Toward a Unified Transaction Cost Theory of Economic Organization

by

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This paper develops a general equilibrium model endogenizing labor specialization, firm size, firm specialization, interfirm trade, and economic fragmentation. In contrast to the standard neoinstitutionalist understanding of firms and markets as substitutes in organizing production, firms and markets are shown to be complements in reaping economies to the division of labor. As a result, firm size varies directly, rather than inversely, with the extent of interfirm trade. Growth is facilitated by increases in the complexity of economic organization, involving increases in the division of labor, the size and specialization of firms, market size and the complexity of interfirm trade. (JEL: D 23, L 22, L 23, O 12, O 4)

1 Introduction

Events that affect the cost of organizing production within or between firms are by no means rare in economic life. A non-exhaustive list includes such otherwise disparate phenomena as infrastructure investment, advances in information technology, innovations in management practice, political regime shifts that affect the rule of law, and currency unification. It seems that economists would be well served to have a theory relating economy-wide changes in transaction costs to organizational outcomes and economic welfare. We do not.

What we have instead is two partial theories, the neoinstitutionalist theory of the firm and the theory of endogenous labor specialization. Taken alone each theory generates predictions that are misleading or incomplete. They are also, however, complementary. This paper integrates these two lines of thought to produce a formal, unified transaction cost theory of economic organization.

The neoinstitutionalist theory of the firm originates with COASE'S [1937] insight that firms exist to conserve on market transaction costs. The use of managers to allocate resources within the firm, however, is also costly. Equilibrium occurs when the cost of directing the work of an additional employee equals the market transaction

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* I wish to thank Sandy Darity, Patrick Conway, Bruce Elmslie, Michael Goldberg and two anonymous referees for helpful comments and discussions during the preparation of this paper.

cost incurred in purchasing an equivalent intermediate good or, in the language of Coase, when marginal internal and external transaction costs are equal. While subsequent work contains many elaborations and refinements (WILLIAMSON [1975] and [1979], CHEUNG [1983], LANGLOIS [1993]), the notion of a trade-off between management and markets in organizing production remains a central pillar of this literature.

The logic of this theory leads one to expect that firm size and extent of interfirm trade should vary inversely. For example, given a fall in external transaction costs, we expect firms to shrink as they shed activities and employees, relying increasingly on the market to procure intermediate goods previously produced internally. While this story is intuitively appealing, the predictions of the Coasean theory of the firm are not borne out. In practice, firm size and interfirm trade often vary directly.

Consider the euro. Currency unification should reduce external transaction costs within the "euro zone" and thus, from a Coasean perspective, cause firms to shrink as managers substitute market transactions for internal production. Instead, the introduction of the euro appears to have contributed to a wave of business mergers and consolidation (VALENCIA [2000]). Whether this also has led to an increase in interfirm trade is difficult to gauge, but the predicted decrease in firm size is counterfactual.

Similarly, looking across economies high external transaction costs are not associated necessarily with large firms. Indeed, exceedingly high market transaction costs may be taken as the defining characteristic of the traditional sector of developing countries (MYINT [1985]). Yet traditional sector "firms" are small, with production often organized at the level of the individual household, and markets (including interfirm trade) relatively underdeveloped. Put simply, firm size and interfirm trade appear to vary directly rather than inversely.

In terms of its formal structure, the inability of the Coasean theory of the firm to accommodate direct variation between "the firm" and "the market" suggests a missing analytical element. As currently formulated, there is nothing in the theory against which both internal and external transaction costs may be traded. A promising candidate to fill this void is some source of gains to organizing production across individuals. Indeed, barring such gains a rational firm owner would produce all intermediates internally, thereby eliminating external transaction costs, and fire all employees, eliminating internal transaction costs as well. The resulting "firm" would consist of a self-employed, autarkic individual.

While many accounts of the gains to organization are possible, here we consider those arising from labor specialization. The theory of endogenous labor specialization posit agents faced by a trade-off between gains to specialization and market transaction costs. In dynamic models, the accumulation of specialized capital goods increases the gains to specialization, driving a growth process characterized by market expansion and the evolution of the division of labor.[1] These models, however,

[1] For static treatments of labor specialization, see BARZEL AND YU [1984], EDWARDS AND STARR [1987], KIM [1989], and YANG [1990]. On the evolution of the division of labor see

give no role to firms in organizing production – the division of labor is coordinated exclusively through market exchange. This "sin of omission" severely limits the type of organizational question these models may be used to address.

This paper provides a formal synthesis of these two approaches to economic organization.[2] Each line of thought provides an analytical element missing from the other. Introducing gains to specialization provides the theory of the firm with an account of why production is coordinated, and the addition of firms provides an alternative to markets in coordinating the division of labor. The resulting theory is a dynamic, general equilibrium extension of the Coasean firm, or alternately a specialization-driven growth model in which both markets and firm are used to organize the division of labor. This synthesis is facilitated by the similarity of conceptual frameworks. Both theories disaggregate production to the level of individual productive activities and view exchange as limited by transaction costs.

The primary results are as follows. First, by considering the three-way trade-off between gains to specialization and internal and external transaction costs, it illustrates the relationships between labor specialization, market size, firm size, firm specialization, the complexity of interfirm trade, and economic fragmentation (the number of autonomous sub-economies into which an economy is divided).

Second, contrary to the logic of Coase, comparative static exercises show that changes in internal and external transaction costs result in direct variation between firm size and interfirm trade. For example, a decrease in external transaction costs leads to both larger firms and greater interfirm trade.

Finally, the dynamic version of the model illustrates the evolution of the economy as a complex system: growth is facilitated by the adoption of increasingly complex patterns of self-organization.[3] In particular, a growing economy experiences increases in the division of labor, vertical disintegration, market integration and increases in the complexity of interfirm trade.

2 The Static Model

2.1 Basic Functions

We begin by deriving a parametric production function for output per worker, which is used to sign the derivatives of a reduced-form production function employed in the model. There are *N ex ante* identical individuals and a continuum of intermediate

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BECKER AND MURPHY [1992], DAVIS [2001a, 2001b and 2003], TAMURA [1992, 1996], and YANG AND BORLAND [1991].

[2] YANG AND BORLAND [1995] have considered a similar set of issues. Their use of discrete variables and constant transaction costs, however, precludes marginal analysis and consequently obscures and sometimes contradicts the logic of optimizing behavior. My use of more general functional forms addresses a concern raised by SMYTHE [1994].

[3] See KRUGMAN [1994] for a discussion of the characteristics of complex systems.

goods, or productive tasks, arranged along the unit interval and indexed by $a \in [0, 1]$. n is the measure of the number of intermediate goods produced by an individual worker. Labor specialization is denoted $s \equiv 1/n$.

Each worker is endowed with h units of human capital and one unit of time, which are allocated uniformly across the intermediate goods she produces. The quantity of resources allocated to producing a given intermediate good is therefore increasing in labor specialization: $h_a = h/n = sh$ and $t_a = 1/n = s$. Intermediate good output is given by $y_a = f(t_a, h_a)$, where $f(..)$ is increasing and concave in both arguments and homogeneous of degree v. Per capita output, y, is found by integrating y_a over the set of productive tasks:

$$(1) \qquad y = \int_0^1 y_a \, da = (1/s)f(s, sh) = s^{v-1}f(1, h) = y(s, h)$$

where the last equality follows from Euler's Theorem. From the Inada conditions, we have $y(s, 0) = 0$, $y_h(s, h) > 0$, $y_{hh}(s, h) < 0$. In addition, we assume $v \in (1, 2)$, implying gains and diminishing returns to specialization: $y_s(s, h) > 0$, $y_{ss}(s, h) < 0$. Finally, separability implies a positive cross partial, $y_{sh}(s, h) = y_s(s, h)y_h(s, h) > 0$, so the return to capital is increasing in labor specialization, a relationship suggested by YOUNG [1928] and ROSEN [1983].

