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The Roles of Structured Management in the Formation of Transactional Relationships[*]

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Abstract

We empirically examine the roles of structured management in the formation of transactional relationships by using the Japanese version of Management and Organizational Practices Survey and the business-to-business transaction data from Teikoku Databank. Our unique approach is to use separate measures of productivity and managerial efficiency in this examination. Our main findings are summarized as follows: First, management scores (a proxy for managerial efficiency) are positively associated with a range of transactional partners even after a level of productivity is controlled for. Second, our estimation using an exogenous event caused by the Great East Japan earthquake appears to suggest that causality is at play in this relationship. Third, firms with higher management scores add and drop transactional partners more frequently than firms with lower management scores. Fourth, firms with higher management scores transact with larger firms. Finally, management scores are positively correlated with TFP, and negatively correlated with a measure of uncertainty. Further, the negative effect of uncertainty on the formation of transactional relationships is mitigated by managerial efficiency. Overall, the empirical results of this paper suggest that both production and managerial efficiency are important factors in facilitating the formation of transactional relationships.

Keywords: Management Practices, Productivity, Transactional Relationship
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1. Introduction

In recent years firms have become increasingly interconnected through business transaction networks and such interconnectedness has non-negligible and amplifying effects on the aggregate performance of an economy (Acemoglu and Azar, 2020). In models of an interconnected economy, firms are typically characterized as being heterogenous regarding productivity and this heterogeneity generates a broad range of implications, ranging from the formation of transactional relationships (Sugita et al., 2021), to structures of input-output linkages (Caliendo et al., 2020), to input misallocations (Boehm and Oberfield, 2020), to shock propagations (Acemoglu et al., 2012; Baqaee and Frahi, 2019), to economic growth (Acemoglu and Azar, 2020). Furthermore, the literature on multi-product firms and international trade document that high-productivity firms produce and trade a high volume and a wide variety of products (e.g., Bernard et al., 2010), reinforcing the perception that production efficiency is underlying firm heterogeneity to determine transactional relationships.

While the link between productivity and transactional relationships has thus received a lot of attention, the role played by structured management remains relatively understudied in this context, not least because data limitations make it hard to separate productivity and managerial efficiency which are highly correlated with each other (Bloom et al., 2019). In this paper, we integrate several datasets available in Japan to shed light on the independent role of structured management in the formation of transactional relationships by measuring managerial efficiency and production efficiency separately.

Our data (described in detail below) allow us to measure both production efficiency and structured management to examine their separate impacts on firms' transactional networks. That is, we empirically investigate how not just productivity but also the quality of management is associated with firm's capability to expand a range of transactional partners, to attract high-quality transactional partners, to change a set of transactional partners, as well as to mitigate transactional hazards. By doing so, we are able to address the following questions; namely, does structured management play an independent role in determining a range of transaction partners? If so, what types of transactional partners are attracted to well-managed firms? Do well-managed firms change transactional partners more frequently? Also, do well-managed firms cope better with transaction-related uncertainty?

In a frictionless economy, cost advantages arising from high production efficiency give firms incentive to acquire additional intermediate goods leading to the formation of new business relationships. In reality, however, it is neither costless nor frictionless to establish transactional relationships (Coase, 1988; Williamson, 1975;

Boehm and Oberfield, 2020), and the presence of frictions can be a critical factor in explaining the misallocation and inefficiency of production networks we observe in the real economy (Baqaee and Frahi, 2020; Bigio and La'O, 2019; Acemoglu and Azar, 2020). Poor management may cause delay of delivery or deliver low-quality products, while well-managed firms are able to deliver high-quality goods in time and to cope with transactional hazards well.

We build on this insight to hypothesize that managerial efficiency is crucial for alleviating transaction-related frictions and ensuring stable and smooth transactions and that well-managed firms expand a range of transactional partners flexibly and attract high-quality transactional partners. To examine these hypotheses, we integrate the Japanese version of Management and Organizational Practices Survey (JP MOPS, hereafter) data with the Japanese Census of Manufacturers and the restricted-use business-to-business transaction data obtained from Teikoku Databank, a major credit reporting agency in Japan. JP MOPS contain information on management practices from which we construct management scores to capture managerial efficiency. The Japanese Census of Manufacturers data are used to measure production efficiency by computing total factor productivity, while the data from Teikoku Databank enable us to identify customer-supplier pairs in business transaction networks and to construct various measures of transactional relationships. As mentioned, the key novelty is that in contrast to typical empirical studies where managerial efficiency is subsumed into production efficiency, we can observe them separately and investigate how each of these heterogeneities play its role in shaping transactional relationships. We use a large exogenous shock to transactional relationships (the Great East Japan Earthquake event) to test if the hypothesized relationships are causal.

