Journal of International Business Studies (2009) 40, 1496–1514
© 2009 Academy of International Business All rights reserved 0047-2506
www.jibs.net

Information technology and transnational integration: Theory and evidence on the evolution of the modern multinational enterprise

Subramanian Rangan[1] and Metin Sengul[2]

[1]INSEAD, Fontainebleau, France; [2]Boston College, Chestnut Hill, USA

Correspondence:
S Rangan, INSEAD, Boulevard de Constance Fountainebleau, 77305 France
Tel: +33 1 60 72 43 14;
Fax: +33 1 60 74 55 00;
E-mail: subramanian.rangan@insead.edu

Received: 15 March 2008
Revised: 26 May 2009
Accepted: 18 June 2009
Online publication date: 15 October 2009

Abstract

Reflecting amplified hazards in cross-border exchange and imperfections in markets for intangibles, internalization has been central in multinational enterprise (MNE) theory. This centrality notwithstanding, the fact is that internalization coheres with lower-powered incentives and carries an implicit drawback, namely, higher realized production costs. With the emergence and deployment of information and communication technology (ICT), modern MNEs are reshaping their transnational governance to address this cost. The modern MNE uses ICT to mitigate transaction costs, and evolves more to arm's length exchange to incentivize lower production costs. A testable prediction is that MNEs in industries more susceptible to and employing more ICT will exhibit a reduced propensity for transnational integration. We examine this hypothesis using available data from 1982 to 1997 for US MNEs across all manufacturing sectors. Regression results and robustness tests are strongly congruent with the prediction. This study, a first to explore empirically the role of ICT in the evolution of transnational exchange, suggests that MNE theory, until now founded primarily on transaction cost economics and a cross-border control theory of value capture, is more likely to keep pace with developments in MNE practice by opening up to incentive theories of exchange governance and a cross-border coordination theory of value creation.
Journal of International Business Studies (2009) **40,** 1496–1514.
doi:10.1057/jibs.2009.55

Keywords: internalization theory; transaction cost theory, transaction cost economics, or transaction cost analysis; theory of FDI and the MNE (ownership–location–internalization)

INTRODUCTION

The multinational enterprise (MNE) has been defined as an economic entity that controls operations dispersed across national borders (Caves, 1996). While the cross-border dispersion of operations is a prerequisite for the "multinational" label, the theory of MNE has centered on control and internalization. Thus, referring to Dunning's OLI (ownership–location–internalization advantages) framework, MNE economist Ethier (1986: 805) underlined internalization as the "Caesar of the OLI triumvirate."[1] Likewise, for Rugman (1980: 370), "existing theories of FDI are really subcases of the theory of internalization." Even earlier, for Vernon (1971), the MNE was an entity unified by ties of control-granting common ownership. For Hymer (1976), too, control of foreign operations was a defining characteristic of MNE. It has been suggested, accordingly, that "the central task of … theory of the multinational … must be to elucidate the … internalization issue" (Ethier, 1986: 806). This contention is reflected in the work of newer MNE scholars such as Antras (2005: 25), who affirms: "The issue of internalization or control is crucial for gaining an understanding of multinational firms."

Their centrality in theory notwithstanding, control and internalization of foreign operations appear, in practice at least over the past two decades, to be intentionally if selectively less sought by MNEs. There is considerable casual evidence that the control-seeking multinational of an earlier era has been becoming control-ceding. An established multinational such as Philips "de-risks" its operating model and cedes control of foreign manufacturing to contractors that continue to work closely with Philips and produce Philips-branded products. General Electric (GE) spins off its transaction processing subsidiary in Bangalore, India, even as the ex-parent continues to be a prime customer for the spun-off independent entity. Other multinationals too, including the likes of American Express and Hewlett-Packard, have been re-architecting the governance of their international operations. The pattern of interest is that even as dispersion and cross-border exchange are becoming more prevalent and prominent in the performance of multinational firms, ownership and control are, as outlined above, being ceded by these entities. Intra-mediate international trade flourishes, but is now frequently coordinated across an arm's length governance regime. What can we hypothesize about the proximate causes and timing of this evolution in transnational exchange? What are the implications for MNE theory and future research?

In an influential article proclaiming this transformation in the organization of transnational exchange, the chief executive officer of the venerable multinational IBM explains: "These decisions are not simply a matter of offloading non-core activities, nor are they mere labor arbitrage. They are about … [opening] the enterprise in multiple ways, allowing it to connect more intimately with partners, suppliers, and customers …" (Palmisano, 2006: 131). In the view of this informed practitioner, "it is becoming increasingly clear that that the twentieth-century [MNE] model is no longer optimal for innovation" (133). The focus, he reckons, "has begun to shift from *protecting* intellectual property … to *maximizing* intellectual capital, … based on *shared* ownership …" (134; emphasis added). He urges: "rather than continuing to focus on past models … scholars would be best served by thinking about the global corporation of the future and its implications …" (130).

Without entering into speculation about the "future," it is our aim in this paper to pick up this call from both a theoretical and especially an empirical angle. In explaining this transformation and its timing in this paper we highlight and focus on the role of information and communication technology (ICT). To established transaction cost economics arguments we join incentive theory arguments and appeal to a broader explanation that, in the spirit of Riordan and Williamson (1985), speaks to both the benefits and the costs of internalization. Our central argument is that whereas the conventional MNE was duly concerned with the mitigation of transaction costs in cross-border exchange, the modern MNE, enabled by ICT, organizes international exchange to also push down production costs. The emergence and deployment of ICT facilitates observability and coordination, and leavens concerns related to asset specificity. Yet that is not sufficient to explain the pattern. After all, ICT lowers internal coordination costs as well, and may provoke greater internalization (Brynjolfsson, 1994; Gurbaxani & Whang, 1991; Zenger & Hesterly, 1997). The fact is, however, that internalization coheres with lower-powered incentives, and carries a consequent if implicit drawback – that is, higher realized production costs. If ICT lowers arm's length transaction costs, and, separately, if arm's length governance incentivizes lower production costs, then ICT and arm's length governance will be employed as complements. That, in fact, is the main hypothesis that we first develop and then examine using available data from 1982 to 1997 for US MNEs across all manufacturing sectors.

Regression results and robustness tests are congruent with this expectation. MNEs in industries more susceptible to and employing more ICT exhibit a reduced propensity to transnational integration. This offers the first empirical evidence about the role of ICT in the evolution of transnational exchange and the modern MNE. To be sure, studies on transnational exchange and separately on ICT do exist. On the one side, a number of studies directly examined the drivers of transnational integration (e.g., Cho, 1990; Desai, Foley, & Hines, 2004; Kobrin, 1991; Lall, 1978). Some of these studies allude to ICT, but none theorizes about or incorporates it into the empirical analyses. On the other side, there exist studies that explicitly consider ICT's influence on economic organization and exchange governance (e.g., Argyres, 1999; Baker & Hubbard, 2003, 2004; Brynjolfsson, Malone, Gurbaxani, & Kambil, 1994). These latter focus on domestic transactions, but do not address international exchange. The only study we are aware of that explicitly brings in ICT in an MNE context is Nachum and Zaheer (2005). That study, however, examines differences in MNE foreign investment motivations across ICT-intensive and non-ICT-intensive industries. Thus, to our knowledge, this is the first study to:

- theorize about how ICT enables MNEs to reshape the governance of transnational exchange to diminish implicit costs of internalization;
- empirically explore the proposed link between ICT and transnational integration (while controlling for traditional and alternative explanations); and
- articulate implications for MNE theory.

To be clear, the modern MNE does not dismiss or disregard the benefits of internalization, but it is now capable of being more sensitive to the costs of internalization. In other words, if the twentieth-century MNE was a defensive entity, focused on value capture through globally controlled transfer and the exploitation of existing proprietary knowledge, then the twenty-first-century MNE is a more selectively integrated global enterprise that cedes ownership in order to foster decentralized value creation. This means that to the conventional logic of "R&D – knowledge intensity – contractual hazards in exchange – intrafirm exchange – transaction cost advantages" we may now join "ICT – information intensity – division of labor benefits in exchange – interfirm exchange – production cost advantages."

TRANSNATIONAL INTEGRATION

Amplified hazards in cross-border exchange and imperfections in markets for knowledge have led international scholars to predict a linkage between internationalization and internalization (Morck & Yeung, 1991). For instance, writing more than 25 years ago, Hennart (1982: 174) declared, "It is … safe to predict that multinational firms will remain for a long time the most efficient institution to further trade and specialization." Porter (1986: 56) held, too, that global strategy rested on cross-border coordination, which, he submitted, "can be difficult to accomplish through arm's length or quasi-arm's length transactions because of risks of contracting with independent parties as well as high transaction costs [necessary to address those risks]." Thus, as noted at the outset, it is canon in the literature that MNEs will have a propensity to internalize foreign operations, and that internationalization and internalization will tend to be linked.

In an empirical paper exploring the motivations for internalization in transnational exchange, Kobrin (1991) focused on *transnational integration*, which he proposed as an ideal indicator of the extent to which the melding of comparative and competitive advantage occurs within – as opposed to across – firms. It is argued that comparative advantage resides in geographic configuration or location, whereas competitive advantage resides in geographic coordination or organization (see also Kogut, 1985). The issue is the extent to which dispersed configuration coincides with decentralized coordination. Transnational integration occurs when a firm disperses value-adding activities across national boundaries *and* integrates at least some of those activities within its own firm boundaries (Markusen, 1995). Colloquially, transnational integration pertains to MNEs "slicing the value chain" and engaging in "intra-mediate trade" (Feenstra, 1998: 32). While the spatial dispersion decision is influenced by scale, transport, and location factors (Brainard, 1997), the integration decision depends on the costs and benefits of coordinating the particular activity at arm's length relative to coordinating it internally (Rugman, 1980). This is where the theory of exchange governance comes in.

