [p - m] \int_{\underline{x}}^{\bar{x}} [D_D(x, a, \alpha\mathbf{e}) + D_E(x, a, \alpha\mathbf{e})] f(x) dx - C(a, 0), \quad (12)$$

conditional on its choice of margin and with benefits from local investment tempered by α. Maximizing by choice of global investment results in the first-order condition

$$\frac{\partial \Omega(a, m)}{\partial a} = [p - m]\alpha \int_{\underline{x}}^{\bar{x}} \left[\frac{\partial D_D(x, a, \mathbf{e})}{\partial a} + \frac{\partial \mathrm{D}_E(x, a, \mathbf{e})}{\partial a} \right] f(x) dx - c_a = 0. \quad (13)$$

Because the central authority's profit function is also supermodular, (11) for all x and (13) defines Nash equilibrium investments which we denote as a^α and $\mathbf{e}^\alpha$. The nodes, however, know the true value of α. Accounting for the equilibrium global investment of the central authority, they each choose their individual level of local investment to $\max_{e_x} \Pi(x, a^\alpha, \mathbf{e})$. Their first-order conditions are

$$\frac{\partial \Pi(x, a^\alpha, \mathbf{e})}{\partial e_x} = m \frac{\partial D_D(x, a^\alpha, \mathbf{e})}{\partial e_x} - c_{\mathbf{e}} = 0 \quad \forall x. \quad (14)$$

Because the level of global investment by the central authority is given, each node's local investments are independent and (14) is only a necessary condition for optimality. Using Assumption 5 the sufficient second-order condition holds for each node.

Under ownership of customers the central authority expects each node to choose e_x to maximize $\Pi^o(x, a, \alpha\mathbf{e})$, resulting in

$$\frac{\partial \Pi^o(x, a, \alpha \mathbf{e})}{\partial e_x} = \alpha \left[m \frac{\partial D_D(x, a, \mathbf{e})}{\partial e_x} + [m - t] \frac{\partial D_E(x, a, \mathbf{e})}{\partial e_x} \right] - c_{\mathbf{e}} = 0 \quad \forall x. \tag{15}$$

The central authority's profit function and first-order condition choosing global investment are as in (12) and (13) respectively. Together (13) and (15) define Nash equilibrium investments. As before, with knowledge of the true α the nodes maximize

$$\Pi^o(x, a^\alpha, \mathbf{e}) = mD_D(x, a^\alpha, \mathbf{e}) + [m - t]D_E(x, a^\alpha, \mathbf{e}) + tD_I(x, a^\alpha, \mathbf{e}) - C(0, \mathbf{e}),$$

by choice of e_x. This yields the first-order condition

$$\frac{\partial \Pi^o(x, a^\alpha, \mathbf{e})}{\partial e_x} = m \frac{\partial D_D(x, a^\alpha, \mathbf{e})}{\partial e_x} + [m - t] \frac{\partial D_E(x, a^\alpha, \mathbf{e})}{\partial e_x} - c_{\mathbf{e}} = 0 \quad \forall x. \tag{16}$$

Again, (16) is the necessary condition for optimality of node local investment given central authority local investment. Using Assumption 5 the sufficient second-order condition is satisfied. Similar to the market organization design, the following lemma establishes that ownership of customers yields higher global and local investment, and the succeeding theorem shows that there is underinvestment in both types of investment relative to first-best.

LEMMA 3. *In the mixed mode, ownership of customers yields greater global and local investment.*

PROOF. Comparing (11) and (15), the central authority expects higher local investment from the nodes under ownership of customers and as a result of investment complementarities global investment is higher. Knowing this, and comparing (14) and (16), nodes have higher local investment under ownership of customers.

THEOREM 3. *In the mixed mode, there is both global and local underinvestment.*

PROOF. From Lemma 3 we need only consider the mixed mode under ownership of customers. For given levels of local investment, from (1) and (13) there is higher global investment in first-best. For a given level of global investment, directly from a comparison of (2) and (16), there is greater investment at each node under first-best. Investment complementarities compound those effects. □

It is worth noting that both global and local investment are increasing in α, supporting the MIS solution as a way to improve the profitability of the mixed mode organization design.

3.4.2. Incentives. Because the central authority gives up and the nodes receive the margin, the impact of changes in the margin on investments is equivocal. The impact of changes in the transfer is not. The following lemma shows that in the mixed mode the optimal transfer is zero.