Firms produce a final composite good in Leontief fashion by combining one unit of each of the intermediate goods. A firm may produce the final composite good by hiring workers to produce the entire range of intermediate goods. Alternately, a firm may produce a subset of the intermediate goods, and rely on interfirm trade to obtain those intermediate goods it does not produce. We denote the number of intermediate goods produced within the firm as z and firm specialization as $q = 1/z$.

By defining the final good in this manner, it serves as the numeraire for measuring output per worker. For example, if a worker produces 4 units of each of one-half of the intermediate goods, then her output is $y = y_a/s = 2$, which (abstracting from transaction costs) is the number of units of the final good the worker would have if she traded 2 units of each of the goods she produced for 2 units of each intermediate good she did not produce.

In coordinating the production of specialists, the firm incurs internal transaction costs, which include management and monitoring costs, losses due to principal-agent conflicts and the like. Internal transaction costs per worker are assumed to increase at a rising rate as a function of firm employees (WILLIAMSON [1975]). Self-management is assumed to be costless, so that internal transaction costs are zero for a firm with a single worker:

$$(2) \qquad i(L) = \gamma i_0(L) > 0, \text{ for } L > 1$$

$$i_L(L) > 0 \text{ for } L > 1,\ i(1) = i_L(1) = 0,\ i_{LL}(L) > 0$$

where L is the number of the firm's employees. The internal transaction cost coefficient $\gamma > 0$ reflects the efficiency of management practice.

Interfirm trade conserves on internal transaction costs but incurs external transaction costs, which include the transportation, information and contracting costs incurred in conducting market transactions. Let J denote the number of firms in an interfirm trading group. External transaction costs are zero for a firm that does not engage in trade, and marginal external transaction costs are assumed to be increasing in the number of a firm's trade partners.[4] Thus, we have $E(J) \geq 0$, $E'(J) > 0$ and $E''(J) > 0$ for $J > 1$, and $E(1) = E'(1) = 0$. We also write $E(J) = \varepsilon E_0(J)$, where the external transaction cost coefficient $\varepsilon > 0$ reflects the quality of the institutions, technology and infrastructure that influence market transaction costs.

Gains to specialization and positive transaction costs imply two identities. First, gains to specialization imply production sets are non-overlapping for workers in a given firm, so $z = nL$ or $q = s/L$. If a firm employs four workers each of whom produce 1/40th of the intermediate goods, labor specialization is forty and firm specialization is $q = s/L = 10$, implying that the firm produces one tenth of the intermediate goods. Second, positive external transaction costs imply non-overlapping production sets for firms in a trading group, $Jz \leq 1$, and Leontief production of the final good implies that all intermediate goods are produced within each trading group, $Jz \geq 1$. Ignoring integer problems, it follows that the number of firms in an interfirm trading group equals firm specialization, $J = 1/z = q$. Thus, firm specialization serves as a proxy for the extent of interfirm trade.

Employing these identities, external transaction costs per worker are given by:

$$(3) \qquad e(L, s) = E(s/L)/L.$$

As derived in the appendix, (3) implies that per capita external transaction costs are increasing and convex in labor specialization, $e_s(L, s) > 0$ and $e_{ss}(L, s) > 0$, and decreasing and convex in firm employment, $e_L(L, s) < 0$ and $e_{LL}(L, s) > 0$, and that labor specialization reduces the impact of firm employment on external transaction costs, $e_{Ls}(L, s) < 0$. Equations (2) and (3) are denominated in units of the final good and are assumed to be twice continuously differentiable.

Using the definitions for labor specialization, firm specialization and firm size, we may define additional organizational variables of interest as follows. *Market size*, denoted m, is the cognate of Smith's [1776] "extent of the market" and is defined by the number of workers in an interfirm trading group. As each interfirm trading group is economically autonomous, we define *economic fragmentation*, M, to be the number of interfirm trading groups in an economy. Finally, we define *market complexity*, X,

[4] This assumption reflects increases in marginal transportation and communication costs among geographically dispersed firms (YANG AND BORLAND [1991]), increases in information costs associated with the increase in the number of relative prices (COASE [1937]), and rivalry in the institutional infrastructure that define and enforce property rights (DAVIS, [2003]).

as the number of interfirm trades per market, *X*. This somewhat crude measure captures the idea that market activity increases non-linearly with the number of participants. These variables may be defined in terms of labor specialization and firm specialization:

(4a) $m = LJ = L/q = s$[5]

(4b) $M = N/m = N/s$

(4c) $$X = \frac{J(J-1)}{2}\frac{q(q-1)}{2}$$

As these variables are not directly the object of firm optimization, to which we next turn, they are set aside until the comparative static exercises in section 3.

2.2 Optimization

A number of additional assumptions facilitate the analysis. First, to avoid complications introduced by the exercise of market power by specialized firms and workers, it is assumed that all markets operate on the basis of contracts negotiated prior to specialization decisions. Since workers and firms are *ex ante* identical, contracts reflect price taking behavior.[6] Price taking behavior, in turn, implies that firms may trade one-for-one for each others intermediate goods (the relative price of intermediate goods produced by any two members of a trading group is one).

Second, in order to focus on interfirm trade, it is assumed that each firm distributes the final composite good to its workers in the form of wage payments, with each worker receiving quantity, w, of the final good. There is therefore no market for final goods apart from the labor market. Following CHEUNG [1983] labor market transaction costs are taken as integral to the internal transaction cost function, and are not separately addressed.

Third, without loss of generality, the transaction coefficients, ε and γ, are normalized to one and subsumed into the transaction cost functions. They are reintroduced below in the section on comparative statics.

Firm profits equal the sum across workers of per capita output less internal and external transaction costs and payments to labor. As each intermediate good must be produced, labor specialization is bounded above by the number of workers in the economy, $s \leq N$, and below by the number of intermediate goods, $s \geq 1$. Firm employment is similarly constrained. Firms choose firm employment and labor

[5] By this equation, market size equals labor specialization, capturing YOUNG'S [1928, 533] assertion that "Adam Smith's dictum amounts to the theorem that the division of labour depends in large part upon the division of labour."

[6] In making this assumption, we follow YANG AND BORLAND [1991]. See BAUMGARDNER [1988] for a paper in which specialists' market power is formally addressed.

specialization to maximize profits, taking the level of human capital and the wage as given:

$$(5) \qquad \max_{L,\, s} \quad \pi(L, s, h, w) = L[y(s, h) - i(L) - e(L, s) - w],$$

subject to $L, s \in [1, N]$.[7]

The Kuhn-Tucker conditions for the firm's problem are

$$(6) \qquad L \geq 1,\ L \leq N,\ d\pi/dL \leq 0 \text{ and } (L - 1)(L - N)(\pi/L - i_L - e_L) = 0$$

and

$$(7) \qquad s \geq 1,\ s \leq N,\ d\pi/ds \geq 0 \text{ and } (s-1)(s - N)(y_s - e_s) = 0$$

When the constraints are non-binding, equations (6) and (7) provide a system of two equations in three variables, L, s and w. A third equation is generated by assuming free entry, implying that a zero-profit condition will hold. The first-order conditions for an interior equilibrium are thus

$$(8) \qquad i_L + e_L = 0$$

$$(9) \qquad y_s - e_s = 0$$

The second-order conditions for an interior equilibrium are

$$(10a) \qquad i_{LL} + e_{LL} > 0$$

$$(10b) \qquad y_{ss} - e_{ss} < 0$$

$$(10c) \qquad \frac{y_{ss} - e_{ss}}{e_{Ls}} > \frac{-e_{Ls}}{i_{LL} + e_{LL}}.$$

(10a) and (10b) follow from (1) - (3). (10c) is considered below.