Exchange Governance Revisited

Exchange governance theory pertains to the analysis and choices (e.g., make vs buy) of forward-looking agents as they attempt, by design, to optimize both effort and alignment in exchange. A base premise in this literature is that economically productive society requires from actors both effort and alignment (Commons, 1932). If effort is low, then production costs will be higher than they otherwise would be. If, on the other hand, actors are not sufficiently mutually aligned, then transaction costs will be high, and mal-adaptation may obtain. A supplementary premise is that all complex contracts tend in one or more ways to be incomplete. Building on the preceding two premises, the work of Coase (1937); Holmstrom and Milgrom (1994); Williamson (1991), among others (see Gibbons, 2005, for a review), has analyzed and deepened our understanding of exchange governance, although from different angles. While transaction cost theory à la Coase and Williamson has been concerned primarily with *protecting* the downside in exchange (i.e., with eliciting alignment and adaptation), incentive theory à la Holmstrom and Milgrom, and Adam Smith much earlier, is concerned primarily with *maximizing* the upside in exchange (i.e., with eliciting effort and ingenuity). Both transaction cost logic and an incentive or property rights logic are congruent on such fundamentals as uncertainty, incomplete contracting, opportunism, bargaining expectations, and discriminating alignment.

In condensed form, as is well established (see Williamson, 2005), this vast literature proposes that exchange has two optimands – effort and alignment; and contractually feasible governance has two archetypes – markets and hierarchies. Markets or arm's length (buy) modes of governance tend to be stronger on inducing effort but weaker on alignment. Hierarchies or internal (make) modes of governance tend, on the other hand, to be stronger on alignment but weaker on inducing effort. The reasoning is that, emanating from fiat power, control properties in internal exchange relative to arm's length exchange tend to be high-powered. In contrast, incentive properties in arm's length exchange, relative to those in internal exchange, tend to be high-powered (Gibbons, 2005, provides ample elaboration).

High-powered incentives tend to be eschewed by internal organizations for a variety of reasons. Among these are concerns related to "crowding out" of less observable yet valuable tasks (such as teamwork); and concerns related to bureaucracy and influence costs (including gaming of the system) (Milgrom & Roberts, 1992). Importantly, internal organization has at its disposal promotion and career incentives (see Kim, 1999). Finally, to the extent that it is the allocation of property rights (to product and process innovations) that constitute high-powered incentives, these are generally more feasible in interfirm market relations than in internal (employer–employee) relations.

The choice of exchange governance regime, oriented to optimize both effort and alignment, is contingent on and influenced by three factors: transaction characteristics, relative transaction costs, and relative production costs. Transaction characteristics are generally taken as antecedent and determinative. Asset specificity, which is inversely proportional to an asset's value in next best use, is a widely discussed transaction characteristic of consequence (Riordan & Williamson, 1985). Transactions subject to unprogrammed but necessary changes are also exposed to the hazard of mal-adaptation. In both cases, *ex post* switching is inhibited owing to high cost or low feasibility. In the context of MNEs, echoing Buckley and Casson (1985), Henisz and Williamson (1999) point to misappropriation of proprietary knowledge and dissipation of brand as other important transaction hazards that firms consider as they contemplate optimal governance modes for international exchange. Other things equal, the greater the level of transaction hazards, the higher the concerns on alignment (or downside concerns), and the higher the propensity to internalize (Martin & Salomon, 2003).

Given transaction characteristics, agents will weigh in a comparative manner transaction and production costs of arm's length vs internal exchange (Williamson, 2005). Transaction costs relate to communicating, monitoring, coordinating, negotiating (including haggling), and, where necessary, enforcing partner behavior to adhere to the intended (even if not expressly stated) terms of the exchange. The transaction costs of markets rise more steeply in the extent of the hazards than do the costs of hierarchy (Williamson, 1991). In the international context, relative transaction costs will also be influenced by the ambient institutional and political context that supports the transaction (Henisz & Williamson, 1999).

Last, but not least, the exchange governance decision will also factor-in production costs in arm's length relative to internal exchange. Activity scale, experience, location (i.e., transport) will no doubt figure in the analysis. Often, however, capabilities, ingenuity, and initiative will play a decisive role (Mayer & Salomon, 2006; Simon, 1982). These latter are to a certain extent exogenous, but to the extent that they are endogenous, it is the incentive regime that is deemed consequential (Holmstrom & Milgrom, 1994). As noted earlier, arm's length exchange brandishes high-powered incentives (and disincentives). Beyond high pay for high performance (which, to a certain extent, is replicable internally), in arm's length exchange the creative agent retains property rights to innovations realized. Innovative methods, designs, and techniques remain the property of the seller and are not automatically transferred or owned by the buyer. As a consequence, relative to internal exchange, incentives are more high-powered, and *ex ante* investments and *ex post* productivity improvements are anticipated to be higher in markets (Grossman & Hart, 1986; Hart & Moore, 1990). Due to this endogeneity of effort and ingenuity, arm's length exchange is, beyond scale effects, expected to generally yield lower production costs.

The Impact of ICT on MNE Transnational Integration

ICT is a non-proprietary infrastructure technology, emerging primarily from advances in the domains of semiconductor chips, digital machines, storage devices, and communications equipment (i.e., hardware), and computing, controlling, database, and communication applications (i.e., software). Scholars have argued and shown, in the domestic setting, that ICT sets off predictable and powerful changes, especially in terms of transaction characteristics and transaction costs (Argyres, 1999; Baker & Hubbard, 2003, 2004; Brynjolfsson, 1994; Brynjolfsson et al., 1994; Gurbaxani & Whang, 1991; Zenger & Hesterly, 1997). There are three effects of ICT that are pertinent for our discussion:

- ICT leavens concerns related to asset specificity;
- ICT increases observability and contractibility; and
- ICT reduces coordination costs.

Given MNEs' greater exposure to competition, greater sensitivity to quality, and greater geographic spread, the considerations of asset specificity, observability, and coordination are particularly relevant and important. To the extent that ICT influences these factors, it is likely to reshape transnational governance within the MNE.

A major impact of ICT is on the need for asset specificity (Brynjolfsson, 1994). When the functions of hardware can be regulated by software, then machines can be repurposed. Their next best uses multiply and their "specificity" declines (see Bartel, Ichniowski, & Shaw, 2007). In concrete terms, a dedicated downstream plant capable of handling inputs from only a parent can now be displaced by a standalone local entity capable of handling inputs from two or more distinct upstream sources (Dedrick & Kraemer, 2005). A decline in asset specificity also makes switching exchange partners more feasible. As a result, *ex post* bargaining and hold-up are lesser issues, and *ex ante* optimal investments can result without integration of downstream and upstream activities. When asset specificity declines, and if ownership is ceded, there is potential for gains in incentive intensity, specialization, and scale. One would hence expect the propensity for arm's length exchange to rise.[2]

A second impact is that ICT can facilitate cost-efficient and effective observability and monitoring. If quality is important, but information about the true quality of a component is available only to the entity fabricating that component, then a buyer might have to internalize the transaction involving the procurement of that component (i.e., the downstream entity might have to integrate backward and make rather than buy). If, due to advances in ICT, the quality characteristics of the component can be ascertained reliably by a machine, compared automatically against desired quality standards, and the results transmitted to the downstream user, then valuable information has become disembodied, and, in turn, quality becomes more credibly and cost-effectively contractible (Bartel et al., 2007). In this sense, ICT has reduced costly information asymmetry and lessened the need for integration. ICT hence enables information to become more disembodied and performance more contractible (Brynjolfsson, 1994; Zenger & Hesterly, 1997).

Third, ICT makes coordination easier and cheaper. This can be expected to shift the balance away from hierarchy more toward markets, because when bandwidth is limited and communication is costly, centralization is optimal. In a setting of multiple entities (three or more), a single message sent to a central agent (headquarters) from one entity (a subsidiary) can be efficiently received and retransmitted to the other entity (another subsidiary) to whom that information is most pertinent. As Hennart (1982) has argued, decentralized multi-way communication would place much larger demands on bandwidth. But the parameters in this very calculus are what ICT advances are changing. To be sure, as multi-way communication becomes more cost-effective, the need for coordination, especially in complicated transactions, does not decline. Simply, the costs of coordination in the market (many-to-many mode) decline, and, in turn, so does the need for centralization (Baker & Hubbard, 2003). A related reason why and how ICT causes relative declines in the costs of market governance is that it enables the development and propagation of a technical grammar that makes *interfirm* communication much more efficient. Supportive evidence comes from Argyres (1999), who documents the powerful role played by shared computer databases in enabling automatic interfirm updating and synchronization in a distributed work setting.