LEMMA 4. *In the mixed mode, the optimal transfer is zero.*

PROOF. From (15) the central authority expects each node's local investment to be decreasing in the transfer. Because of investment complementarities, the central authority's global investment from (13) is also decreasing in the transfer. Both directly from (16) and indirectly from complementarities with the central authority's global investment, each node's local investment is decreasing in the transfer. □

Because the transfer is zero, the central authority only needs to set the margin. The central authority then maximizes what it believes to be its profit function,

$$\max_m \Omega(a, m) = [p - m] \int_{\underline{x}}^{\bar{x}} [D_D(x, a^\alpha(m), \mathbf{e}^\alpha(m)) + D_E(x, a^\alpha(m), \mathbf{e}^\alpha(m))]f(x)dx - C(a^\alpha(m), 0), \tag{17}$$

subject to the restriction $p \geq m \geq 0$ and where the inefficiency in local investment is accounted for in the investment functions.

In the commercial real estate example, the mixed mode corresponds to the head office investing in national promotion, and affiliates investing in local advertising and client visits. Similar to the market, under ownership of customers, local investments in generating owned clients are more fully rewarded when those clients purchase real estate away from their head office, and thus investments are higher (Lemma 3). Moreover, investments are higher when only the head office and the affiliate that owns the client receive profits from foreign sales because this increases affiliate local incentives to generate owned clients (Lemma 4). Nonetheless, the client-owning affiliates still divide profits with the head office, and thus underinvest locally, which in turn causes the head office to underinvest nationally (Theorem 3).

3.5. Comparison of Investments Between Designs

The different structure of investment decisions between the three organization designs limits the types comparisons that can be made between them. We consider the market and mixed mode designs under ownership of customers because, from Theorems 2 and 3, ownership of customers reduces the degree of underinvestment that occurs in each. Investments in the hierarchy result from (3) and (4), in the market they result from (8) and (9), and in the mixed mode they result from (13), (15) and (16) where the transfer is zero from Lemma 4. Summarizing the comparison of levels of investment between organization designs, we find that under reasonable conditions a hierarchy results in higher levels of investment than either of the other two organization designs. The following theorem provides a sufficient condition under which the hierarchy yields higher investments than the mixed mode.

THEOREM 4. *A sufficient condition for the hierarchy to have higher global and local investment than the mixed mode is that the inefficiency from information asymmetry is small relative to the optimal margin.*

PROOF. Let m^* be the margin that results from (17). In our formulation, the condition in the theorem is $p\alpha \geq m^*$. It is directly apparent that (3) is satisfied at a larger a than (13) and, with $t = 0$ in mixed mode from Lemma 4, (4) is satisfied at a larger e_x than (16). Assumption 9 reinforces these effects. □

The condition in Theorem 4 is not necessary for the result. In the mixed mode the lack of coordination produces a global investment that is not based on accurate expectations of local investment, a^α. As an argument to the demands in (16), from investment complementarities, the underinvestment in global investment will cause lower local investment. Because of α, global investment from (13) is also lower. The intuition is that a smaller inefficiency reduces local underinvestment in the hierarchy whereas a smaller margin increases local underinvestment in the mixed mode. When there is no information asymmetry, there is no inefficiency and the hierarchy yields first-best investments. In order to derive a similar comparison between the hierarchy and the market, we need to use our result from Lemma 2. Our next theorem provides sufficient conditions under which the hierarchy yields higher investments than the market.

THEOREM 5. *If the optimal transfer in a market is zero, then a sufficient condition for the hierarchy to have higher global and local investment than the market is that the inefficiency from information asymmetry is small relative to the optimal margin.*

PROOF. A sufficient condition for the optimal transfer to be zero is provided in Lemma 2. Let m^* represent the margin that results from maximizing $\Gamma(m, 0)$. Aggregate (8) as in proof of theorem 2 giving (10). We can directly compare (3) with (10) and (4) with (9), noting that $t = 0$. In our formulation, the condition is $p\alpha > m^*$. (3) is satisfied at a larger a than (10) and (4) is satisfied at a larger e_x than (9). Assumption 9 reinforces the result. □

The intuition is similar to that of Theorem 4 in that a smaller margin increases underinvestment in the market as well. If the inefficiency from the information asymmetry is large enough, directly from inspection of (3) and (4) as compared to (8) and (9), then Theorem 5 is invalid and the market yields higher levels of both global and local investment than the hierarchy. We state that as a corollary to Theorem 5.