Equation (8) gives the Coasean equilibrium of the firm for a general equilibrium model: optimizing firms choose employment to equate marginal internal and external transaction costs per worker. The general equilibrium framework employed here supports the free entry assumption and resulting the zero-profit condition. This eliminates π/L in equation (6), implying that it is transaction costs per worker, not

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[7] It may at first appear that equation (5) does not properly account for the cost of those intermediates the firm acquires through trade. Recall, however, that output per worker is measured in units of the final good and that intermediates trade one-for-one. Thus, the firm's output of the final good equals its output of intermediates less transaction costs.

total transaction costs, which the firm seeks to minimize. Let LL, shown in Figures 1a and 1b, denote the locus defined by (8) in the *s*-*L* plane.

Equation (8) indicates the optimal mix of markets and firms in organizing production as determined by the trade-off between internal and external transaction costs per worker.[8] The constraints on L correspond to extreme outcomes regarding this mix and are never binding. Along the line $L = 1$, workers are self-employed and marginal internal transaction costs equal zero. This corresponds to a *pure market economy*: firms consist of individual workers and production is organized entirely through interfirm trade.

Along the line $L = s$, each firm produces the entire range of intermediate goods and marginal external transaction costs equal zero. This corresponds to a *pure command economy*: firms do not engage in trade and production is organized entirely through the authority of the firm manager. The point $(s, L) = (1, 1)$ corresponds to *interpersonal autarky*: each firm consists of a single worker producing the full range of intermediate goods. Since marginal internal and external transaction costs are zero in interpersonal autarky, the LL curve passes through this point. Otherwise, (8) implies that both marginal transaction costs must be positive, implying that the LL curve lies between the pure market and command economy lines.

Holding firm employment constant, an increase in labor specialization increases firm specialization, making firms more reliant on interfirm trade and increasing marginal external transaction costs. An increase in firm employment is necessary to reduce external transaction costs and re-establish equilibrium, implying that the LL curve is positively sloped

$$\text{(11)} \qquad dL/ds|_{LL} = \frac{-e_{Ls}}{i_{LL} + e_{LL}} > 0.$$

[8] While the Coase equilibrium is usually expressed in terms of the marginal productive activity, rather than the marginal employee, with activities per worker (labor specialization) held constant these vary proportionately implying the difference is one of form and not substance.

Figure 1a

An Interior Equilibrium

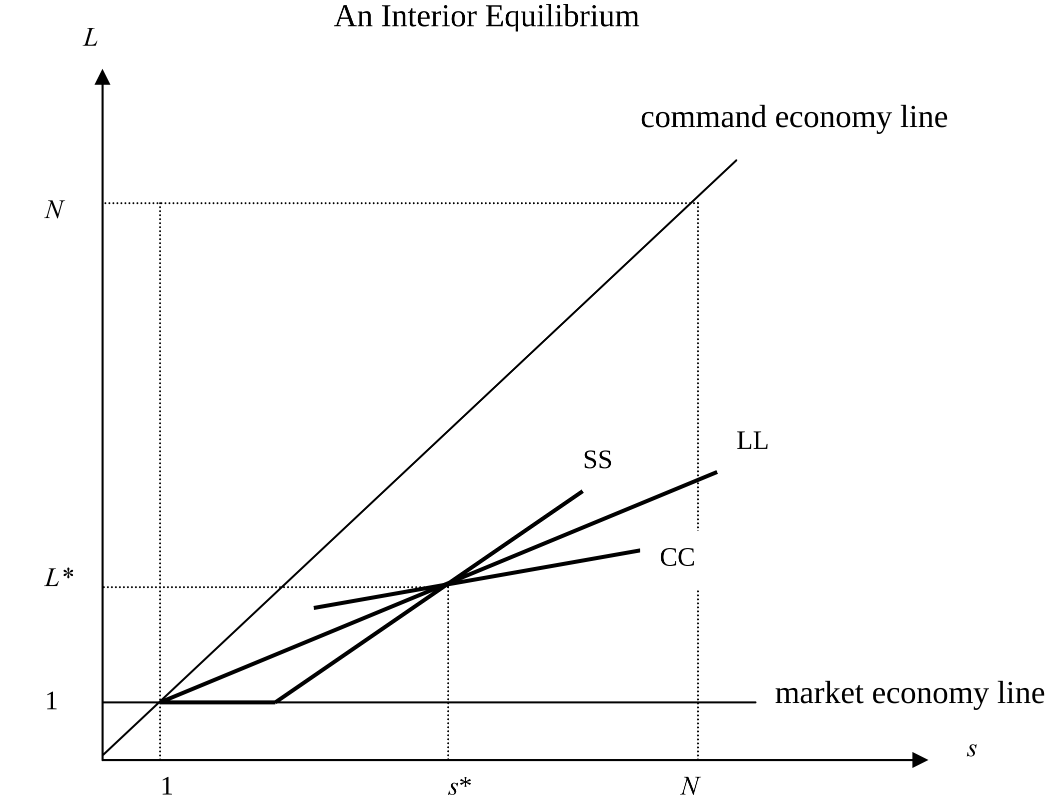
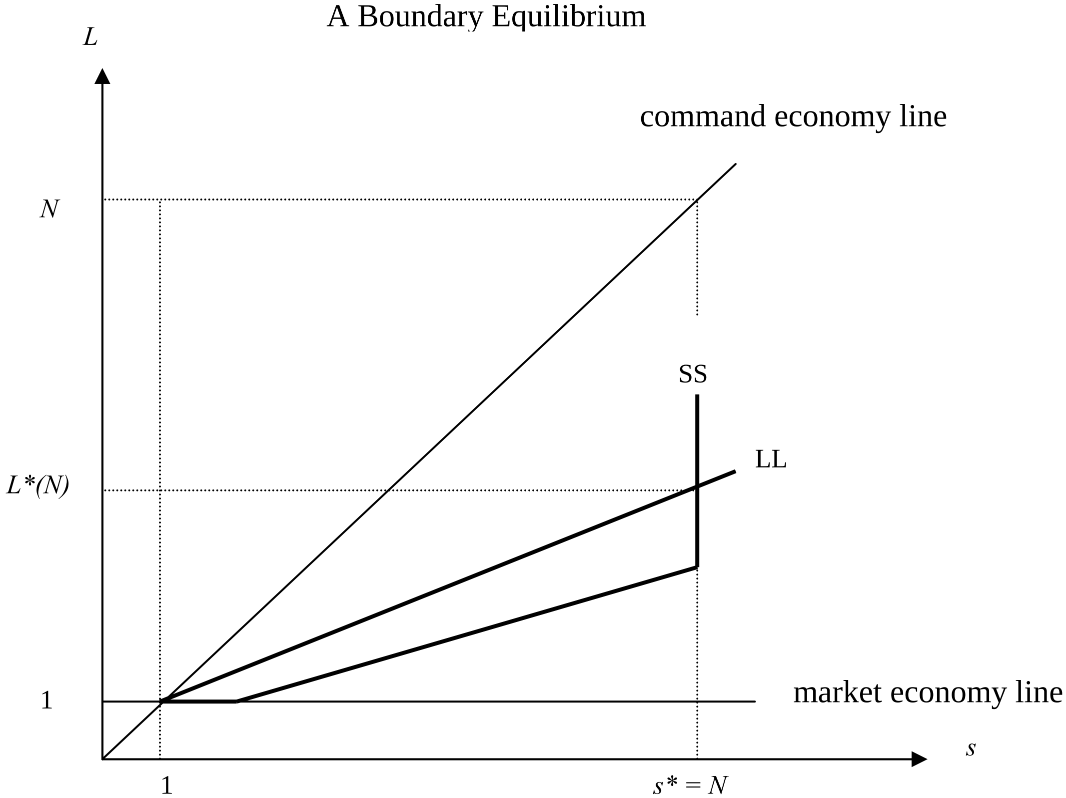


Figure 1b

A Boundary Equilibrium



The SS curve, also shown in Figure 1, is the locus of points satisfying equation (9), $y_s - e_s = 0$. Equation (9) is the equilibrium condition for labor specialization found in the endogenous specialization literature (YANG AND BORLAND [1991], BECKER AND MURPHY [1992], and TAMURA [1992, 1996]): firms choose s by equating the gains to specialization with marginal market transaction costs. For $h > 0$ there are positive gains to specialization, implying that the SS curve lies below the pure command economy line, along which marginal external transaction costs equal zero.