In sum, the emergence and deployment of ICT reduces transaction hazards (especially related to asset specificity) and transaction costs (especially related to observability, contractibility, and coordination). To keep with the exchange governance drivers outlined above, it is necessary to also understand the link between ICT and production costs. To be clear, ICT is not an incentive instrument, and it cannot influence production costs through that mechanism. Yet, where ICT mitigates transaction costs, the difference between internal and arm's length transaction costs diminishes. In optimizing total costs (i.e., transaction plus production costs), attention can then turn from transaction costs to production costs. As explained above, internalization coheres with lower-powered incentives and in consequence carries a drawback, namely, higher realized production costs. Accordingly, as Palmisano (2006: 130) has written, with the emergence of ICT and "shared modes of connecting business activity," modern MNEs "can hand over more and more of the work they had previously performed in-house … to outside specialists." In theory terms, with the emergence and deployment of ICT, it is more attractive and feasible for MNEs to evolve from internal to arm's length exchange so as to access the (lower production costs) benefits of incentive intensity inherent in the market mode.

As mentioned above, given MNEs greater exposure to competition, greater sensitivity to quality, and greater geographic spread, ICT influences might be expected to be particularly salient to MNEs in their "open economy" setting. There are three reasons why ICT influences on exchange governance are especially apropos MNEs. First, a core of the above arguments resides in the production and use of information. Information is a "weightless" asset (unhampered by transport cost considerations), and the applicability of the above arguments in an open economy MNE context should be high. Second, observability, and hence control and coordination, is a prime challenge, especially when firms operate across national borders and at great distances (Antras, 2005). Hence the relief provided by ICT is likely to be even more valuable in an MNE transnational context. Lastly, heterogeneity in latent capabilities and ingenuity is likely to be greater across countries (Porter, 1990). Hence opportunities for value creation via governance shifts are probably higher in the open economy MNE context (relative to a purely domestic setting). Taken together, and based on the preceding, we propose that MNEs in industries more susceptible to and employing more ICT will exhibit a reduced propensity to internalization:

> **Hypothesis 1**: Other things being equal, the greater the adoption and deployment of ICT in an industry, the lower will be MNE transnational integration in that industry.

To be clear, our argument is not that ICT facilitates only superior arm's length exchange. ICT also lowers internal monitoring and coordination costs, and may provoke greater internalization (Brynjolfsson, 1994; Gurbaxani & Whang, 1991). In circumstances where internal monitoring is infeasible or unsatisfactory, even though a focal actor might have advantage in supervising the use of an asset and hence its ownership, that focal actor might choose to externalize because of high internal transaction costs (Baker & Hubbard, 2003). By externalizing the ownership of the asset, the costs of mal-adaptation are borne by (or at least shared by) the exchange partner, and the arm's length arrangement is superior for both actors (see Grossman & Hart, 1986; Hart & Moore, 1990; Holmstrom & Milgrom, 1994). If ICT makes internal monitoring more feasible, then in such situations it can induce greater internalization. If ICT can reduce internal transaction costs it may also induce greater internalization in situations where focal actors have superior operating competencies. Further, if ICT enhances a firm's ability to circumscribe and isolate internal activities, rewards can be more directly linked to performance, much like an internal market (Zenger & Hesterly, 1997). In this sense, too, ICT (especially technologies that enable actors to acquire knowledge; Bloom, Garicano, Sadun, & Van Reenen, 2009) may support larger firms with autonomous units. Still, the totality of the theoretical arguments outlined above would suggest that the effect of ICT on transnational integration is likely tilted toward less rather than more internalization. The net effects are, strictly speaking, an empirical matter. We shall turn to the empirics after considering moderating factors.

ICT and knowledge intensity. The prediction in Hypothesis 1 above pertains especially to "information intensive" activities such as procurement, manufacturing, inbound and outbound logistics, and transaction processing. The pattern is evident in the MNE illustrations (i.e., Philips and GE) mentioned at the outset. There are other clusters of activities where concerns of appropriability are unlikely to be mitigated by ICT. Prime among these are research and development (R&D) activities. As noted earlier, "knowledge intensity" (indicated by R&D spending) is related to higher transnational integration due to value appropriation concerns (Kobrin, 1991; Rugman, 1980). These concerns (e.g., leakage of product and process knowledge) do not evaporate with the emergence of ICT. In fact, in knowledge-intensive industries, ICT is likely to be used to coordinate internal exchange across specialized but geographically dispersed locations. Codifying and digitizing proprietary knowledge can aid cost-effective dissemination. ICT can enable knowledge workers dispersed across countries to collaborate and work simultaneously or sequentially on problems (e.g., software development, key account management). However, ease of dissemination may cut both ways. While ICT facilitates the scaling and cross-border coordination of knowledge-intensive activities, weak appropriability ("impactedness"; see Caves, 1996) can be expected to make internalization the choice of governance for these activities. Accordingly, we propose:

> **Hypothesis 2**: Greater knowledge intensity of MNEs in an industry reduces the negative effect of ICT investment intensity on MNE transnational integration in that industry.

ICT and internationalization. Further, because of transport costs and local content regulations, in certain industries (such as beverages, chemicals, and automobiles) MNEs must undertake a high degree of local value-added in the host regions in which they operate (Head & Ries, 2001). MNE foreign operations in these industries tend to be relatively large and elaborated. In such industries, where the size of foreign operations and affiliates, in proportion to headquarters, tends to be big, one can expect that intrafirm control and coordination needs and efforts will, as well, be proportionately greater. MNEs here are likely to deploy ICT to better monitor and coordinate their foreign operations. As Desai and his colleagues (2004) underline, one not unimportant reason for intrafirm coordination is tax optimization. We can therefore expect the relative size of MNE foreign operations to moderate ICT influence on transnational integration. Accordingly:

> **Hypothesis 3**: Greater relative size of MNE foreign operations in an industry reduces the negative effect of ICT investment intensity on MNE transnational integration in that industry.

DATA AND METHODS

To explore the above hypotheses we assembled a panel, industry-level dataset focused on US manufacturing MNEs. We focus on manufacturing for three reasons: manufacturing still dominates international transactions; the manufacturing focus aids comparability with existing studies (including Cho, 1990; Kobrin, 1991; Lall, 1978); and pertinent disaggregated data on services do not yet exist.

Our data are annual, and they span the same 16-year period, 1982–1997, examined in Desai et al. (2004). By stopping in 1997 we abstain from the "tech bubble" and Internet speculation that followed subsequently. As in existing studies, our data come from four well-known sources: the US Bureau of Economic Analysis (BEA), the US Census Bureau, the OECD, and Compustat. Within manufacturing, the data are disaggregated mainly at the two-digit SIC level. This is the level of detail at which the BEA publishes the relevant data on US MNEs and their foreign operations. The same reason, that is, BEA detail of reporting, guides the choice of the 15 two-digit industries included in the analysis.[3] Together, the 15 industries and 16 years yield 240 observations.

A limitation that we have in common with most existing studies of transnational integration, including Cho (1990) and Kobrin (1991), is that within a given year our observations are aggregate at the industry level. Industry aggregation can mask variation in the behavior of individual firms within the sector. Ideally, therefore, one would want to use firm-level data. However, while firm-level transnational integration data are accessible (via special permission) at the BEA, neither this latter nor any other source collects, let alone reports, firm-level figures on our focal independent variable, ICT investment intensity. Indeed, the industry-level BEA ICT spending data that we use are the most widely employed measure of ICT in existing studies (e.g., Brynjolfsson & Hitt, 1996; Brynjolfsson et al., 1994; Nachum & Zaheer, 2005; but see firm-level survey efforts reported in Bloom et al., 2009). Given that the influence of ICT on MNE integration has not been previously explored, we would submit that this limitation notwithstanding the proposed empirical analyses with industry data should be instructive. In interpreting the results of the analysis this limitation should, however, be borne in mind.

Dependent Variable: Transnational Integration

Following Kobrin (1991), we posit that a "true" indicator of transnational integration is the relative volume of MNEs' intrafirm product flows. In the international business literature, product interdependence is considered to be the "most fundamental" of various intrafirm flows (cf. Kobrin, 1991: 19). Accordingly, we measure our dependent variable, transnational integration, exactly as in Kobrin (1991). The numerator of this measure is the sum of US MNEs' parent-to-affiliate, affiliate-to-parent, and affiliate-to-affiliate exports, and the denominator is the sum of parent total exports and affiliate total sales. For such comparative purposes as ours this measure is especially valuable, since it allows us to contrast arm's length and intrafirm flows (Hipple, 1990: 1265).

In the appendix Table A1 we present these estimated transnational integration ratios by industry and across four selected years spanning our data. The cross-sectional pattern is as in Kobrin (1991). The high-transnational integration industries are motor vehicles, instruments, machinery, electronics, and chemicals. Clearly, it is not a coincidence that four out of these preceding five are also high-R&D industries. The low-transnational integration industries are other transport (aircraft), food, printing and publishing, and paper and allied products.

Independent Variable: ICT Investment Intensity

We calculate ICT investment intensity by taking BEA industry-specific "real" annual investment on ICT and dividing that by the annual number of employees in the industry.[4] Each individual element within ICT (such as personal computers, or communications equipment, or packaged software) has a government-estimated, quality-adjusted price deflator. Using these estimated price deflators the BEA converts nominal investments into constant dollar or "real" investment figures, which are the values we use. The practical effect of correcting for price deflation is that ICT investment ramps up much more rapidly than the nominal figures would suggest. In the appendix Table B1 we report these ICT investment intensity estimates by industry over four selected years spanning our data. It is evident in these figures that ICT investment intensity rose dramatically during the 1980s and 1990s. It is also evident that there is considerable variation in ICT investment intensity across industries.