In a recent paper, Bernard et al. (2021) decompose firm size heterogeneity into factors driven by production capability (productivity) and those driven by transactional networks. Their key finding is that transactional networks account for more than 50 percent of variation in firm size heterogeneity, and they interpret this as suggesting that firm attributes such as managerial talent and marketing capacity may be orthogonal to firm attributes that determine productivity (see also Foster et al., 2016). Our paper is in a similar spirit but instead of treating production networks as given and focusing on separating productivity and networks as independent determinants of firm size or growth, we examine whether managerial quality has an impact, independent from productivity, on the production networks themselves (number, quality, and churn of transaction partners). In other words, we try to open the black box of what determines the transactional networks heterogeneity itself, by exploiting a rare opportunity to use two

separate empirical measures of production efficiency and managerial efficiency, without having to rely on structural model estimations.

Our main findings are summarized as follows. First, higher management scores are positively associated with a broader range of transactional partners even after the productivity level is controlled for. Furthermore, our estimations using panel data and the exogenous event point to this relationship as being causal. We also observe a similar effect of productivity on a range of transactional partners. It is, however, worth emphasizing that structured management turns out to be at least as important in determining a range of transactional partners as productivity.

Second, firms with higher management scores add and drop transactional partners more frequently than firms with lower management scores. We also find that firms keep a core set of high productive transactional partners and add or drop peripheral low productive transactional partners, which is similar to the patterns of product variety expansion documented in Bernard, Redding and Schott (2010).

Third, the average labor productivity of transactional partners is positively associated with TFP, but there is no such relationship with management scores. We do, however, find a positive association between management scores and the size of transactional partners. Finally, management scores are positively correlated with TFP, and negatively correlated with how firms perceive the uncertainty of the business environment they face. Furthermore, the negative effect of uncertainty on a range of transactional partners becomes smaller as management scores and TFP become higher.

Overall, the empirical results of this paper suggest that both production and managerial efficiency are important factors in facilitating the formation of transactional relationships. In particular, the findings above can be interpreted as indicating that better managed firms expand a range of transactional partners, change their portfolio of transactional partners more flexibly, attract larger transactional partners, and mitigate transaction-related uncertainty to a larger extent.

This study contributes to existing strands of the literatures on structured management, business-to-business network, product variety expansion and organizational economics in several ways. First, our findings point to the importance of managerial efficiency in the formation of transactional relationships. Similar to Bernard et al.’s (2021) concept of "firm capability," fundamental firm heterogeneity relating to the formation of transactional relationships is not determined by production efficiency alone, but at the very least is a non-trivial combination of managerial and production efficiency. This in turn indicates the need to extend the theoretical analyses of business

relationships and networks beyond the approach in which productivity is a single important firm heterogeneity to form transactional relationships.

Second, to the best of our knowledge, the relationship between structured management and transactional relationships has not been examined empirically in the literature on structured management. Existing studies about structured management have focused on the link between productivity and management (Bloom and Van Reenen, 2007; Bloom et al., 2019; Gosnell et al., 2020), the role of management in international trade (Bloom et al., 2021) and the role of management in times of crisis (Lamorgese et al., 2021). This study thus uncovers a new role of structured management in firm activities.

Third, the empirical findings from this study illuminate mechanisms for a range of transactional partners shared with and different from findings about multi-product firms. We observe frequent churning of transactional partners similar to the patterns in product variety choices. While productivity plays a central role in churning product varieties and determining a range of product varieties, our findings suggest that both productivity and managerial efficiency play such a role in determining a range of transactional partners.

Fourth, theoretical studies on organizational economics emphasize the role of uncertainty in the determination of transactional relationships. Despite this importance, empirical evidence has been scarce, especially, beyond case studies. We try to make progress on this front by using our unique and sufficiently large data set.

Finally, our rich data set allows us to provide a broader and more comprehensive view regarding the roles of structured management, productivity and uncertainty in transaction networks.

The rest of the paper is organized as follows. Section 2 describes the data from the Japanese version of Management and Organizational Practices Survey (JP MOPS) and business-to-business transactional network data from Teikoku Databank. In section 3, we explain our empirical framework and estimation strategy in order to help to interpret our findings. In Section 4, we present our core estimation results for the relationship between management and a range of transactional partners from cross-sectional and panel estimations as well as estimations using exogenous variation due to the Great East Japan Earthquake. In section 5, we report estimation results from the investigation of how managerial efficiency is related to firm's capability to form its portfolio of transactional partners. Section 6 concludes.

2. Data

2.1 Japan MOPS

Our data on managerial efficiency come from the Japanese version of Management and Organizational Practices Survey (hereafter JP MOPS, *soshiki-management-ni-kansuru-chosa*) conducted in 2017 by the Economic and Social Research Institute (ESRI), Cabinet Office, Japan. The JP MOPS closely follows the protocol of the 2015 US MOPS (Bloom et al., 2019) and we use only its manufacturing part in our empirical analyses.[4] To be included in the survey, manufacturing establishments must be located in Japan as of July 1st, 2014 and employ at least 30 workers. The maximum number of establishment-level observations we can use from this data set is 11,405.