Holding labor specialization constant, an increase in firm employment reduces firm specialization and, thus, marginal external transaction costs. An increase in labor specialization is required to restore the balance between the gains to specialization and marginal external transaction costs, indicating that the SS curve is positively sloped:

$$(12) \qquad dL/ds|_{SS} = \frac{y_{ss} - e_{ss}}{e_{Ls}} > 0,$$

where the sign follows from (1) and (3).

Two additional functions will be useful in analyzing the model. First, taken together, (8) and (9) may be used to illustrate the trade-off between gains to specialization and total transaction costs per worker. As the LL curve increases monotonically, we can define optimal firm size as a function of labor specialization: $L^* = L^*(s)$, such that $(L^*(s), s)$ satisfies (8). Using this relationship, we can write per capita transaction costs as a function of s:

$$(13a) \qquad t(s) = i(L^*(s)) + e(L^*(s), s)$$

$$(13b) \qquad t_s(s) = e_s(L^*(s), s) > 0$$

$$(13c) \qquad t_{ss}(s) = e_{ss}(L^*(s),s) - \frac{e_{Ls}(L^*(s),s)^2}{i_{LL}(L^*(s)) + e_{LL}(L^*(s),s)} > 0$$

Substituting from (13b) into (9) the condition for optimal labor specialization may be expressed as $y_s - t_s = 0$: firms choose employment and labor specialization to equate the marginal gains to specialization with marginal total transaction costs per worker.

Second, an additional equilibrium condition may be derived by considering the trade-off between the gains to specialization and internal transaction costs:[9]

$$(14) \qquad y_s = (-e_s/e_L)i_L.$$

Differentiating (14) with respect to L and s gives

[9] Define the function $L = f(s)$, $f'(s) = -e_s/e_L > 0$, such that $e(f(s), s) = E$, where E is constant. (14) is found by maximizing profits with respect to s and subject to $L = f(s)$ and imposing the zero-profit condition.

$$(15) \quad dL/ds|_{CC} = \left[\frac{-e_s/e_L - dL/ds|_{SS}}{-e_s/e_L - dL/ds|_{LL}}\right]\left[dL/ds|_{LL}\right] > 0.$$

Equation (14) indicates that the greater the gains to specialization the greater the willingness of firms to incur management costs. The locus of points satisfying (14) is shown in Figure 1a as the CC curve. The first term in (15) is positive and less than one (see appendix), implying the CC curve has a positive slope and is less steep than LL.

Examination reveals that if any two of the equilibrium conditions (8), (9) and (14) are satisfied, the third will be met as well. It follows that any one of the three may be taken as redundant, and in general we omit (14). Equation (14) proves useful in the comparative static exercises, however, because the CC curve is invariant with respect to external transaction cost shocks.

2.3 Equilibria

There is nothing in the analysis that precludes the existence of multiple or unstable equilibria, which will occur if the SS and LL schedules intersect more than once. Statements about the curvature of SS and LL, however, depend upon third and higher order derivatives of the objective function, about which it is difficult to make credible assumptions. To simplify the discussion of the model, it is assumed hereafter that the SS curve is steeper than the LL curve for unconstrained values of s, $dL/ds|_{SS} > dL/ds|_{LL}$. (13c) gives this restriction on relative slopes a ready interpretation: $y_{ss}(s, h) < t_{ss}(s)$, which implies that total transaction costs rise more quickly at the margin than do the gains to specialization. In an economy with an expanding division of labor, this implies that transaction costs grow faster than output, which accords with WALLIS AND NORTH's [1986] finding that the share of transaction costs in the US economy expanded over the period from 1902 to 1970.

The restriction on relative slopes both satisfies the second-order condition (10c), which requires that $dL/ds|_{SS} > dL/ds|_{LL}$ hold only in a neighborhood of the equilibrium, and ensures that any intersection of the two curves will be unique. It follows that an interior equilibrium, such as illustrated in Figure 1a, will be a global maximum. Interior equilibria are characterized by incomplete specialization, $s < N$, and economic fragmentation, $M = N/s > 1$, indicating the economy consists of multiple, autonomous markets.

As illustrated in Figure 1b, if the two curves do not intersect for $s < N$ the model produces a stable boundary equilibrium at the intersection of LL curve and the line $s = N$. Boundary equilibria are characterized by *complete specialization* in that labor specialization equals population size. Thus, they correspond to economies characterized by a single market, which indicates the greatest degree of coordination and interdependence allowed by the model.

The model provides a formal argument regarding the role of the gains to specialization in motivating the coordination of production. In the absence of gains to specialization, the SS curve coincides with the pure command economy line, $L = s$. Thus, equilibrium occurs at $(s, L) = (1, 1)$, indicating interpersonal autarky: each firm consists of a self-employed worker who produces the full range of intermediate goods and is, thus, economically self-sufficient.

This seemingly benign result has striking implications. In the absence of gains to specialization there is no incentive for agents to coordinate production. As a result, there are no firms and no markets. Thus, the model implies that the institution of the firm and the phenomenon of exchange and, thus, the majority of what we consider the subject matter of economic inquiry, exist due to efforts to extract the benefits of economies to specialization.

3 Comparative Statics

Here we consider the organizational and welfare implications of exogenous shocks to the capital-labor ratio and the transaction cost coefficients. As noted in the introduction, firm and market size tend to vary directly in response to a given shock, rather than inversely as might be expected from a Coasean perspective. In each case, we begin at an interior equilibrium with $s < N$ and the transaction cost coefficients are normalized to one.