Control Variables

While our focus here is on ICT, there are of course other explanations of MNE transnational integration that are established in existing studies (see Cho, 1990; Kobrin, 1991; Lall, 1978). Since we adopt Kobrin's (1991) measure of transnational integration, we include as a baseline the four variables in that study: *knowledge intensity* (which we measure as US MNEs' R&D/sales ratios), *advertising intensity* (which we measure as US firms' advertising/sales ratios), *scale* (which we measure as average number of employees per establishment in the industry), and *internationalization* (which we measure as US MNEs' foreign/total employment ratios).[5]

Beyond these, we enter three more variables that we regard as controls for alternative explanations for changes in transnational integration that one may attribute incorrectly to ICT. *International competition* (estimated as imports divided by production plus imports minus exports, that is, as annual industry import share in apparent consumption)[6] is a potential determinant of transnational integration. Import competition invariably creates pressure on prices, and triggers a quest for lower production costs. In addition, when downstream buyers face more upstream suppliers the threat of holdup declines, and the proportion of internal exchange is expected to decline. A similar logic holds for upstream suppliers, whose worries about recovering sunk costs decline with a rise in the number of downstream buyers. Hence international competition "thickens the market, facilitating leaner, less integrated firms …" (McLaren, 2000: 1239). Likewise, we enter *developing country exposure* (which, using data in Feenstra, 2000, we estimate as annual share of industry export sales destined for developing countries)[7] to control for contextual uncertainty faced by US MNEs. As explained in Henisz and Williamson (1999), if the institutional context changes, exchange governance patterns can also be expected to change. In this case, increasing exchange with developing countries might increase perceived uncertainty and induce a decline in transnational integration. Developing countries confront MNEs with weaker institutional supports and greater transaction hazards (Henisz, 2000). In such host locations MNEs tend to opt for lower-commitment and lower-exposure modes of foreign operations. Often they trade at arm's length, and when they take equity, they tend to avoid whole ownership. It follows that the extent of transnational integration in such locations will tend to be lower than in developed countries. *Diversification* (which, following Denis et al., 2002, we estimate as the annual average number of two-digit SIC sectors in which the firms in the industry operate) can also cause a decline in transnational integration, because firms' propensity to integrate is lower in non-core businesses (Desai et al., 2004; Hennart, 1982). For a given firm, knowledge in core business is more critical to protect and enhance. Further, throughout the value chain, investments in "specific assets" are likely to be higher (Gertner, 2001) and risk and uncertainty tolerance are likely to be lower (Campa & Guillén, 1999: 1467) in core businesses than in non-core businesses.

Estimation

In choosing our estimation method, we took into consideration the cross-section and time-series nature of our data. If panel data exhibit neither industry- nor time-specific heterogeneity, then the simple OLS estimation is sufficient, and preferred. To check for individual and time effects, we ran these tests: two-sided Breusch–Pagan test, Honda test, King–Wu test, standardized LM test, and Gourieroux, Holly and Monfort test (see Baltagi, 2001: 58–62 for detailed explanations). All tests rejected the null of zero industry effects (but the null for zero time effects was not rejected).[8] Having found industry-specific effects in our data, we then performed Hausman's specification test, which is based on the difference between the within (fixed effects) and GLS (random effects) estimators. The results of these tests indicated that, using the current specification, the hypothesis that industry-level effects are adequately modeled by a random-effects model is rejected. We hence focus on and report regressions with industry fixed effects.

In addition to the potential problem of heteroskedasticity, one might also be concerned that some of the right-hand-side variables might be correlated with the error term. It might be the case that MNEs decide the level of transnational integration and the level of investment in ICT and R&D at the same time, or factors unobservable to us (but observable to MNEs) might affect the levels of all these variables. Either of these would result in simultaneity: a shock that affected transnational integration might also affect investment in the same year. Separately, MNEs might decide on the level of their ICT investment with a certain level of transnational integration in mind. When and if this is the case, we potentially face a type of selection bias in our estimation. Standard regressions yield inconsistent estimates, because common unobserved factors influence both the investment in ICT and the level of transnational integration (hence, ICT investment intensity and the error term, i.e., the unexplained portion of transnational integration, might be correlated). To address the potential issue of simultaneity, keeping with convention, we lag all right-hand-side variables 1 year. This lagging attenuates potential simultaneity problems.[9]

To address the issue of ICT as a potential choice variable, we adopted a two-stage least-squares instrumental variables approach (see Johnston & DiNardo, 1997 for a review). In the first stage we estimate ICT investment intensity. In this model, in addition to using all other right-hand-side variables from the main (second stage) model,[10] in order to "over-identify" we include three additional instruments: *computation power*; *total investment*; and *capital intensity* (see appendix Table C1). Computation power is measured as millions of instructions per second per dollar (data from Withington, 1997), and is meant to capture the influence of advances in power and speed of ICT on a firm's decision to invest in ICT. As computing power rises (i.e., as the price of this input declines), its business attractiveness and intensity in use is expected to rise (Jorgenson, 2001). Spending on ICT is also expected to track the general investment cycle (Brynjolfsson et al., 1994). Meant to reflect the general investment cycle, total investment (itself influenced by shifts in the cost of capital, demand, and investment rules and regulations) is measured as the log of real investment by industry by year (with data from BEA). Finally, capital-intensive industries (e.g., chemicals, and pulp and paper) can also be expected to use ICT more intensely. In such industries that tie up physical capital, ICT is well suited to optimize rates of utilization, machine switching costs, and quality, all of which are key influences on efficiency (see Belorgey, Lecat, & Maury, 2006; Motohashi, 1997).[11] Capital intensity is measured as total real capital stock per employee (with data from the NBER-CES Manufacturing Industry Database). Importantly, these three additional variables just described are correlated primarily with the variable being instrumented, namely, ICT investment intensity, and not with the error term of the main model (Nevo & Rosen, 2008).[12] Taken together, these variables satisfy the key requirement of acceptable instruments (see Murray, 2006).

Then, in the second stage, we re-estimated the main regressions substituting the predicted (fitted) values of ICT investment intensity from this first-stage estimation.[13] Fitted values are, in principle, asymptotically independent of the current error term and exogenous vis-à-vis the dependent variable in the main regression, that is, transnational integration. Hence, to obtain consistent estimates,

Table 1 Means, standard deviations, bivariate zero-order correlations (lower triangle), and bivariate within-industry correlations (upper triangle)

	Mean	*s.d.*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1. MNE transnational integration	0.24	0.13		−0.01	0.03	0.20	−0.03	0.21	−0.03	−0.03	−0.22
2. ICT investment intensity	1.58	1.61	0.20		0.51	0.28	−0.19	0.29	0.58	0.36	−0.59
3. Knowledge intensity	0.03	0.02	0.62	0.61		0.06	−0.57	0.30	0.31	0.34	−0.26
4. Advertising intensity	0.03	0.02	−0.18	0.29	−0.13		0.01	0.17	0.24	0.16	−0.29
5. Scale (log)	4.13	0.60	0.32	0.15	0.29	−0.22		−0.37	−0.37	−0.34	0.19
6. Internationalization	0.29	0.09	0.65	0.28	0.45	0.01	0.34		0.29	0.32	−0.16
7. International competition	0.12	0.08	0.74	0.07	0.40	−0.37	0.37	0.37		0.34	−0.56
8. Developing country exposure	0.39	0.11	−0.17	0.10	0.03	0.26	0.16	−0.02	0.03		−0.20
9. Diversification	2.74	0.58	−0.27	−0.24	−0.27	−0.18	0.36	0.08	−0.28	−0.04	

N=225.
All variables, except MNE transnational integration, are lagged 1 year.

we use fitted values of ICT investment intensity in all models (i.e., direct effects and interactions) and reported regressions.

We report sample statistics, bivariate zero-order and within correlations in Table 1. Although in our dataset there are no critically collinear variables (i.e., over 0.8 in absolute value; Kennedy, 2003), we nevertheless calculated variance inflation factors (VIFs) on industry-demeaned data. All VIFs were less than 3, much lower than the critical value of 10, indicating no serious multicollinearity. In order to further alleviate concerns related to potential multicollinearity, we re-ran all regressions without moderately correlated variables (e.g., R&D intensity, scale, international competition). Their inclusion/exclusion – one by one or in combination – did not affect the sign or significance of other variables. We are hence confident that the reported results are not driven by multicollinearity.

RESULTS

In Table 2 we present regression results, which we organize as follows: model 1 is the baseline specification; model 2 introduces ICT into the baseline specification; models 3, 4, and 5 bring in the hypothesized interaction effects individually and then jointly. Consider now the results in model 1 in Table 2. As in Kobrin (1991), internationalization is positive and significant (keeping with the view that in industries where foreign value-added is significant, internal coordination is sought within the international network, including for tax optimization); and the scale variable is insignificant. On the other hand, knowledge intensity, measured as R&D investment intensity, is insignificant; and advertising intensity takes a positive and significant coefficient (the advertising intensity variable is significant in one-tailed tests in all models). These results diverge from those reported in Kobrin (1991). One explanation is that accounting for unobserved heterogeneity and simultaneity in empirical analyses, as we do here, changes the influence of intangibles on transnational integration. Indeed, the results are qualitatively identical with Kobrin (1991) when models are estimated without fixed effects and without lagging right-hand side variables. As for the other variables in the baseline specification, consistent with Henisz and Williamson (1999), transnational integration declines with a rise in developing country exposure. Also consistent with expectations, increases in diversification and increases in international competition both correlate with a decrease in transnational integration.