The JP MOPS contains a total of 16 management practice questions regarding monitoring, targeting, bonuses, promotion, and dismissal practices.[5] These management practice questions are a multiple-choice question and survey respondents were instructed to choose at least one answer that best describes management practices employed at their establishment in 2015 as the reference year and in 2010 as the recall question. For example, one of the management questions about monitoring was "During 2010 and 2015, how frequently were the key performance indicators reviewed by managers at this establishment?" and survey respondents were asked to choose from "Yearly, Quarterly, Monthly, Weekly, Daily, Hourly or more frequently and Never."[6] We utilize such pieces of information to calculate management scores for each establishment by the same procedure as Bloom et al. (2019). Management scores measure a degree of structured management at the establishment level and serves as a proxy for managerial efficiency in this study.

The JP MOPS also includes business expectation questions about a value of shipments and the number of employees in 2017 and 2018. More specifically, based on their best knowledge at the beginning of 2017, survey respondents were instructed to forecast a total value of shipments at their establishment during 2017 and the number of employees at their establishment at the end of 2017. Regarding 2018 business expectation, they were asked to forecast these numbers for three scenarios (low, medium, high) and assign a probability to each scenario. We use respondents' answer to the 2018 business expectation to measure business uncertainty and use it as an important control variable in our empirical analysis below.

[4] This survey was also conducted for food and drink retail industry and information technology service industries. We excluded these industries from our analyses because business expectation questions were asked only for manufacturing and because it is hard to measure total factor productivity from available data for these industries.

[5] These 16 management questions are identical to the ones in the 2015 US MOPS. See Kambayashi, Ohyama and Hori (2021) for the details of the JP MOPS.

[6] See http://www.esri.go.jp/jp/prj/current_research/service/manage/menu_manage.html for more detailed information on the survey questions in the JP MOPS.

2.2. Business-to-business transaction data

We compiled our business-to-business transactions data from restricted-use Teikoku Data Bank database. Teikoku Databank is a public company that collects a wide range of information about Japanese firms and business-to-business transactions to offer corporate credit reporting and business solution services. They compile such information by sending enumerators to firms or conducting telephone interviews. For the sake of their own benefits, most Japanese firms are willing to cooperate on these interviews and to provide accurate information. The business and credit information collected by reliable corporate credit reporting companies help firms to have business relationships by resolving informational asymmetry about business and financial conditions between transactional partners.

In this study, we utilize Teikoku Databank's COSMOS2 database containing about 1.4 million firms annually that account for more than 90 percent of all sales in the Japanese economy. Business entities not in this database are mostly unincorporated small businesses. The COSMOS2 database includes information on the statement of accounts, main transactional partners, major shareholders and banks, and it is updated on an annual basis.

The COSMOS2 data on transactional relationships are a key element in this study. Combining the transactional relationship data with the JP MOPS opens up a new and unique opportunity for examining how structured management, in addition to productivity, affects the formation of transactional relationships. In the COSMOS2 database, a customer-supplier pair is recorded as a transaction pair, by which we can identify a transactional relationship and construct measures for the characteristics of transactional relationships.[7] In this study, we define two firms to have made at least one business-to-business transaction during a certain year if the firms are listed as a pair of transaction partners. We can trace information about business-to-business transactions back to the year 1994.

To merge COSMOS2 with the JP MOPS, we need to aggregate establishment-level variables in the JP MOPS into firm-level variables. Thus, the unit of analysis is a firm in the empirical investigation of this study. We take a weighted average of establishment-level variables by using the relative size of establishment within a firm as a weight, where an establishment size is measured by the number of employees.[8]

[7] Each firm in the database was asked to list up to 5 important transaction partners. This way looks restrictive, but it captures most of domestic transactional relationships because firms on both sides of transactional relationships list the names of their transactional partners.

[8] A firm ID number is assigned to each establishment in the Japanese manufacturing census. Seventy percent of establishments in our sample have only a single establishment.

2.3. Other data sources

We also link the JP MOPS data to the Japanese Census of Manufactures to construct productivity measures. The Ministry of Economy, Trade and Industry administers the Japanese Census of Manufactures and gathers information about Japanese establishments in the manufacturing sector every year. All establishments with at least four employees located in Japan are subject to the manufacturing census every year, and establishments with 30 employees or more must provide more detailed information about their characteristics and assets than establishments with less than 30 employees.

Japanese establishments in the manufacturing sector are required by the Statistics Act to provide accurate information about their characteristics such as name, location, value-added, the number of employees, a value of shipment, total wage payment, fixed capital, and so forth. Among those variables, we utilize value-added, the number of employees and fixed capital to estimate total factor productivity by supplementing it with the industry-level data on labor hours from the Japanese Monthly Labor Statistic Survey and industry-level capital accumulation from the Japanese Corporate Enterprise Statistics Survey.