COROLLARY. *If the inefficiency from the information asymmetry is sufficiently large, then the market yields higher levels of global and local investments than the hierarchy.*

As compared to both the hierarchy and market organization designs, there are direct coordination costs to contend with in the mixed mode. These coordination costs revolve around expectations of the central authority concerning the efficiency of local investment and also depend upon the magnitude of the information asymmetry. That is, the information asymmetry (α) causes the central authority to underinvest (a^{α}), thereby causing the nodes to underinvest ($\mathbf{e}^{\alpha}$). It is this lack of synchronization in investment that forces the organization to bear the opportunity costs of miscoordination. Our final theorem shows that the advantage of the mixed mode relative to the market decrease with the size of the inefficiency from the information asymmetry.

THEOREM 6. *As the size of the inefficiency from the information asymmetry increases, both global and local investment is reduced in the mixed mode relative to the market.*

PROOF. From (8) and (9), investments in a market are unaffected by the information asymmetry. In the mixed mode, from (15) the central authority's expectations of local investment are decreasing in the inefficiency from the information asymmetry. Using (13), global investment is lower. From Assumption 9 and (16), local investments are also lower. □

An increase in the magnitude of the inefficiency from the information asymmetry increases coordination cost in the mixed mode through a reduction in the central authority's estimate of local investment, coordination costs that manifest themselves through lower global and local investment. When the inefficiency is extremely large, Theorem 6 results in the market yielding higher levels of both types of investment than the mixed mode. The combined effects of Theorems 4, 5, and 6 and the corollary to Theorem 5 admit the following: in some cases the mixed mode is dominated by the alternative organization designs. Where the information asymmetry has little effect, the hierarchy results in higher levels of both types of investment than either the market or the mixed mode. Where the information asymmetry has a larger effect, the market results in higher levels of both types of investment than either the hierarchy or the mixed mode. As compared to the hierarchy, the costs of coordinating investment in the mixed mode are a relative disadvantage. As compared to the market, the effects of the inefficiency from the information asymmetry is a disadvantage. In those cases, the benefits of collocating investment decision rights and information is outweighed by coordination costs and the information asymmetry.

Corresponding to the commercial real estate example, better information at the head office concerning where to invest in local advertising and which potential clients to visit results in higher relative investments in a hierarchy versus the mixed mode or the market (Theorem 4 and 5), The worse the information, the higher are relative investments in the market versus the hierarchy (Corollary). Moreover, the worse is the information concerning local investment, the higher are investments in the market versus the mixed mode (Theorem 6). As a result, there may not be a situation where the mixed mode—where investments are divided between the head office in national promotion and affiliates directing local advertizing and client visits—is optimal.

4. Conclusion

Previous research suggests that collocation of decision rights and information is desirable. In a model of an organization with two levels, two types of decisions, information asymmetries and externalities, we operationalized two solutions to collocate decision rights and information: an MIS solution and an organizational redesign solution. Although each solution improves organization performance, neither is perfect. Moreover, our results do not unconditionally support the conclusion that collocation is desirable.

We find that there is global and local underinvestment in the hierarchical, market, and mixed mode organization designs. In addition, we find that the MIS solution, reducing the effect of the information asymmetry, can improve the profitability of either the hierarchy or the mixed mode through increases in both types of investment. We also show that one IT-enabled organizational redesign solution, ownership of customers, can improve the profitability of either the market or the mixed mode through increases in both types of investment.[5] In our analysis, there is no clear winner between the different organization designs—we provide sufficient conditions under which a hierarchy is better than the market, and a single sufficient condition under which a hierarchy is better than the mixed mode.

Our results provide understanding of the mechanics behind the tension between coordination and motivation in the presence of IT. Although it is obvious that

[5] Increased profitability in the market from increases in local investment are detailed in Nault (1997).

the choice between the hierarchy and the market is governed by the impact of the information asymmetry, our findings concerning the mixed mode are surprising. Our last three theorems suggest that the mixed mode may be less profitable than the hierarchy when the inefficiency from the information asymmetry is low, and less profitable than the market when the inefficiency from the information asymmetry is high, leaving no room for a level of the information asymmetry that results in the mixed mode being best. That indicates that collocation of investment decision rights and information that result in decisions that require coordination may not be the right strategy when there are significant coordination costs—costs that are large when synchronizing global and local investment is important. The latter occurs when externalities between the two types of investment are great.