Turn now to model 2, where we introduce ICT, our focal independent variable. While all other variables are signed and significant as before, consistent with Hypothesis 1, ICT investment intensity is negative and statistically significant. Even as liberalization may be facilitating more internationalization, ICT is facilitating less internalization. To appreciate the significance of this result it is useful to bear in mind three points. First, we are here examining the role of intrafirm flows in MNEs' *own* international exchange. If the denominator in our dependent variable included non-MNE exchange, then this result might be less interesting. Second, recall that ICT is without doubt also an aid to internal coordination. Hence ICT, in principle, strengthens the numerator as well as the denominator in our dependent variable. The negative coefficient on ICT is the estimated net effect, which is that (consistent with Palmisano, 2006) ICT is aiding the melding of comparative and competitive advantage to take place more across than within firms. This relates to the third point: to our

Table 2 Fixed-effects regressions explaining MNE transnational integration, 1982–1997

Variable (hypothesis)	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
Knowledge intensity	−0.228	0.157	0.329	0.030	0.265
	(0.365)	(0.364)	(0.373)	(0.375)	(0.357)
Advertising intensity	0.490†	0.516†	0.457	0.540†	0.445
	(0.280)	(0.290)	(0.289)	(0.296)	(0.282)
Scale (log)	−0.007	0.013	0.021	0.006	0.016
	(0.031)	(0.033)	(0.034)	(0.033)	(0.034)
Internationalization	0.270***	0.276***	0.285***	0.304***	0.340***
	(0.072)	(0.072)	(0.073)	(0.075)	(0.080)
International competition	−0.308**	−0.205*	−0.177†	−0.205*	−0.152†
	(0.088)	(0.089)	(0.091)	(0.088)	(0.092)
Developing country exposure	−0.087*	−0.075*	−0.081*	−0.074†	−0.084*
	(0.037)	(0.038)	(0.038)	(0.038)	(0.038)
Diversification	−0.032***	−0.039***	−0.038***	−0.039***	−0.038***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
ICT investment intensity (H1)		−0.011**	−0.008*	−0.014**	−0.012**
		(0.004)	(0.004)	(0.005)	(0.004)
ICT investment intensity × Knowledge intensity (H2)			−0.127†		−0.244**
			(0.097)		(0.095)
ICT investment intensity × Internationalization (H3)				0.045*	0.077**
				(0.027)	(0.032)
R^2 (overall)	0.95	0.96	0.96	0.96	0.96
R^2 (within)	0.16	0.17	0.18	0.18	0.19
F-test: ICT = 0		6.77**	3.96**	9.37**	7.41**
F-test: ICT = 0 and Interactions = 0			3.75**	4.69**	4.86**

Significance level: $^{\dagger}p<0.10$; $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$.
N=225.
Constant and industry-fixed effects are included, but not reported.
Robust standard errors in parentheses.
All right-hand-side variables are lagged 1 year.
Significance levels are reported one-sided where hypothesized, two-sided otherwise.

knowledge this is the first non-casual empirical evidence linking ICT to multinational firms de-integrating foreign operations.

In quantitative terms (with a caveat that our industry-level data should be regarded as indicative), and focusing on elasticities at the mean for the variables in model 2, the results indicate that a 10% increase in ICT investment intensity would decrease transnational integration by 0.7%. This is actually a sizable effect. To calibrate, we may contrast these with the substantive effects of significant control variables. Computations indicate that a 10% increase in advertising intensity, internationalization, international competition, developing country exposure, and diversification would affect, respectively, a 0.7% and 3.3% increase, and a 1.0%, 1.1%, and 4.4% decrease in MNE transnational integration. To appreciate the actual (absolute and relative) effect of ICT investment intensity, note that while other factors remained steady, or showed only modest changes over the 1982–1997 period, the mean ICT investment per employee rose by nearly 270% (going from $810 to $2980) over that same period.

Models 3–5 present coefficient estimates for the hypothesized interaction terms. For brevity, focusing only on model 5, we can see that the interaction term ICT × knowledge-intensity is significant, but takes the negative sign, contrary to our prediction. Hence these results are not aligned with Hypothesis 2. Pending further research, one explanation we may propose is that even in knowledge-intensive industries MNEs are moving from "protecting" to "maximizing."[14] Recent research in organizational economics theorizes that incentive properties may matter more in such "human capital intensive" settings (Roberts & Van den Steen, 2000). This finding aligns with the emergence of "ecosystems," open innovation, and shared ownership (Chesbrough, 2003). Finally, as indicated by a positive coefficient on the ICT × internationalization interaction term, Hypothesis 3 is supported. In sectors where foreign operations bulk large in proportion to the total, MNEs employ ICT to manage internal control and coordination. In these sectors, then, transnational integration declines with increases in ICT, but to a lesser extent.

Robustness Checks

To explore the robustness of the above results and address certain potential concerns and alternative explanations, we conducted supplementary empirical analysis exploiting available data. A first set of concerns relate to measurement and operationalization of our independent variable, ICT investment intensity. One potential concern relates to the fact that we treat ICT investment as a flow rather than as a stock. We contend this is reasonable, because at least during the 1980s and 1990s the pace of obsolescence in the ICT world has been staggering. As one US Federal Reserve Bank president put it, "computers depreciate faster than other forms of capital" (Poole, 2003). Still, to check whether a stock treatment nullifies the results, we created a separate measure by cumulating ICT investment on a rolling 3-year basis and then re-ran the regressions on this variable. While the magnitude of the coefficient is (understandably) smaller on the ICT stock variable, it continues to maintain a negative sign and strong statistical significance in all models. This clarifies that support for Hypothesis 1 is not due to a "flow" treatment.

Separately, one might argue that, arithmetically, industry-level ICT spending per employee will register increases if the number of industry employees decreases. Thus if firms in one industry were (for some non-ICT-related reasons) engaged in greater outsourcing to firms in another industry, employment figures in the first industry would decline, and because it is a per employee measure, our indicator of ICT investment intensity would show an increase. To explore this concern, we ran our regressions with an alternative measure of ICT investment intensity, namely, ICT investment as a percentage of total focal industry production. In these regressions, too, the ICT investment intensity coefficient remained negative and statistically significant.

Additionally, arguably, MNEs are above-average spenders on ICT within their respective industries. In order to approximate this potentially higher MNE ICT investment intensity, we follow studies in labor economics and assume that ICT is a complement to human capital. That these newer technologies bias the labor market in favor of higher (educated) human capital is well established (Lawrence & Slaughter, 1993). Accordingly, we assume, between two firms equal in other respects, that the one with the higher human capital (read MNE) is likely to benefit more from and therefore invest more in ICT. Applying this logic, we multiplied industry-year ICT investment intensity figures into an industry-year MNE human capital multiple, which, following Lall (1980) and others (see Dunning, 1993: Chapter 6), we estimate as the ratio of average annual employee compensation of US MNEs to that of all US firms in the same industry. Not surprisingly, the estimated multiples reflect higher human capital in MNEs than in the average US firm in the same industry. Consistent with expectations, the MNE ICT investment intensity estimates are systematically higher than the corresponding figures for US firms. Whether we use the MNE-adjusted or unadjusted ICT investment estimates, our regression results are qualitatively unchanged.

A second set of concerns relate to the fact that our dependent variable, MNE transnational integration, is a proportion, and is hence always positive and bounded between 0 and 1. This can raise two issues. First, when there are limit observations in the data, this may impose a bias in the estimation because the data are truncated. Second, since the variance of a proportion depends on its particular value, the use of a proportion as the dependent variable may impose a bias in the estimation due to potential violation of the homogeneity of variance assumption. The first issue does not materialize, because our data do not include any limit observations. There is hence no bias imposed in our estimates due to truncation. As for the second issue, there are two transformations – logarithmic ($\log[y/(1-y)]$) and arcsine-root ($\arcsin\sqrt{y}$) – that one can employ to address the violation of the homogeneity of variance assumption (Bartlett, 1947). We re-ran our regressions employing both of these preceding transformations and found that in both cases the results do not change. We conclude therefore that our results are not an artifact of our empirical specification.

A separate concern is related to potential serial correlation. In regression analysis of time-series data, serial correlation of the error terms violates the OLS assumption that the error terms are uncorrelated. While it does not bias the coefficient estimates, the standard errors tend to be underestimated (and the *t*-scores overestimated) when the serial correlations of the errors are positive. Hence it is necessary to establish the robustness of the results to potential serial correlation. To check, we re-estimated all models using Prais–Winsten estimates with panel-corrected standard errors. This method is, in essence, similar to a Park–Kmenta timewise autoregressive/cross-sectionally heteroskedastic model (see Baltagi, 1986, for a review and comparison with error-components models), but yields relatively more conservative variance–covariance estimates (Beck & Katz, 1995). In this estimation method, disturbances are assumed to be heteroskedastic (i.e., each industry has its own variance) and contemporaneously correlated across industries (i.e., each pair of industries have their own covariance), and there is first-order autocorrelation within industries. In these regressions, too, ICT investment intensity was significantly and negatively related to transnational integration.