Since there are no common identifiers between the JP MOPS and these data sets, we conduct data matching through name, telephone number and address of establishments. We could merge the JP MOPS data with the Japanese Census of Manufactures for 9,983 establishments out of 11,405 (i.e., 88 percent).

2.4 Research variables and summary statistics

As mentioned, we follow the procedure in Bloom et al. (2019) to construct management scores and capture managerial efficiency by management scores. Survey respondents were instructed to select at least one answer for each multiple-choice management practice question, and this answer is evaluated on a scale of 0 to 1.[9] For the survey question above, for example, the maximum score of one is assigned to "Hourly or more frequently" and the minimum score of zero is assigned to "Never." We take a simple average of the scores from the 16 management practice questions to construct a single measure of management quality. This variable is called "management scores" and serves as one of our main variables of interest. In principle, a more structured (i.e., more incentivized) management practice gets a higher management score and can be regarded as a "better management practice" to reflect the view that the quality of operational efficiency embedded in a set of management practices. In this paper, we interpret higher

[9] When multiple answers are possible, we averaged scores of those answers.

management scores as indicating more structured or more efficient management and we use high managerial efficiency and structured management synonymously.

We take a production function approach to estimate total factor productivity (TFP) by using establishment-level data on the values of production, labor, capital and materials (see Table A1 in Appendix for the construction of each variable). We simply assume a Cobb-Douglas production function and use the 10-year panel data between 2006 and 2015 to estimate the parameters of the production function by the system general method of moment (Blundell and Bond, 1998). In this study, residuals from this estimation are our measure of establishment-level productivity.[10]

Organizational economics often argues that uncertainty and bilateral dependency are critical for shaping transactional relationships (Tadelis and Williamson, 2013). Some unforeseen events may damage a value created from a transaction, which results in requiring transactional parties to make costly adjustments. Therefore, firms tend to avoid forming transactional relationships when uncertainty looms large. Bilateral dependency is often discussed in the context of transaction-specific assets, but its essence is that "the identity of the parties matters for the continuity of a relationship" (p.164, Tadelis and Williamson, 2013). Regardless of reasons, the difficulty of finding and switching to alternative transactional partners affects the formation of transactional relationships.

To alleviate the concern that these two factors confound our main results through the correlation with managerial efficiency, we include their empirical measures as an important control variable in our regression analysis. We use the information from the JP MOPS on each establishment's business expectation about its future values of shipments in 2018 to measure a degree of uncertainty as perceived by the firms in our sample. Specifically, the business forecasts were classified in MPOS surveys into high, medium and low scenarios and the respondents assigned a probability to each scenario. We use these responses to calculate a weighted mean and a weighted standard deviation of forecasted values of shipment from these three scenarios and construct their coefficient of variation as our measure of uncertainty. The basic rationale for this variable is that the volatility of the forecasts in different scenarios becomes higher as firms perceive their business environment to be under a greater degree of uncertainty. We also use firm-level return on assets and construct its coefficient of variation as an alternative measure of uncertainty. See the appendix for the definition of each variable.

A variable for bilateral dependency is constructed from the transactional network data by calculating a fraction of potential customers in a given industry with which the

[10] We also tried other panel data estimation methods such as random effect model, fixed effect model and the difference general method of moments to estimate total factor productivity. The main results of this paper do not change qualitatively if these alternative measures of total factor productivity are used.

focal firm does not currently form transactional relationships. We call this variable "specialization ratio," with a higher value of this variable intended to capture larger bilateral dependency as a firm transacts with a few selected buyers in the same industry.

Table 1 provides summary statistics on main research variables – management scores, total factor productivity, and centrality measures from transaction networks – and important control variables. The average number of suppliers a firm transacts with (i.e., degree centrality) is 28 firms during the year 2015 and the average number of customers is about 27 firms. As we can see from Table 1, the distribution of the number of transaction partners is quite skewed with a fat left tail and a thin right tail; for the number of suppliers, it is 5 firms at the first quartile, 8 firms at the median, and 17 firms at the third quartile.

Turning to management scores, the average value of management scores at the firm level is 0.483. This can be interpreted as indicting that a typical Japanese firm in our sample employs about 48 percent of "desired" structured management practices. A management score is 0.359 at the first quartile and is 0.613 at the third quartile. As consistent with the results from the U.S. and UK MOPS, we observe a substantial variation in management scores across Japanese manufacturing firms. In line with the productivity literature (Syverson, 2011), our productivity measure is also dispersed across firms. Summary statistics on TFP show that one standard deviation of our productivity measure in our sample is 1.8 (i.e., exp(0.579)) and this difference is translated into a 1.6 times difference in a volume of outputs from the same amount of inputs. Although we do not report in Table 1, the correlation between management scores and TFP is 0.35 for the year 2010 and 0.33 for the year 2015. Thus, the correlation is positive and modest (See Table A2 for partial correlation between them).