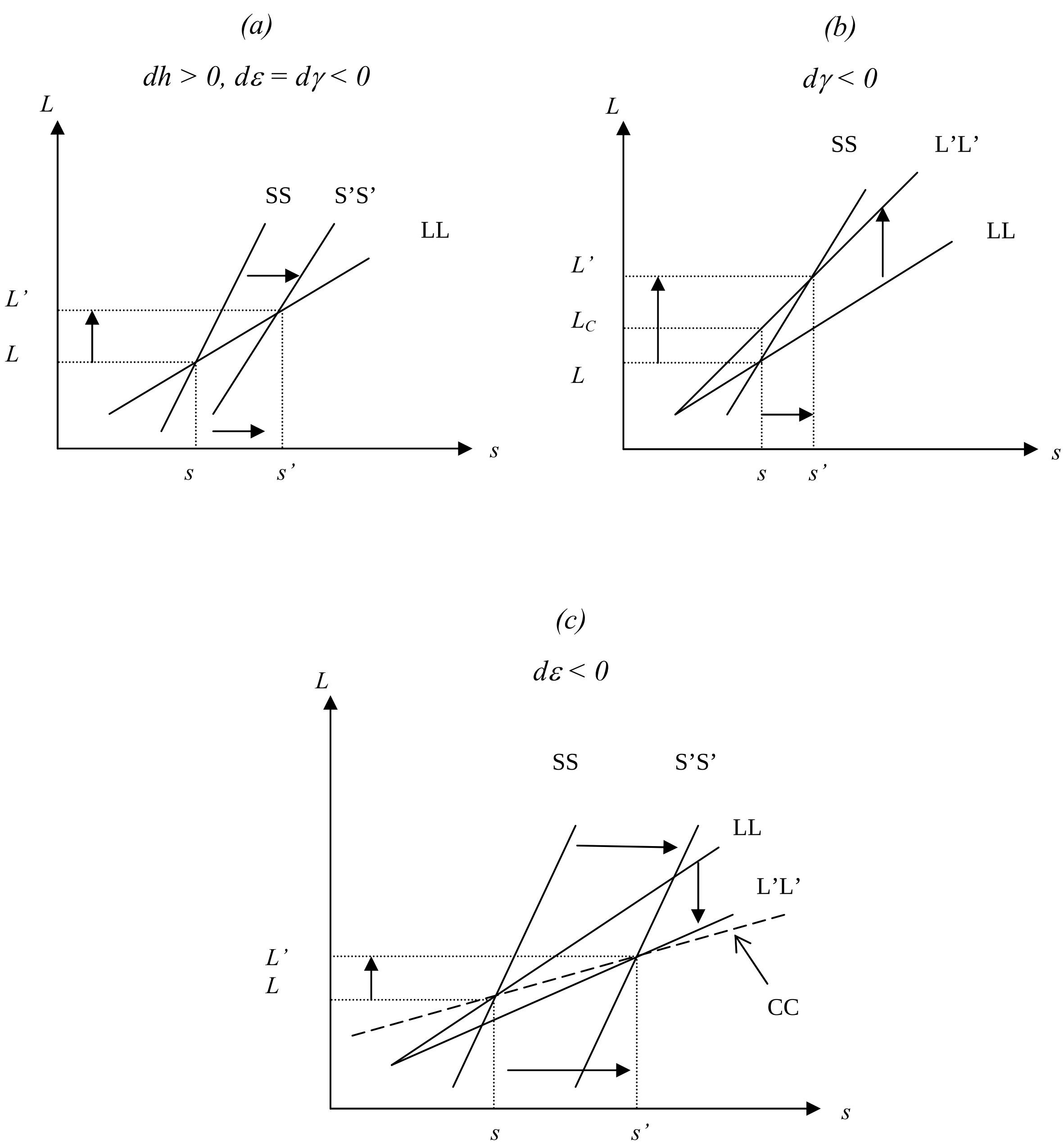
To illustrate how the model may be used to shed light on a variety of topics, shocks to transaction cost coefficients are given specific interpretations, including changes in the efficiency of management practice, the rule of law and information technology. This is not intended as a claim that the model at hand fully explains these phenomena, but rather to suggest something of the range of economic events to which the model might apply.

3.1 Capital Accumulation

The effects of an exogenous increase in the capital-labor ratio are illustrated in Figure 2a. An increase in the capital-labor ratio raises the gains to labor specialization, shifting the SS curve to the right. The LL curve is independent of h and is thus unaffected. Equilibrium levels of labor specialization and firm employment both rise.

Figure 2

Comparative Statics



As derived in the appendix, the (incremental) changes in labor specialization, firm employment and firm specialization are given by

$$\text{(16a)}\quad ds/dh = \frac{y_{sh}}{t_{ss}\text{-}y_{ss}} > 0$$

$$\text{(16b)}\quad dL/dh = \left[\left.\frac{dL}{ds}\right|_{LL}\right]\frac{ds}{dh} > 0$$

$$\text{(16c)}\quad dq/dh = \frac{1}{L}\left[1 - \frac{s}{L}\left.\frac{dL}{ds}\right|_{LL}\right]\frac{ds}{dh} > 0.$$

These results suggest that countries and regions with higher levels of human capital will have a more advanced division of labor, larger firms, and greater interfirm trade. Employing the Envelope Theorem, an increase in the capital-labor ratio also increases net per capita income: $dw/dh = y_h > 0$.

(16a) shows the positive effect of capital accumulation on specialization decisions. The sign of (16a) depends sensitively on the positive cross-partial, $y_{sh} > 0$, which (loosely) captures the notion that the longer one stays in school the greater the return to specialization. It also illustrates the role of transaction costs in mediating the impact of capital accumulation on optimal specialization: rapidly rising marginal transaction costs reduce the incentive to increase labor specialization.

(16b) and (16c) indicate the roles of firms and markets in organizing the increase in the division of labor. To interpret these equations note that the slope of the LL curve enters positively in (16b) and negatively in (16c), and recall that the LL curve captures the trade-off between firms and markets in organizing production. Thus, the more quickly internal transaction costs rise relative to external transaction costs, the flatter the LL curve and, by (16b) and (16c), the greater the role of markets relative to firms in organizing the increase in the division of labor.

The implications for the model's other organizational variables can be derived readily from (16) and (4). Greater specialization of firms implies a rise in the number of firms in an interfirm trading group, $dJ = dq > 0$, and market complexity, $dX = (q - 1/2)dq > 0$. An increase in labor specialization implies larger markets, $dm = ds > 0$, and a corresponding reduction in economic fragmentation, $dM = -(N/s^2)ds < 0$. Taken together, these result suggest a positive relationship between the level of human capital and the complexity of economic organization.

3.2 Management Practice

Changes in management practice enter the model through their effect on the internal transaction cost coefficient, γ. We examine an increase in the efficiency of management practice (fall in *gamma*), such as might result from reduced monitoring costs. As illustrated in Figure 2b, a decrease in the internal transaction cost coefficient causes the LL curve to rotate upward, closer to the pure command economy line. Thus lower management costs make firms more attractive relative to markets as mechanisms for organizing production. This in turn results in an increase in labor specialization, firm employment and firm specialization:

$$\text{(17a)}\quad ds/d(-\gamma) = \frac{i_L e_{Ls}}{\Delta} > 0$$

$$\text{(17b)}\quad dL/d(-\gamma) = \left[\left.\frac{dL}{ds}\right|_{SS}\right]\frac{ds}{d(-\gamma)} > 0$$

$$\text{(17c)}\quad dq/d(-\gamma) = \frac{1}{L}\left[1 - \frac{s}{L}\left.\frac{dL}{ds}\right|_{SS}\right]\frac{ds}{d(-\gamma)} > 0,$$

where $\Delta = (i_{LL} + e_{LL})(y_{ss} - t_{ss}) < 0$. It follows that economies with better management will have a greater division of labor and larger, more specialized firms.

From a partial equilibrium, Coasean perspective it not surprising that a fall in management costs increases firm employment. What is surprising is that it also increases firm specialization, which implies greater reliance on interfirm trade. Following the logic of Coase, one would expect interfirm trade to decrease as firms chose to organize production internally rather than through the market. Indeed, we can get the Coasean result by holding labor specialization constant, which is equivalent to ignoring any changes in the gains to organization. In this case, firm employment rises to L_C and interfirm trade, proxied by $q = s/L$, falls.

As (s, L_C) lies on the L'L' curve, it equates marginal internal and external transaction costs per worker. In the model's general equilibrium framework, however, (s, L_C) is to the left of the SS curve, indicating unexploited gains to specialization. As a result, both firm employment and interfirm trade will rise as the equilibrium moves right along the L'L' curve to (s', L'). That the net effect on firm specialization is positive results from the fact that, holding q constant, a rise in firm employment decreases external transaction costs *per worker*. (Graphically, firm specialization is constant along rays from the origin, $L/s = 1/q$, and greater along rays that are flatter. These can be shown to cut the SS curve from below, $L/s > dL/ds|_{SS}$, so that firm specialization rises as one moves from left to right along the SS curve.)