We checked also the robustness of the results to two additional control variables. One corresponds to *MNE distributed specialization*, which we estimated as annual inter-affiliate share in foreign affiliates' total sales (using data from the US Bureau of Economic Analysis, US Direct Investment Abroad). We put in this control variable as a proxy for the importance of local-for-regional or local-for-global strategies in MNEs' operations. Shifts in this ratio indicate shifts in interdependence in the MNE network, which, in turn, can affect transnational integration (Nohria & Ghoshal, 1997). In regressions including this control the main results were unchanged, and the control itself was, as expected, positive and significant. We incorporated also a *time trend* variable ($1982 = 1, \ldots, 1997 = 16$) as a control for unobservable "secular" developments during the 1980s and 1990s, particularly liberalization. Liberalization allows MNEs to have greater control of affiliates abroad (Desai et al., 2004). If MNEs are required less and less to share ownership of foreign affiliates, then MNEs might integrate affiliates more tightly into their global networks (Desai et al., 2004). Tighter integration can serve several objectives, including better worldwide tax optimization. On this reasoning, one might expect transnational integration to increase with the trend term. Again, in supplementary regressions including such a time trend, the main results did not change. The time trend itself was, as expected, positive and significant.[15]

DISCUSSION

In existing MNE theory, internationalization and internalization have understandably been linked (e.g., Hennart, 1982; Kobrin, 1991; Porter, 1986). In recent years, however, researchers (e.g., Antras, 2005; Feenstra, 1998) and practitioners (e.g., Palmisano, 2006) have been arguing that the link between internationalization and internalization may be weakening. The results of our empirical analyses give credence to these newer views. Our analyses show clearly that ICT is central to this profound if still incipient development. To our knowledge this is the first study to:

- theorize about how ICT enables MNEs to reshape the governance of transnational exchange to diminish implicit costs of internalization;
- empirically explore the proposed link between ICT and transnational integration (while controlling for traditional and alternative explanations); and
- articulate implications for MNE theory.

Taken together, the preceding arguments and the empirical results hold three main implications for MNE theory. First, congruent with transaction cost and incentive theories of exchange governance, the modern MNE is elaborating its transnational governance architecture to take advantage of the emergence of ICT. In particular, where the use and deployment of ICT are greater, the centrality of internalization in the modern MNE is declining. This means that to the conventional logic of "R&D – knowledge intensity – contractual hazards in exchange – intrafirm exchange – transaction cost advantages" we may now join "ICT – information intensity – division of labor benefits in exchange – interfirm exchange – production cost advantages."

Second, to enhance our understanding of the evolution of modern MNEs we can fruitfully complement the transaction cost theories of the firm with incentive theories of the firm (see Antras, 2005). From an empirical standpoint, we would submit that *knowledge* intensity is being joined by *information* intensity as a predictor of patterns of international exchange and their governance.

Third, as suggested in Nachum and Zaheer (2005) and described in Palmisano (2006), modern MNEs are elaborating their international activities not only on market-seeking motivations, but also – more and more – on efficiency-seeking motivations. This implies that MNE scholars may fruitfully devote greater attention to vertical and not only horizontal FDI (Hanson, Mataloni, & Slaughter, 2001). In the context of Dunning's OLI framework, the L (location-specific advantages), which previously has been in the background, is likely to move to the foreground. This raises the question of how we should dimensionalize the L advantages.

This requires more thinking, and is an area for future research. Should we (as international economists tend to do) consider relative wages, unit costs, skilled labor endowments, and such? Should we incorporate fiscal policies (especially tax rates and regulations) as part of location-specific advantages? The work of Desai and his colleagues (2004) persuasively shows that fiscal (as distinct from physical) optimization is going to be key in influencing MNE transnational integration.

Having highlighted the contributions of this study, we should acknowledge as well that more remains to be done. For instance, it would be illuminating to explicitly include indicators of asset specificity to explore how that important variable moderates the influence of ICT on transnational integration. If ICT reduces the cost of asset specificity then this should be indicated by a negative sign on the ICT × asset specificity interaction term. Extending the empirical analysis with more fine-grained and more recent data will be complementary and valuable. The inclusion of data from recent years could reveal the impact of the advent of the Internet. Examining the proposed relationships and comparing findings with firm-level data would no doubt be especially valuable. Fine-grained data at the firm level will also be helpful to disentangle potential distinctive influences of information technologies vs communication technologies (see Bloom et al., 2009) on MNE transnational integration.

CONCLUSION

In this paper we analyzed available industry-level US data across all manufacturing sectors from 1982 to 1997 to determine the impact of ICT deployment on transnational integration – measured as intrafirm shares in multinationals' own export and foreign sales. In regressions factoring in a variety of controls and robustness checks, ICT deployment was significantly and negatively related to transnational integration. Internationalization and internalization are less tightly coupled than they were in a pre-ICT era. A corollary, already visible in the data, is that the prominence of MNEs in international transactions is declining: between 1982 and 1997, the share of total US manufacturing exports accounted for by US MNEs declined from 65% to 57%.

In explaining this transformation we joined incentive theory arguments to transaction cost economics arguments and proposed a broader explanation of exchange governance that speaks to both the benefits and the costs of internalization. Our central argument is that whereas the conventional MNE was duly concerned with the mitigation of transaction costs in cross-border exchange, enabled by ICT, the modern MNE organizes international exchange to also push down production costs. ICT has reduced asset specificity, made quality more contractible, aided decentralized coordination, and shifted outward the tradeoff frontier in exchange relating incentive intensity (effort) and cooperative adaptation (alignment). The modern MNE uses ICT to mitigate transaction costs, and evolves more to arm's length exchange to incentivize lower production costs.

Given the emergence of the Internet and the even more widespread adoption of ICT, further research seems warranted into the changing relationship between internationalization and internalization. Even while transaction cost theory will remain key to understanding the behavior of twenty-first-century multinational firms, incentive and production cost theories of the firm promise to complement that understanding of the evolution in the organization of these special entities.

ACKNOWLEDGEMENTS

For helpful comments during the development of this paper we thank Ron Adner, William Alterman, Gareth Dyas, Antonio Fatas, Javier Gimeno, Dominique Heau, Tarun Khanna, Bruce Kogut, Robert Lawrence, Christoph Loch, Catherine Mann, Ilian Mihov, Tomasz Obloj, James Rauch, Jeffrey Reuer, Daniel Sichel, Vanessa Strauss-Kahn, Timothy Van Zandt, Oliver Williamson, and Enver Yucesan; and Vit Henisz and three anonymous *JIBS* reviewers. We are grateful to the US Bureau of Labor Statistics and INSEAD for financial support of this research.

NOTES

[1]As described in Dunning (1980), the O refers to firm-specific capabilities, including those in research, marketing, and managing; the L refers to location-specific factors, especially pertaining to the destination of foreign direct investment; and the I refers to the relative benefits of internalization.

[2]Separately, even where asset specificity remains high (because, say, it creates net value), the *cost* of achieving that specificity can decline markedly because of ICT. An illustration from Argyres (1999) is illuminating. Compared with client-specific prototyping performed manually by engineers employing traditional methods, the cost of computer-aided design and prototyping, equally client specific, is reduced, measured in terms of time and material

investment, by an order of magnitude. In turn, the consequence of holdup in the same transaction is less daunting. It is much more difficult to be held up when the investment at risk is not large. This is to clarify that what matters is not asset specificity *per se* as much as the cost of asset specificity, which has also tended to decline owing to the development and deployment of ICT. This effect, too, is compatible with the model and logic outlined in Riordan and Williamson (1985).

[3]The 15 two-digit industries covered are: food and beverages; chemicals and drugs; primary metals; fabricated metals; machinery; electrical and electronic equipment; motor vehicles; other transport (mainly aircraft); textile products and apparel; lumber, wood, and furniture; paper and allied products; printing and publishing; rubber and miscellaneous plastics; glass, stone, clay, and nonmetallic mineral products; and instruments and related products.

[4]While some existing studies focus only on capital equipment (i.e., hardware), we include software, maintenance, and service expenditures, because the deployment and maintenance of software (e.g., billing systems, supply chain, and customer management) will affect the actual ability of firms to coordinate within and across organizational boundaries. Specifically, we use the following 15 ICT-related investment categories reported in BEA data: mainframe computers; personal computers; direct access storage devices; computer printers; computer terminals; computer tape drives; computer storage devices; integrated systems; prepackaged software; custom software; own-account software; communication equipment; instruments; photocopy and related equipment; and office and accounting equipment. In supplementary analysis, wherein we used only the last category, office and accounting equipment, as in Brynjolfsson et al. (1994) we found no sign reversals in any of the variables of interest.

[5]We follow Blonigen (2001) here in using US MNEs' foreign to total employment ratio to proxy importance of international operations. This ratio is not only a good indicator of the "extent of multinationality" that Dunning and others proposed would increase transnational integration (see e.g., Siddharthan & Kumar, 1990), but also, unlike alternatives based on sales figures, it does not pose problems related to exchange rate and other nominal-to-real conversions.

[6]We also included an alternative operationalization of import competition wherein the numerator excludes intrafirm imports. Under this alternative specification, results were unchanged.

[7]Destination-specific data are not available for MNE intrafirm trade at the level of aggregation we are interested in. For our measurement purposes, developing countries include all countries except Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

[8]To cross-validate, we re-estimated all models by including year fixed effects. In these regressions, echoing the results of the above-mentioned pooling tests, when included, none of the year dummies was significant (separately or jointly), and, importantly, the inclusion of year fixed effects did not affect the sign or significance of any right-hand-side variable.