Regarding our uncertainty measure (coefficient of variation of business expectations), its mean value and standard deviation are 0.112 and 0.085, respectively. We see variation in this measure of uncertainty, which implies that some firms expect their business outcomes to be less volatile than other firms.

(Table 1 here)

3. Empirical framework

3.1 Conceptual framework

In this section, we present a simple analytical framework to guide our empirical examinations as well as to help interpret our empirical results in Section 4. We neither intend to directly test the model nor to derive general implications from it. To achieve

these aims, we extend the product variety model of Mayer et al. (2014) by adding the elements of managerial efficiency and uncertainty to it. Managerial efficiency in the model is the main factor along with productivity and adds another element to a source of firm heterogeneity for the formation of transactional relationships whereas uncertainty is intended to capture transactional environments.

We consider a situation in which suppliers have an opportunity to provide various kinds of intermediate goods to their customers, though all the implications below can be applied to customers. For simplicity, suppliers are assumed to serve one customer for each intermediate good so that the number of intermediate goods they supply corresponds to the number of their customers.

The inverse demand function for intermediate good j is specified linearly as

$$p_j = \alpha - \gamma q_j - \eta Q \qquad (1)$$

where p_j is the price of intermediate good j, q_j is the amount of intermediate good j demanded by customer firms, and $Q \equiv \int_{i\in\Omega} q_i \, di$ is the aggregate demand for the set of all intermediate goods in the economy Ω. The parameters α and η are demand shifters and γ captures the degree of substitutions between the intermediate goods. This demand function can be written as

$$q_j = \frac{1}{\eta M+\gamma}\left(\alpha + \frac{\eta}{\gamma} M\bar{p}\right) - \frac{1}{\gamma} p_j \qquad (2)$$

as long as $p_j \leq \frac{1}{\eta M+\gamma}(\gamma\alpha + \eta M\bar{p}) \equiv p^{max}$, where M is the number of intermediate goods available in the economy and $\bar{p} \equiv \frac{1}{M}\int_{i\in\Omega} p_i \, di$ is the price index.

A supplier faces different marginal costs of providing each intermediate good. The marginal cost of intermediate good j depends on the supplier's productivity and its degree of transactional hazards. A source of transactional hazard represents uncertainty surrounding the business and is denoted by σ. The marginal cost of intermediate good j is given by

$$v_j(m, \sigma, \omega) = \frac{\sigma}{m}\omega^{-j} \qquad (3)$$

where $\omega \in (0,1)$ is the level of supplier's productivity and m is the supplier's managerial efficiency. The marginal cost decreases with the productivity level ω and increases with the index of intermediate goods. In other words, high productivity suppliers can produce their core intermediate products cheaply. The marginal cost also

reflects the idea that high managerial efficiency mitigates the adverse effect of σ on the marginal cost. The identity of a supplier is now determined by the triplet (m, σ, ω).

The profit maximizing price and quantity of intermediate good j with cost v_j are $q_j(v_j) = \frac{1}{\gamma}[p_j(v_j) - v_j]$. The profit from intermediate good j is

$$\pi_j(v_j) = \frac{1}{\gamma} p_j(v_j)[p_j(v_j) - v_j] \quad (4)$$

For intermediate good j, the zero profit condition pins down the cutoff level $\bar{v}_j$ for v_j: $p(\bar{v}_j) = \bar{v}_j = p^{max}$. Using $\bar{v}_j$, the profit function (4) can be expressed as

$$\pi_j(v_j) = \frac{1}{4\gamma}(\bar{v}_j - v_j)^2 \quad (5)$$

The cutoff level $\bar{v}_j$ for the marginal cost translates to the cutoff level for pairs of the managerial efficiency and the degree of uncertainty (m, σ). To focus on supply decisions driven by the managerial efficiency, define uncertainty-adjusted managerial efficiency $\tilde{m}$ as $\tilde{m} \equiv \frac{m}{\sigma}$. The cutoff level for uncertainty-adjusted managerial efficiency $\tilde{m}$ is determined by $\bar{v}_0 = \frac{1}{\bar{\tilde{m}}}$ since $v_0(m, \sigma, \omega) = \frac{\sigma}{m}$. Firms earn positive profits from supplying their core intermediate products if $\bar{\tilde{m}} < \tilde{m}$. In addition, their profits from the *n*th intermediate goods are positive if it holds that $\omega^{-n}\bar{\tilde{m}} \leq \tilde{m}$.

The total number of intermediate goods produced by a firm with uncertainty-adjusted managerial efficiency $\tilde{m}$ is

$$N(\tilde{m}) = max\{n \,|\, \omega^{-n}\bar{\tilde{m}} \leq \tilde{m}\} + 1 \quad (6)$$

provided that $\bar{\tilde{m}} < \tilde{m}$. Given that the number of intermediate goods corresponds to the number of customers, managerial efficiency affects a range of transaction partners and firms with higher managerial efficiency serve more customer firms.