Intuitively, unexploited gains to specialization at (s, L_C) correspond to gains to serving a larger market. Increasing output by increasing employment, however, gives rise to higher internal transaction costs. Focusing on a narrower range of intermediate goods allows the firm to offset some of the rise in management costs. With market integration, therefore, firms become both larger and more specialized.

Combining (17) with (4), an increase in management efficiency it increases market size and the complexity of interfirm trade and decreases economic fragmentation. It also increases net per capita income, $dw/d(-\gamma) = i(L) > 0$. Greater management efficiency is associated with a more complex economic organization and higher economic welfare.

3.3 Corruption, the Rule of Law and Transportation Technology

External transaction costs include a number of distinct components including information, communication and transport costs as well as the cost of writing, interpreting and enforcing contracts. As such they may be affected by a variety of otherwise dissimilar events: the adoption of a common currency, the introduction new transportation technology (US railroads in the Nineteenth century) or infrastructure (the interstate highway system), and public sector reform leading to a reduction in corruption or improvement in the rule of law.

As illustrated in Figure 2c, a decrease in the external transaction cost coefficient, ε, shifts the SS curve to the right and rotates the LL curve downward. As these shifts produce opposing changes in s and L, it is useful to include the CC curve in Figure 2c, shown as a dashed line. Examination of (14) shows that the CC curve is invariant in ε. Thus, the equilibrium moves to the right along the CC curve, resulting in an increase in labor specialization, firm employment and firm specialization:

$$\text{(18a)}\quad ds/d(-\varepsilon) = \frac{e_s e_{Ls}}{\Delta}\left[\frac{1}{LL} - \frac{-e_L}{e_s}\right] > 0$$

$$\text{(18b)}\quad dL/d(-\varepsilon) = -\frac{e_L e_{Ls}}{\Delta}\left[\frac{-e_s}{e_L} - SS\right] > 0$$

$$\text{(18c)}\quad dq/d(-\varepsilon) = -\frac{ds}{Ld\varepsilon}\left[1 - \frac{s}{L}\frac{(-e_s/e_L) - SS}{(-e_s/e_L) - LL}LL\right] > 0\,,$$

where SS and LL stand for the slopes of the SS and LL curves.

Incorporating the additional organizational variables, (18) implies that across economies lower external transaction costs are associated with a greater division of labor, larger markets and firms, greater interfirm trade and greater economic integration. These results are in broad accord with informal observation, especially as regards economic organization in the traditional sector of less developed countries.[10]

[10] Low levels of economic interdependence and organization in the traditional sector may also be accounted for by low levels of human capital, as indicated in (16). In the dynamic model, however, causation is seen to run from high transaction costs to low human capital: high transaction costs may undermine the incentive to invest in specialized human capital.

Note that a fall in external transaction costs results in *increased* firm employment. As with the analysis of internal transaction costs above, this is the opposite of what would be expected from a partial equilibrium, Coasean perspective. The intuition of Coase is preserved, however, in the relative effects of shocks to internal and external transaction costs. Given shocks sufficient to generate the same increase in labor specialization, a fall in external transaction costs results in a greater increase in interfirm trade than a fall in internal transaction costs:

$$\frac{dq/d\varepsilon}{ds/d\varepsilon} > \frac{dq/d\gamma}{ds/d\gamma}.$$

Similarly, the fall in internal transaction costs generates a greater increase in firm employment:

$$\frac{dL/d\varepsilon}{ds/d\varepsilon} > \frac{dL/d\gamma}{ds/d\gamma}.$$

3.4 Information Technology

Some shocks, such as an advance in information technology, arguably affect the cost of organizing production both within and between firms. As a rough approximation, we consider the effects of a proportional fall in both transaction cost coefficients. As these are initially set at unity, we have $d\varepsilon = d\gamma < 0$. The fall in external transaction costs shifts the SS curve to the right, while the LL curve is unaffected since both coefficients fall equally. Thus, up to a scalar multiple, $dh/d(-\varepsilon)|_{SS} = -e_L/y_{sh} > 0$, the organizational impact is identical to that for an increase in the capital-labor ratio:

$$\text{(19a)} \quad ds/d(-\varepsilon)|_{d\varepsilon=d\gamma} = \frac{-e_L}{y_{sh}}\frac{ds}{dh} > 0$$

$$\text{(19b)} \quad dL/d(-\varepsilon)|_{d\varepsilon=d\gamma} = \frac{-e_L}{y_{sh}}\frac{dL}{dh} > 0$$

$$\text{(19c)} \quad dq/d(-\varepsilon)|_{d\varepsilon=d\gamma} = \frac{-e_L}{y_{sh}}\frac{dq}{dh} > 0\,.$$

The impact on economic welfare is given by $dw/d(-\varepsilon)|_{d\varepsilon=d\gamma} = i(L) + e(L, s) > 0$.

4 Economic Development and the Evolution of Organization

Abstracting as it does from population growth and technical progress, the model does not generate perpetual growth. It does, however, illustrate the role of organizational change in exploiting the gains to labor specialization and, thereby, overcoming diminishing returns to capital. The focus on organization, in turn, highlights the role of transaction costs as a determinant of long run economic performance.

Provided transaction costs increase sufficiently slowly in labor specialization, the model exhibits increasing marginal returns to capital and growth proceeds according to a virtuous cycle of mutually reinforcing increases in labor specialization and the capital-labor ratio. Both high and low level stationary equilibria are possible, and these capture, in a stylized manner, the organizational characteristics of traditional and industrial economies. During transition to the steady state, a growing economy exhibits the hallmark of an evolving complex system: it adopts increasingly complex patterns of self-organization.

4.1 Specialization and Increasing Returns

As noted in the previous section, an increase in the capital-labor ratio increases equilibrium labor specialization. Greater labor specialization, in turn, allows specialized capital goods to be utilized more intensively, increasing the return to capital. Provided this effect is sufficiently strong, the model exhibits increasing marginal returns to capital.

As indicated by (16), at internal equilibria labor specialization is increasing in the capital-labor ratio. Thus, we may write $s^* = s^*(h)$, $s^{*\prime}(h) > 0$. Net per capita income is given by $w(h) = y[s^*(h), h] - t[s^*(h)]$, with first and second derivatives

$$(20a) \quad r(h) = y_h[s^*(h), h]$$

$$(20b) \quad r'(h) = y_{hh}[s^*(h), h] + y_{hs}[s^*(h), h]s^{*\prime}(h)$$

where $r(h) = w'(h)$ is the marginal product of capital.

As indicated by the second line of (20), capital accumulation has two effects on the marginal product of capital. The *direct effect*, captured in the first term, results from diminishing marginal returns to capital in the production of each intermediate good and is negative. The *indirect effect*, captured by the second term, is positive: an increase in the capital-labor ratio increases equilibrium labor specialization, allowing for greater utilization of task-specific capital and increasing the marginal return to capital. If the direct effect outweighs the indirect effect, the model exhibits diminishing marginal returns, with the familiar neoclassical implication that accumulation driven growth is self-limiting.

If the indirect effect more than offsets the direct effect, however, production exhibits increasing marginal returns to capital. In this case, the model supports a virtuous cycle of growth due to mutually reinforcing increases in labor specialization and the capital-labor ratio. Recalling from (16) that $s^{*\prime}(h) = y_{hs}/(t_{ss} - y_{ss})$, it is clear that the indirect effect is larger the more slowly marginal transaction costs rise in labor specialization. The model, thus, suggests that the ease with which an economy accommodates a more advanced division of labor determines whether it is subject to increasing or diminishing returns to capital.