[9]To further establish the robustness of the results to potential simultaneity problem, we ran our regressions including a lagged DV on the right-hand side (see Greve & Goldeng, 2004). While inclusion of the lagged DV, which itself was highly significant, rendered some control variables insignificant, ICT investment intensity coefficient was still negative and statistically significant.

[10]As the dependent variable in this first stage, ICT investment intensity, is measured at the US (and not at MNE parent) level by industry, we accordingly measure knowledge intensity as US firms' R&D spending as a percentage of their total sales, and MNE intensity as the percentage of US employees working for US multinational parents.

[11]Baker and Hubbard's (2004) study of the use of on-board computers for fleet usage optimization in the trucking industry is in this same spirit of superior capital "exploitation."

[12]Zero-order correlations for computation power, total investment, and capital intensity are 0.32, 0.68, and 0.45, respectively, with the instrumented variable (ICT investment intensity), as opposed to 0.04, 0.35, and 0.19 with the error term.

[13]Three observations about the results of the first-stage regressions are in order (see appendix Table C1). First, all three instruments are significant, and, as expected, positively signed. (Given that computation power does not vary by industry, it is quite an indication that this variable is even moderately significant.) Second, most control variables (especially knowledge intensity) also have a statistically significant impact on ICT investment intensity. Finally, industry-fixed effects (not shown) tend to be significant, and account in good measure for the high overall R^2.

[14]To check further, in supplementary regressions (not shown here), we included a three-way interaction term with ICT investment intensity, knowledge

intensity, and internationalization. This three-way interaction term was positive and highly significant (but did not affect the sign and significance of other variables). This suggests that the two-way interaction of ICT investment intensity and knowledge intensity changes for the levels of the third factor, internationalization. More clearly, the ICT investment intensity $\times$ knowledge intensity interaction is less negative and more positive (in the direction hypothesized), the higher the internationalization of the industry.

[15]We also checked for a potential moderation effect of time trend on the ICT investment intensity – MNE transnational integration link. It has been suggested that complementary investments in new organizational processes (re-engineering) and in application software are necessary to derive the full benefits of ICT (Brynjolfsson & Hitt, 1996), and complementary "ecosystem" ICT investments by exchange partners are expected to boost the impact of ICT. Expecting that such complementary developments occurred gradually over the 1980s and 1990s, and given that processes and routines that are initially tacit become more explicit over time (Kogut & Zander, 1993), one might expect the effect of ICT investment intensity on MNE transnational integration to have increased over time. There was statistical support for this prediction too.

REFERENCES

Antras, P. 2005. Property rights and the international organization of production. *American Economic Review*, 95(2): 25–32.
Argyres, N. S. 1999. The impact of information technology on coordination: Evidence from the B-2 "stealth" bomber. *Organization Science*, 10(2): 162–180.
Baker, G. P., & Hubbard, T. N. 2003. Make versus buy in trucking: Asset ownership, job design, and information. *American Economic Review*, 93(3): 551–572.
Baker, G. P., & Hubbard, T. N. 2004. Contractibility and asset ownership: On-board computers and governance in US trucking. *Quarterly Journal of Economics*, 119(4): 1443–1479.
Baltagi, B. 1986. Pooling under misspecification: Some Monte Carlo evidence on the Kmenta and the error components techniques. *Econometric Theory*, 2(3): 429–440.
Baltagi, B. 2001. *Econometric analysis of panel data*, (2nd ed.). New York: John Wiley & Sons.
Bartel, A., Ichniowski, C., & Shaw, K. 2007. How does information technology affect productivity? Plant-level comparisons of product innovation, process improvement, and worker skills. *Quarterly Journal of Economics*, 122(4): 1721–1758.
Bartlett, M. S. 1947. The use of transformations. *Biometrics*, 3(1): 39–52.
Beck, N., & Katz, J. N. 1995. What to do (and not to do) with time-series cross-section data. *American Political Science Review*, 89(3): 634–647.
Belorgey, N., Lecat, R., & Maury, T.-P. 2006. Determinants of productivity per employee: An empirical estimation using panel data. *Economics Letters*, 91(2): 153–157.
Blonigen, B. A. 2001. In search of substitution between foreign production and exports. *Journal of International Economics*, 53(1): 81–104.
Bloom, N., Garicano, L., Sadun, R., & Van Reenen, J. 2009. *The distinct effects of information technology and communication technology on firm organization*. Working Paper No. 14975, National Bureau of Economic Research.
Brainard, S. L. 1997. An empirical assessment of the proximity-concentration trade-off between multinational sales and trade. *American Economic Review*, 87(4): 520–544.
Brynjolfsson, E. 1994. Information assets, technology, and organization. *Management Science*, 40(12): 1645–1662.
Brynjolfsson, E., & Hitt, L. M. 1996. Paradox lost? Firm-level evidence on the returns to information systems spending. *Management Science*, 42(4): 541–558.
Brynjolfsson, E., Malone, T. W., Gurbaxani, V., & Kambil, A. 1994. Does information technology lead to smaller firms? *Management Science*, 40(12): 1628–1644.
Buckley, P. J., & Casson, M. 1985. *The economic theory of the multinational enterprise*. New York: St Martin's Press.
Campa, J. M., & Guillén, M. F. 1999. The internalization of exports: Firm- and location-specific factors in a middle-income country. *Management Science*, 45(11): 1463–1478.
Caves, R. E. 1996. *Multinational enterprise and economic analysis*, (2nd ed.). Cambridge: Cambridge University Press.
Chesbrough, H. W. 2003. The era of open innovation. *Sloan Management Review*, 44(3): 35–41.
Cho, K. R. 1990. The role of product-specific factors in intra-firm trade of US manufacturing multinational corporations. *Journal of International Business Studies*, 21(2): 319–330.
Coase, R. H. 1937. The nature of the firm. *Economica*, 4(16): 386–405.
Commons, J. R. 1932. The problem of correlating law, economics, and ethics. *Wisconsin Law Review*, 8: 3–26.
Dedrick, J., & Kraemer, K. L. 2005. The impacts of IT on firm and industry structure: The personal computer industry. *California Management Review*, 47(3): 122–142.
Denis, D. J., Denis, D. K., & Yost, K. 2002. Global diversification, industrial diversification, and firm value. *Journal of Finance*, 57(5): 1951–1979.
Desai, M. A., Foley, C. F., & Hines, J. R. 2004. A multinational perspective on capital structure choice and internal capital markets. *Journal of Finance*, 59(6): 2451–2487.
Dunning, J. H. 1980. Toward an eclectic theory of international production: Some empirical tests. *Journal of International Business Studies*, 11(1): 9–31.
Dunning, J. H. 1993. *Multinational enterprises and the global economy*. Reading, MA: Addison-Wesley.
Ethier, W. J. 1986. The multinational firm. *Quarterly Journal of Economics*, 101(4): 805–833.
Feenstra, R. C. 1998. Integration of trade and disintegration of production in the global economy. *Journal of Economic Perspectives*, 12(4): 31–50.
Feenstra, R. C. 2000. *World trade flows, 1980–1997*. Davis, CA: Institute of Governmental Affairs, University of California.
Gertner, R. H. 2001. *Explaining vertical integration practices*, Working Paper, University of Chicago.
Gibbons, R. 2005. Four formal(izable) theories of the firm? *Journal of Economic Behavior & Organization*, 58(2): 200–245.
Greve, H. R., & Goldeng, E. 2004. Longitudinal analysis in strategic management research. In D. Ketchen & D. Bergh (Eds.), *Research methods in strategy and management*, Vol. 1: 35–163. New York: Elsevier.
Grossman, S., & Hart, O. 1986. The costs and benefits of ownership: A theory of lateral and vertical integration. *Journal of Political Economy*, 94(4): 691–719.
Gurbaxani, V., & Whang, S. 1991. The impact of information systems on organizations and markets. *Communications of the ACM*, 34(1): 59–73.