The output of a supplier with risk-adjusted managerial efficiency $\tilde{m}$ is $q_j(\tilde{m}) = \frac{1}{2\gamma}\left(\frac{1}{\bar{\tilde{m}}} - \frac{1}{\tilde{m}}\omega^{-j}\right)$. This implies that the amount of goods supplied to customer j increases with the management quality, other things constant. The total amount of the good supplied by uncertainty-adjusted management quality $\tilde{m}$ is

$$Q^s(\tilde{m}) = \int_{i\epsilon\Omega(\tilde{m})} q_i(\tilde{m})\, di = \int_{i\epsilon\Omega(\tilde{m})} \frac{1}{2\gamma}\left(\frac{1}{\bar{\tilde{m}}} - \frac{1}{\tilde{m}}\right)\omega^{-i} di \quad (7)$$

The total amount of the good supplied also increases with management quality $\tilde{m}$ since $\Omega(\tilde{m})$ is a non-decreasing function of $\tilde{m}$ and $q_i(\tilde{m})$ increases with $\tilde{m}$.

3.2 Estimating equations

The conceptual framework in the previous section generates the main empirical implication that guides us to conduct our empirical analysis. The number of transaction partners are affected by (a) managerial efficiency m, (b) productivity level ω, and (c) uncertainty σ. Especially, as we can see from Equation (5), the number of transaction partners increases as both managerial efficiency m and productivity level ω are higher, other things equal. A novel aspect of our empirical investigation into this relationship, permitted by the richness of our data, is to include management quality m as the determinants for a range of transaction partners while productivity level ω and a degree of uncertainty σ are being controlled for at the firm level. The baseline estimation equation is

$$ln(CM_i) = \beta_0 + \beta_1 m_i + \beta_2 \omega_i + \beta_3 \sigma_i + \beta_4 X_i + \varepsilon_i \quad (8)$$

where m_i, ω_i, and σ_i are empirical counterparts to managerial efficiency, production efficiency, and business uncertainty of firm *i*, respectively. We estimate the range of transaction partners broadly by going beyond the number of direct transactional partners. Thus, the dependent variable CM_i is centrality measures of the transactional network, such as the number of direct transaction partners (degree centrality) and page rank centrality. The variable X_i is a set of control variables that includes firm *i*'s characteristics such as size, a degree of firm *i*'s specialization ratio, measurement-related noise control, location dummies and sub-industry (three-digit Japanese standard industry classification) dummies.

An implication from equation (7) is that managerial efficiency and productivity scale up the supply of a particular good. If purchasing a large amount of goods from one supplier is operationally more efficient than a small amount of goods from many suppliers, these factors are likely to be positively associated with the size and productivity level of transactional partners. Therefore, suppliers with high management quality and productivity will tend to serve large customers with high productivity (Verhoogen, 2021). Instead of using centrality measures of the transactional network in our baseline estimation equation (8), we use the average labor productivity and the average size of transactional partners as a dependent variable for this empirical exercise.

We also look into dynamic aspects regarding the formation of transactional relationships, utilizing the panel nature of the data and replacing the dependent variable of centrality measures in equation (8) by variables indicating the addition or deletion of transactional partners over time. To explore the relationship between managerial efficiency, productivity, and uncertainty, we first examine partial correlations among these variables and then include the interaction terms of uncertainty with managerial

efficiency and productivity in our baseline estimation equation (8) to examine whether managerial efficiency and productivity mitigate adverse effects of uncertainty on a range of transactional relationships.

3.3 Estimation strategy

Management practices and transactional relationships are, of course, not independent of each other. For example, firms may adopt good management practices by learning from other firms to which they are connected through business-to-business transaction networks. To give just one example, the celebrated Toyota "just-in-time" production management system, by its nature, is bound to reverberate through all of its supply chain. As a result, unobservable factors affect firms' decisions on both the formation of transactional relationships and the adoption of structured management. Therefore, estimation results obtained from cross-sectional regressions raise a concern about potential endogeneity problems.

As in most studies, we do not have exogenous variations in regard to the adoption of management practices, which prevents us from cleanly establishing the causal relationships between managerial efficiency and the formation of transactional relationships. One way of partially addressing this issue is to use panel estimations with many control variables, specifically, fixed-effect model estimations, which is what we do first.[11] While within-firm panel estimation controls for several possible confounds, one might still be concerned that both the choice of management practices and that of transaction partners may be correlated with other time-varying unobservable factors. To obtain a better sense of the causal connection between management quality and transactional relationships, we use the Great East Japan Earthquake as a quasi-natural experiment because it disrupted transactional relationships exogenously.