Population size places an upper limit on the division of labor and, thus, to the role of increases in the division of labor in a virtuous cycle of growth. Define h_N as the level of the capital-labor ratio at which optimal specialization equals population size, $s^*(h_N) = N$. For $h \geq h_N$ there is a single market in which labor is fully subdivided and each firm employs $L^*(h_N)$ workers. Beyond h_N the accumulation of capital increases per capita output but does not increase the division of labor, implying the indirect effect is zero. As a result, $r(h)$ is decreasing in h for $h > h_N$.

4.2 The Dynamic Model

In the dynamic model, the variables of the static model are treated as functions of time, indexed by τ. The dynamic budget constraint and a CES utility function are given by

$$(21) \qquad h(\tau+1) = w(h(\tau)) - c(\tau), \text{ and}$$

$$(22) \qquad U = \sum_{\tau=0..\infty} b^{-\tau} u(c(\tau))$$

where $b > 1$ and $u(c(\tau)) = c(\tau)^{1-\varepsilon}/(1-\varepsilon)$ for $\varepsilon > 0, \neq 1$, and $ln(c(\tau))$, for $\varepsilon = 1$.[11]

Agents choose a consumption stream $\{c(\tau)\}_{\tau \geq 0}$ to maximize (22) subject to (20), (21), $h(0) = h_0$ and $c(\tau), h(\tau) \geq 0$. First-order conditions imply that the rate of growth of consumption is given by

$$(23) \qquad g_c(\tau) = \left[\frac{r(h(\tau+1))}{b}\right]^{1/\varepsilon} - 1,$$

implying that consumption is increasing provided the return to capital is greater than the (gross) discount rate. As preferences are homogeneous, per capita output and the capital-labor ratio grow at identical rates: $g_w(\tau) = g_h(\tau+1) = g_c(\tau)$.

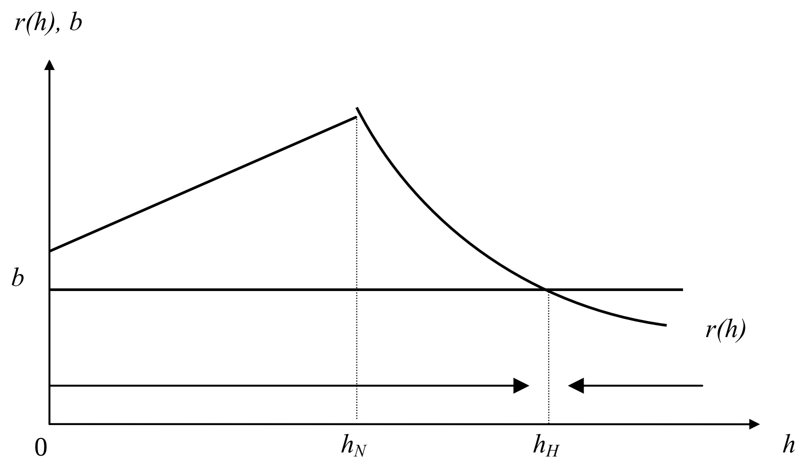
[11] With multiple steady states, the use of a discrete time framework with full periodic depreciation of capital each period sharpens the analysis by allowing an analytic solution. These assumptions may be justified intuitively if each period is interpreted as a separate generation and one ignores intergenerational human capital spillovers. Qualitative aspects of the dynamic model, such as the existence of multiple local maxima and a threshold value of the capital-labor ratio, are not sensitive to this specification. Analysis of a dynamic model with continuous time and no capital depreciation is available from the author on request.

While the model is flexible enough to produce both increasing and diminishing returns to capital, the nature of growth with diminishing returns to capital and no technical progress are well known from the Solow model and its derivatives. Thus, here we consider only those cases in which organizational change gives rise to increasing marginal returns.[12] It is also useful to characterize economies according to their production functions as being *high productivity* economies provided $r(0) \geq b$ and *low productivity* economies otherwise.[13]

As illustrated in Figure 3a, the marginal product of capital in a high productivity economy is greater than b and increasing for $h < h_N$. Starting from a low initial level of the capital-labor ratio, the economy experience positive and increasing rates of growth of income, capital and consumption due to the interaction of capital accumulation and the division of labor. Once the capital-labor ratio reaches h_N, the division of labor is complete. Thereafter, the virtuous cycle is broken, the marginal product of capital declines, and growth slows as the economy approaches a stationary equilibrium at h_H.

Figure 3a

Stationary State for a Productive Economy



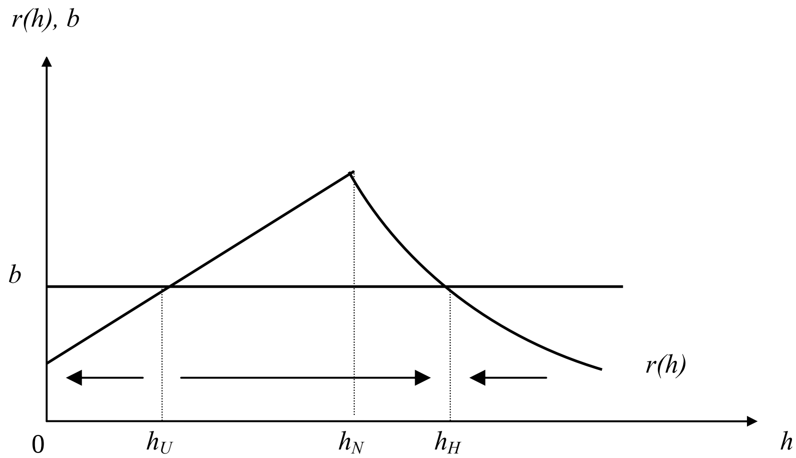
As shown in Figure 3b, a low productivity economy will have three stationary states, at $h_L = 0$, h_U and h_H, where h_U is defined implicitly by $r(h_U) = b$, $h_U < h_N$. h_U constitutes a development threshold. If the initial capital-labor ratio is greater than the threshold level, the economy undergoes a virtuous cycle of accumulation and specialization until the division of labor is complete; thereafter approaching the high-level equilibrium at h_H. Similarly, a country with a low initial capital-labor ratio will

[12] See DAVIS [2001b] for a division of labor growth model in which the realization of increasing or diminishing marginal returns depends on an economy's institutional structure.

[13] If we impose the familiar Inada condition, lim $h \rightarrow 0$, $r(h) = \infty$, then increasing marginal returns implies the marginal product of capital is infinite for $h < h_N$.

Figure 3b

Stationary States for an Unproductive Economy



undergo a viscous cycle, consuming its capital and adopting ever lower levels of labor specialization. This case may be relevant to countries in which the traditional sector expands in response to civil unrest.

4.3 The Evolution of Organization

The defining characteristic of complex systems is the capacity for self-organization, as demonstrated by the spontaneous emergence of higher-order structures among individual actors.[14] In the static model, self-organization consists of the formation of firms and interfirm trading groups. The dynamic model captures an additional element, the evolution of organization over time. A growing economy adopts increasingly complex organizational structures. The increase in organizational complexity is evident in the pattern of interfirm trade. Though not explicitly modeled, following WILLIAMSON [1975] an increase in the complexity of the firm's internal organization may be inferred from the increase in firm employment.

The implications of growth for the evolution of the organization of production are found by combining the dynamics of accumulation described by Figures 3a and 3b and the comparative statics of capital accumulation. An economy with an initial capital-labor ratio $h(0) < h_N$ and converging to the high-level stationary state will experience a gradual increase in the capital-labor ratio. From (16), the accumulation of capital raises the gains to labor specialization, implying increases in labor specialization, firm and market size, vertical disintegration, market integration and increases in the complexity of interfirm trade. In short, the economy adopts increasingly complex organizational structures in order to reap the rising gains to labor specialization. An economy approaching the low-level stationary state will

[14]In KRUGMAN [1994], complexity consists of the spontaneous emergence of manufacturing centers or cities among competing locations.

experiences these processes in reverse. Beyond h_N, labor is fully specialized and the organization of production is static as the economy approaches the high-level equilibrium at h_H.