Hanson, G. H., Mataloni, R. J., & Slaughter, M. J. 2001. *Expansion strategies of US multinational firms*. Working Paper No. 8433, National Bureau of Economic Research.
Hart, O., & Moore, J. 1990. Property rights and the nature of the firm. *Journal of Political Economy*, 98(6): 1119–1158.
Head, K., & Ries, J. 2001. Overseas investments and firm exports. *Review of International Economics*, 9(1): 108–122.
Henisz, W. J. 2000. The institutional environment for multinational investment. *Journal of Law, Economics and Organization*, 16(2): 334–364.
Henisz, W. J., & Williamson, O. E. 1999. Comparative economic organization: Within and between countries. *Business and Politics*, 1(3): 261–277.
Hennart, J.-F. 1982. *A theory of multinational enterprise*. Ann Arbor, MI: University of Michigan Press.
Hipple, F. S. 1990. The measurement of international trade related to multinational companies. *American Economic Review*, 80(5): 1263–1270.
Holmstrom, B., & Milgrom, P. 1994. The firm as an incentive system. *American Economic Review*, 84(4): 972–991.
Hymer, S. H. 1976. *The international operations of national firms: A study of direct foreign investment*. Cambridge, MA: MIT Press.
Johnston, J., & DiNardo, J. 1997. *Econometric methods*. New York: McGraw-Hill.
Jorgenson, D. W. 2001. Information technology and the US economy. *American Economic Review*, 91(1): 1–32.
Kennedy, P. 2003. *A guide to econometrics*, (5th ed.). Cambridge, MA: MIT Press.
Kim, S. 1999. High-powered incentives vs low-powered incentives: Why low-powered incentives within firms? *Seoul Journal of Economics*, 12(1): 27–50.
Kobrin, S. 1991. An empirical analysis of the determinants of global integration. *Strategic Management Journal*, 12(Summer Special Issue): 17–31.
Kogut, B. 1985. Designing global strategies: Comparative and competitive value-added chains. *Sloan Management Review*, 26(4): 15–28.
Kogut, B., & Zander, U. 1993. Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies*, 24(4): 625–645.
Lall, S. 1978. The pattern of intra-firm exports by US multinationals. *Oxford Bulletin of Economics and Statistics*, 40(3): 209–222.
Lall, S. 1980. Monopolistic advantages and foreign involvement by US manufacturing industry. *Oxford Economic Papers*, 32(1): 102–122.
Lawrence, R. Z., & Slaughter, M. J. 1993. International trade and American wages in the 1980s: Giant sucking sound or small hiccup? In M. N. Baily & C. Winston (Eds.), *Brookings papers on economic activity: Microeconomics*: 161–210. Washington, DC: Brookings Institution.
Markusen, J. R. 1995. The boundaries of multinational enterprises and the theory of international trade. *Journal of Economic Perspectives*, 9(2): 169–189.
Martin, X., & Salomon, R. M. 2003. Knowledge transfer capacity and its implications for the theory of the multinational corporation. *Journal of International Business Studies*, 34(4): 356–373.
Mayer, K. J., & Salomon, R. M. 2006. Capabilities, contractual hazards, and governance: Integrating resource-based and transaction cost perspectives. *Academy of Management Journal*, 49(5): 942–959.
McLaren, J. 2000. Globalization and vertical structure. *American Economic Review*, 90(5): 1239–1354.
Milgrom, P., & Roberts, J. 1992. *Economics, organization & management*. Englewood Cliffs, NJ: Prentice Hall.
Morck, R., & Yeung, B. 1991. Why investors value multinationality. *Journal of World Business*, 64(2): 165–187.
Motohashi, K. 1997. ICT diffusion and its economic impact in OECD countries. *OECD Science Technology and Industry Review*, 20(Special Issue): 13–45.
Murray, M. P. 2006. Avoiding invalid instruments and coping with weak instruments. *Journal of Economic Perspectives*, 20(4): 111–132.
Nachum, L., & Zaheer, S. 2005. The persistence of distance? The impact of technology on MNE motivations for foreign investment. *Strategic Management Journal*, 26(8): 747–767.
Nevo, N., & Rosen, A.M. 2008. *Identification with imperfect instruments*. Working Paper No. 14434, National Bureau of Economic Research.
Nohria, N., & Ghoshal, S. 1997. *The differentiated network: Organizing multinational corporations for value creation*. San Francisco, CA: Jossey-Bass.
Palmisano, S. J. 2006. The globally integrated enterprise. *Foreign Affairs*, 85(3): 127–136.
Poole, W. 2003. Whither investment? Speech delivered at Missouri Valley Economics Association, St Louis, Missouri, 28 February 2003, http://fraser.stlouisfed.org/historicaldocs/wp/, Accessed 2 October 2009.
Porter, M. E. 1986. Competition in global industries: A conceptual framework. In M. E. Porter (Ed.), *Competition in global industries*: 15–60. Boston, MA: Harvard Business School Press.
Porter, M. E. 1990. *The competitive advantage of nations*. New York: The Free Press.
Riordan, M., & Williamson, O. E. 1985. Asset specify and economic organization. *International Journal of Industrial Organization*, 3(4): 365–378.
Roberts, D. J., & Van den Steen, E. 2000. *Shareholder interests, human capital investment and corporate governance*. Stanford GSB Research Paper 1631.
Rugman, A. 1980. Internalization as a general theory of foreign direct investment: A re-appraisal of the literature. *Weltwirtschaftliches Archiv*, 116(2): 365–379.
Siddharthan, N. S., & Kumar, N. 1990. The determinants of inter-industry variations in the proportion of intra-firm trade: The behavior of US multinationals. *Weltwirtschaftliches Archiv*, 126(3): 581–591.
Simon, H. A. 1982. *Models of bounded rationality: Behavioral economics and business organization*. Cambridge, MA: MIT Press.
Vernon, R. 1971. *Sovereignty at bay: The multinational spread of US enterprises*. New York: Basic Books.
Williamson, O. E. 1991. Comparative economic organization: The analysis of discrete structural alternatives. *Administrative Science Quarterly*, 36(2): 269–296.
Williamson, O. E. 2005. The economics of governance. *American Economic Review*, 95(2): 1–18.
Withington, F. G. 1997. The resurgence of the mainframe computer. *Spectrum*, 93: 1–11.
Zenger, T. R., & Hesterly, W. S. 1997. The disaggregation of corporations: Selective intervention, high-powered incentives, and molecular units. *Organization Science*, 8(3): 209–222.

APPENDIX A

Table A1 US MNEs' transnational integration ratios, by industry, selected years between 1982 and 1997 (percentages)

	1982	*1987*	*1992*	*1997*
Manufacturing	26.48	34.65	32.10	35.92
Food and kindred products	11.53	14.04	19.94	16.93
Textile products and apparel	14.60	15.30	25.95	24.24
Lumber, wood, furniture, and fixtures	14.29	9.98	16.75	22.64
Paper and allied products	13.44	17.90	18.82	18.33
Printing and publishing	12.48	11.91	5.94	6.88
Chemicals and allied products	23.82	27.45	26.76	33.12
Rubber and plastic products	17.92	25.10	26.26	27.39
Stone, clay, and glass products	17.78	16.36	14.95	17.58
Primary metals products	20.19	17.38	16.10	17.92
Fabricated metal products	14.58	15.86	20.44	20.04
Industrial machinery and equipment	31.76	46.71	40.76	46.21
Electronic and other electric equipment	26.60	38.90	32.45	32.98
Motor vehicles and equipment	45.39	52.66	50.38	52.75
Other transport (including aircraft)	8.56	11.38	9.89	10.37
Instruments and related products	32.47	41.42	36.30	32.84

Source: Authors' estimates based on methods from Kobrin (1991) and data from US Bureau of Economic Analysis, United States Direct Investment Abroad (various issues).

APPENDIX B

Table B1 US information and communication technology (ICT) investment per employee, by industry, selected years between 1982 and 1997

	Constant 1996 dollars (in thousands)			
	1982	*1987*	*1992*	*1997*
Manufacturing	0.81	1.10	1.76	2.98
Food and kindred products	0.70	0.95	1.22	1.82
Textile products and apparel	0.16	0.22	0.39	0.79
Lumber, wood, furniture, and fixtures	0.17	0.24	0.37	0.66
Paper and allied products	1.09	1.24	1.90	2.74
Printing and publishing	0.72	1.32	2.14	3.92
Chemicals and allied products	3.24	3.59	8.57	10.60
Rubber and plastic products	0.23	0.35	0.55	1.16
Stone, clay, and glass products	0.80	1.01	0.68	1.85
Primary metals products	0.81	0.84	0.89	1.48
Fabricated metal products	0.30	0.44	0.66	1.21
Industrial machinery and equipment	1.12	1.47	2.28	4.47
Electronic and other electric equipment	1.32	1.75	2.23	4.96
Motor vehicles and equipment	2.22	0.60	1.22	2.66
Other transport (including aircraft)	0.59	1.74	1.64	2.60
Instruments and related products	0.91	1.85	3.60	5.80

Sources: Authors' estimates based on data from US Census Bureau, Statistical Abstract of the United States; US Bureau of Economic Analysis, Detailed Data for Fixed Assets and Consumer Durable Goods, real cost investment (various issues).

APPENDIX C

Table C1 First-stage regression explaining ICT investment intensity, 1982–1997

Variable	
Knowledge intensity	20.363***
	(3.985)
Advertisement intensity	−7.370†
	(3.801)
Scale (log)	−0.983
	(0.614)
MNE intensity	−3.330***
	(0.919)
International competition	−6.126**
	(1.809)
Developing country exposure	−0.887
	(0.664)
Diversification	−0.357*
	(0.172)
Computation power (/1000)	0.144†
	(0.109)
Total investment (log)	2.224***
	(0.306)
Capital intensity	3.095***
	(0.456)
R^2	0.91

Significance level: †p< 0.10; *p< 0.05; **p< 0.01; ***p< 0.001.
N=225.
Constant and industry-fixed effects are included, but not reported.
Robust standard errors in parentheses.
All right-hand-side variables are lagged 1 year.
Significance levels are reported one-sided for the instruments, two-sided otherwise.

ABOUT THE AUTHORS

Subramanian Rangan is Shell Fellow in Business and the Environment, and Professor of Strategy and Management at INSEAD. His research focuses on international business, and examines macro- and microstructural influences in cross-border competition among and cross-border cooperation within multinational firms. He received a PhD in political economy and government from Harvard University. Born in India, he is a US citizen.

Metin Sengul is an assistant professor at Boston College. In his research, he studies control as a key organizational concern, both within and outside the boundaries of the firm. He focuses on dynamics and behavior of multi-business and multinational firms, and how instruments of corporate control influence an organization's ability to capture value under various threats. Born in Turkey, he received his PhD in strategy from INSEAD, France.

Accepted by Witold Henisz, Area Editor, 18 June 2009. This paper has been with the authors for three revisions.