A magnitude 9.0 of earthquake occurred off the coast of Northeastern Japan on March 11th, 2011, causing powerful tsunami waves that devastated manufacturing facilities in the disaster-stricken area. Many production facilities in the area were forced to stop their operation completely for several months, and it took time for them to recover from the disastrous event (Todo et al., 2015). Not surprisingly, this shook a supply chain in Japan. Many firms in the area and firms that had transactional ties with them were forced to reorganize their transactional relationships and, especially, to replace terminated

[11] Management scores are available at two points in time, one for 2015 as the reference year and the other for 2010 as the recall question. The correlation between 2010 and 2015 management scores is 0.81. Although this correlation is high, the correlation between TFP and management scores in 2010 (0.35) is quite similar to that in 2015 (0.33). This may indicate that 2010 management scores still capture structured management in 2010 well.

transactional partners by new transactional partners. The necessity of forming new transactional relationships during this reorganization process would be exogenous and uniform among the firms affected by the earthquake. Thus, unobserved factors that influence the formation of transactional relationships are unrelated to management scores in this setting. While this exogenous shock does not allow us to estimate the average treatment effect of managerial efficiency on the transactional relationships, it gives us a clue as to whether managerial efficiency has a causal impact on the formation of new transactional relationships.

To implement the identification strategy above, we use the information from three decrees issued by the Japanese government after the earthquake and identify 41 municipalities as the area hit hard by the earthquake and the tsunami (Carvalho et al., 2021). We combine this information with the transaction data and empirically identify firms located in the area affected by the earthquake and firms having transaction relationships with at least one firm in the area.[12] Based on this identification, a dummy variable is created to indicate whether a firm belongs to a disrupted transaction network. We then estimate a two-stage least squares regression to examine whether managerial efficiency played a role in establishing new transactional relationships to replace terminated transactional partners due to the Great East Japan Earthquake. In the first stage, we obtain a predicted number of terminated transaction partners by regressing the number of terminated transaction partners on the instrument (disrupted network dummies) and other controls. In the second stage, the number of new transactional relationships is the dependent variable, while the key explanatory variable is management scores interacted with the predicted value of the number of terminated transaction partners from the first stage. This interaction term is intended to capture the effect of managerial efficiency on the replacement of terminated transactional partners by new transactional partners.

4. Empirical Results

4.1 Characteristics of transactional relationships

Before we present the results of our empirical analysis, we describe the general characteristics of our transactional network data. Figure 1A exhibits transaction shares in terms of sales within a given region and across regions for the year 2015, where entries in a row sum up to 100 percent.[13] The vertical axis indicates the location of suppliers

[12] The location of a firms is empirically identified by the location of its headquarters.

[13] As is common in the literature on Japan's spatial economy (e.g., Carvalho et al., 2020), the country is divided into eight geographical regions; (i) Hokkaido (the Northernmost island); (ii) Tohoku (the Northeastern region, most affected by the Great East Japan Earthquake); (iii) Kanto (Tokyo and surrounding areas); (iv) Chubu (with the main city of Nagoya), (v) Kinki (Osaka-Kyoto and surrounding areas), (vi) Chugoku (the part of the main island of Honshu facing the Sea of Japan), (vii) the island of Shikoku, and

whereas the horizontal axis indicates the location of customers. As we can see, diagonal entries range from 34.78 percent to 63.76 percent and account for a large share of transactions. Another noteworthy characteristic is that Kanto region, where Tokyo is located, accounts for large shares of transactions from other regions (max:34.61 and min:17.11). These characteristics suggest that most transactions are made within a region, and, when transactions are made between regions, firms supply most of their products to the Kanto region.[14]

The distribution of transaction shares within an industry and across industries are displayed in Figure 1B. In contrast to Figure 1A, diagonal elements are modest. Therefore, within-industry transactions are not a dominant pattern. Our data show that firm-to-firm transactions are made through Retail/Wholesale, Manufacturing and Service sectors since these sectors account for a large share of transactions in Figure 1B.

We next examine whether a pair of transactional partners in our data are similar to or different from each other in terms of firm size (i.e., sales) and labor productivity. The horizontal axis in the upper (lower) part of Figure 1C indicates absolute values of difference in size (labor productivity) and the vertical axis indicates frequencies of the differences. While the histograms in Figure 1C have long tails, the differences in both size and labor productivity are concentrated around zero. Note that these differences approach to zero when a pair of transaction partners are similar to each other with respect to these characteristics. Figure 1C thus indicates that similar firms in terms of size and productivity are paired in business-to-business transactions. Given that some differences in size or labor productivity deviate from zero, some large firms buy from or sell to small firms, and some high productivity firms transact with low productivity firms.

(Figure 1 here)

4.2 The Relationship between managerial efficiency and production efficiency with a range of transactional partners

We start by using cross-sectional data to examine how managerial efficiency and production efficiency affect a range of transactional partners. In this empirical examination, we use the logarithm of degree centrality and the logarithm of page rank centrality as the dependent variable to capture a range of transactional partners. While the

(viii) Kyushu-Okinawa region, including the Southernmost island of Kyushu and the Ryukyu archipelago.