As noted earlier, the potential for a virtuous cycle of growth due to capital accumulation and the division of labor depends on marginal transaction costs rising relatively slowly as the division of labor increases. Of the various reasons that transaction costs may rise slowly, two are of particular note. First, the economies of scale and the public good characteristics of transportation and communications infrastructure suggest an important role for public investment in reaping the gains to specialization.[15] Second, the rule of law and enforcement of property rights may also affect the rate at which marginal transaction costs rise. Economic development, with its accompanying increases in market size and the division of labor, implies the depersonalization of exchange and an increasing role for formal relative to informal enforcement mechanisms (North [1990]). If formal institutions are weak, the substitution of formal for informal enforcement may well result in rapidly rising market transaction costs.

5 Conclusion

The primary purpose of this paper is to develop a dynamic, general equilibrium, transaction cost theory of organization. It does so by integrating two existing transaction cost theories of organization, the neoinstitutionalist theory of the firm and the theory of endogenous labor specialization. The model generates predictions regarding the organizational and welfare impacts of phenomena that influence transaction costs, including changes in management practice, the rule of law and corruption, public infrastructure investment, the adoption of a common currency and advances in information technology.

The model stresses the idea that firms and markets are complements in reaping the gains available from the adoption of complex production structures, which contrasts the neoinstitutionalist vision of firms and markets as substitutes for organizing production. This contrast is most apparent in the comparative static exercises, showing that a decrease in either form of transaction cost increases the division of labor and results in greater use of both markets and firms to organize production. It is also reflected in the dynamic model, in which growth is facilitated by the adoption of increasingly complex organizational structures, involving increases in the division of labor, firm size and interfirm trade.

[15] See DAVIS [2003] for a formal analysis of the role of government in facilitating the division of labor.

Appendix

Noting that $E'(J) > 0$ and $E''(J) > 0$, the derivatives reported for $e(L, s) = E(s/L)/L$ in equation (3) may be signed as follows:

$$e_L(L, s) = -[(s/L)E' + E]/L^2 < 0$$

$$e_s(L, s) = E'/L^2 = > 0$$

$$e_{Ls}(L, s) = -[(s/L)E'' + 2E')/L^3 < 0$$

$$e_{ss}(L, s) = E''/L^3 > 0$$

$$e_{LL}(L, s) = (s^2E'' + 4LsE' + 2L^2E)/L^5 > 0.$$

In order to sign the comparative statics in section 2, we begin by showing that $L/s > EE > SS$, where $EE = -e_s/e_L$ is the slope of the line along which $e(L, s)$ is constant and SS is the slope of the SS curve. These inequalities also serve to sign equation (15).

The first inequality, $L/s > EE$, follows from

$$EE = -e_s/e_L = \frac{E'/L^2}{\left[(s/L)E'+E\right]/L^2} = \frac{E'}{(s/L)E'+E} < L/s.$$

For $EE > SS$, we employ the Le Chatelier principle. Let $s^*(L)$ be the solution to the problem $max_{\ s > 1}\ \pi(s, L) = y(s) - e(s, L) - i(L) - w$, where w and L are taken as given. The solution function $s^*(L)$ is such that $\pi_s[s^*(L), L] = 0$, implying $ds^*/dL = \frac{e_{Ls}}{y_{ss} - e_{ss}}$. Let $P(L) = \pi[s^*(L), L]$ be the maximized objective function.

Next, let $\hat{s}(L)$ be the solution to the constrained maximization problem: $max_{\ s > 1}\ \pi(s, L)$, subject to $e(s, L) = e[s^*(L_0), L_0]$ for some L_0. The constraint implies $d\hat{s}(L)/dL = -e_L/e_s$. Let $Q(L) = \pi[\hat{s}(L), L]$ be the value of the objective function under constrained maximization. Applying the Le Chatelier principle, it follows that $Q_{LL}(L_0) < P_{LL}(L_0)$, or

$$\pi_{sL}[\hat{s}(L_0), L_0]\hat{s}'(L_0) + \pi_{LL}[\hat{s}(L_0), L_0] < \pi_{sL}[s^*(L_0), L_0]s^{*\prime}(L_0) + \pi_{LL}[s^*(L_0), L_0]$$

$$-e_{Ls}[-e_L/e_s] - (e_{LL} + i_{LL}) < -e_{Ls}\left[\frac{e_{sL}}{y_{ss} - e_{ss}}\right] - (e_{LL} + i_{LL})$$

$$-e_s/e_L > \frac{y_{ss} - e_{ss}}{e_{Ls}}$$

or *EE* > *SS*, as defined above. Note that the arguments of *P* and *Q* may be suppressed in the lines above since the constraint is non-binding at L_0 , implying $\hat{s}(L_0) = s^*(L_0)$. Since L_0 was freely chosen, we may assign it to be the value of *L* in the initial equilibrium of a comparative static exercise, i.e. such that L_0 satisfies (8) and (9).

Total differentiation of (8) and (9) implies

$$\begin{bmatrix} y_{ss}\text{-}e_{ss} & -e_{Ls} \\ e_{Ls} & i_{LL}+e_{LL} \end{bmatrix}\begin{bmatrix} ds \\ dL \end{bmatrix} = \begin{bmatrix} -y_{sh} & 0 & e_s \\ 0 & -i_L & -e_L \end{bmatrix}\begin{bmatrix} dh \\ d\gamma \\ d\varepsilon \end{bmatrix}$$

or

$$\begin{bmatrix} ds \\ dL \end{bmatrix} = \frac{1}{\Delta}\begin{bmatrix} -y_{sh}(i_{LL}+e_{LL}) & \text{-}i_L e_{Ls} & e_s(i_{LL}+e_{LL})-e_L e_{Ls} \\ y_{sh}e_{Ls} & -i_L(y_{ss}-e_{ss}) & -e_s e_{Ls}-e_L(y_{ss}-e_{ss}) \end{bmatrix}\begin{bmatrix} dh \\ d\gamma \\ d\varepsilon \end{bmatrix}$$

where $\Delta = (i_{LL}+e_{LL})(y_{ss}\text{-}t_{ss}) < 0$

Comparative statics for *s* and *L* follow directly from the matrix above. For example, for ε we have

$$ds/d\varepsilon = -\frac{1}{\Delta}[e_s(i_{LL}+e_{LL})-e_L e_{Ls}] = -\frac{e_s e_{Ls}}{\Delta}\left[\frac{EE-LL}{LLEE}\right] < 0$$

$$dL/d\varepsilon = \frac{1}{\Delta}[-e_s e_{Ls}-e_L(y_{ss}-e_{ss})] = \frac{e_L e_{Ls}}{\Delta}\left[EE-SS\right] < 0$$

The signs follow directly from the derivatives of e(..) and *EE* >*SS* >*LL*. Comparative statics involving firm specialization follow from *q = s/L*:

$$dq/d\varepsilon = d(s/L)/d\varepsilon = \frac{ds}{Ld\varepsilon}\left[1-\frac{s}{L}\frac{dL/d\varepsilon}{ds/d\varepsilon}\right] = \frac{ds}{Ld\varepsilon}\left[1-\frac{s}{L}\frac{EE-SS}{EE-LL}LL\right] < 0$$

The comparative statics of $d\gamma = d\varepsilon < 0$ follow from those for *h* and $dh/d\varepsilon|_{SS} = e_L/y_{sh}$.

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