To obtain the understanding of the mechanics described above required a model of an organization with well-defined decisions, outcomes, and alternative allocations of decision rights. We believe that particular situational characteristics, such as our externalities and agency problems, are critical in analyses of organization design. As Mackenzie (1978) suggests, ''. . . *it is unsound to argue for or against extremes of centralization or decentralization in the absence of the types of specific issues and conditions that are considered important*'' (p. 203)

The IT required for ownership of customers is network related: database matching, transaction processing, and electronic funds transfer, all from and to remote locations. In the mid-1990s, with telecommunications services falling in price, increasing in capability, and increasingly available (e.g., the Internet), we believe these types of applications of IT will become ubiquitous. We argue that implementing ownership of customers is possible in markets where an ongoing relationship exists between the customer and the organization. A good illustration where ownership of customers is implemented is in the commercial fueling industry we use as an example where Pacific Pride Systems operates an IT-based commercial fueling network (HBS Case Services 1988). Because of the ongoing relationships between firms, many industrial markets either employ or can employ IT-based ownership of customers (Nault 1997). In the bulk fuel industry clients purchase fuel for geographically dispersed depots. Servicing the geographically dispersed depots from one distributor's location is not efficient, so transfers are arranged between the distributor that owns the client and other distributors that provide fuel for the client's dispersed depots. Another example where implementation of ownership of customers is possible is service firms such as law, accounting, consulting, engineering, and as we suggested in our core example, commercial real estate firms. Local branches of service firms often have contracts with conglomerated clients that have dispersed operations. Those clients are often unwilling to incur the cost of transporting the service firm's personnel to the dispersed locations—and often choose the service firm based on the breadth of service locations. Moreover, the service firm's expertise may be location specific, such as our example in commercial real estate. In those cases the branch at the location of the conglomerate's head office owns the client, and branches in other locations perform local functions. The billing arrangement usually rewards the head-office branch and the local offices.

There are connections between the location of decision rights and the issue of where the organization begins and ends. The latter is the study of efficient boundaries of the firm and transactions cost theory (Williamson 1981). Our results do not answer the question of whether nodes should be inside or outside the employment relationship. One argument for nodes being outside is that IT reduces the costs of electronic communication, thereby lowering coordination costs (Malone et al. 1987). Counterbalancing that view is that the combination of coordination costs, operations risk, and opportunism risk leads to mixed organization designs, in a ''move to the middle'' (Clemons and Row 1992, Clemons et al. 1993). Part of the issue concerns effects that we have not modeled here, for example which nodes should be part of the organization. For that membership question in a franchising context Nault and Dexter (1994) found that the trade-off between adoption and investment externalities can result in less than universal adoption by potential franchisees. Combining membership with the other aspects of our model may be a profitable avenue of future research. Another particularly important avenue for future research would be to combine the changes in organization design enabled by IT with the theory of incomplete contracts and ownership.[6]

[6] Helpful comments were provided by colloquium participants at the University of California Irvine, the University of Washington and the University of British Columbia. Partial support has been provided by the Social Science and Humanities Research Council of Canada.

Appendix

We prove below that it is in the interest of the central authority to resolve an information asymmetry between the central authority and nodes concerning global investment.

PROPOSITION. *It is a dominant action for the central authority to inform the nodes of its relationship between global investment and demands.*

PROOF. It is necessary to show that this is the case for the market and the mixed mode. Similar to our modeling of the information asymmetry in Assumption 8, suppose the effectiveness of the nodes' global investment was reduced to the proportion β. Consider first the market. The left-hand side of (9) would be multiplied by β, giving lower local investment, resulting in lower contributions to global investment, thereby making the market less profitable. Because the central authority decides the division of profits through its choice of the margin, the central authority is worse off. Consider next the mixed mode. Here the nodes would underestimate the effectiveness of central authority global investment, multiplying the left-hand side of (16) by β. That reduces local investment, which in turn reduces global investment by the central authority, making the mixed mode less profitable. The remainder of the argument is the same as for the market. □

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