[14] Qualitatively similar results are obtained if we use 47 prefectures to examine these relations and if the row and column are flipped so that transaction shares are displayed from the customers' viewpoint. Within a region, most transactions are made within a prefecture. When transactions are made across prefectures, firms supply most of their products to the largest prefecture (in terms of population) in the region.

degree centrality captures a range of direct transactional partners, the page rank centrality is intended to measure a degree of the connectedness with other firms beyond direct transactional partners. Our empirical measures of managerial efficiency and production efficiency are management scores and total factor productivity (TFP), respectively, and they are variables of our main interest in the regression analyses below. The number of employees, firm age, uncertainty measures, firm's specialization ratio, location and sub-industry dummies are included as control variables.

In Table 2, we report estimation results for the determinants of a range of transactional partners from the ordinary least squares regressions. In this regression, all variables are measured in 2015. Our estimation results show that the coefficients on management scores and TFP are positive and statistically significant at conventional significance levels in all the specifications. These cross-sectional regression results indicate that firms have a wider range of transactional partners as management is more structured, their productivity is higher or both. Note that the coefficient on management scores remains statistically highly significant in the specification (5) of Table 2A even after the productivity level is controlled for. The magnitudes of management scores and TFP are also economically substantial. According to our estimation in the specification (5) of Table 2A, the coefficient on management score indicates that a change in management scores from the first quartile to the third quartile (i.e., from 0.36 to 0.61) is associated with a 16 percent difference (0.64 x (0.61-0.36)) in the number of transactional partners, which is equivalent to 9 firms (55 x 0.16) for firms with the average number of transaction partners (which is 55 firms). A similar calculation for the TFP indicates a 69 percent increase in the number of transactional partners (which is 39 firms).

Turning to the control variables, it is interesting to see that the coefficient on uncertainty measures (C.V. of business expectations and C.V. of past returns on sales) is negative. It appears to suggest that the number of transaction partners increases as the degree of uncertainty is reduced. We will examine this effect further below, in Section 5.3. The number of employees and firm age are positively associated with a range of transactional partners whereas the firm's specialization ratio is negatively associated with it. In other words, larger and older firms have more transaction partners and firms reduce the number of transactional partners when they supply their goods to a specific industry.

Table 2B shows the same patten of correlations among the key variables as we saw in Table 2A. In particular, management scores are positively correlated with the page rank centrality after TFP is controlled for along with other key variables. Thus, this result indicates that better managed firms not only have a broader range of direct transactional

partners but also are connected directly or indirectly with firms that also have more transactional partners in the business transaction networks.

(Table 2 here)

We further examine these determinants for a range of transactional partners by exploiting panel aspects of the data. Our measures of structured management and productivity are available at two points in time, the years 2010 and 2015. The estimation results from pooled OLS, random-effect model, and fixed-effect model estimations are reported in Table 3.[15] In columns (1) to (3) of Table 3, both the effects of management scores and of productivity on the degree centrality (i.e., the number of direct transactional partners) are estimated to be positive regardless of the estimation methods. The results thus indicate that management scores are positively associated with a range of transactional partners even controlling for firm fixed-effects. The estimated effects of management scores on the number of transactional partners are reduced to 0.45 from 0.68 in magnitude in the fixed-effect panel estimations compared to the cross-section estimations in Table 2A, but the effects are still substantial. Note also that the drop in the effects of TFP (0.053 from 0.772) is larger in magnitude than management scores in the fixed effect model. This may suggest that, in relative to TFP, within-variation in management scores are a more significant factor in explaining a range of transactional partners than cross-sectional variation. We have similar results when the dependent variable is replaced by the page rank centrality in columns (4) to (6), although the coefficient on management score is no longer statistically significant at conventional significance levels in the fixed-effect model.

The panel estimation results above indicate, by and large, that both managerial efficiency and production efficiency influence a range of transactional partners. This result underscores that structured management plays at least a critical role in determining a range of transactional partners.

(Table 3 here)

4.3. Managerial efficiency and production efficiency as the determinants for a range of transactional partners

[15] The coefficient of variation of business expectation is not available for the year 2010. In this analysis, therefore, this (perceived) uncertainty measure is subsumed into error terms.

The OLS and panel estimation results above offer interesting insights, but we cannot draw strong causal inferences from them. However, as mentioned, a quasi-natural experiment caused by the 2011 Great East Japan Earthquake permits us to obtain some insights on a possible causal relationship between managerial efficiency and a range of transactional partners.

We first demonstrate the restructuring process of transactional networks graphically to see whether our empirical setting can serve as valid exogenous event. Panel A of Figure 2 compares how the average number of new transactional partners changed by the level of management scores in 2010 (above the mean vs. below the mean).[16] It shows that management scores were positively correlated with the number of new transactional partners during the exogenously imposed restructuring of transactional networks following the earthquake. In this comparison, Tier 0 means that a firm was located in the earthquake-stricken area and Tier 1 means that a firm's direct transactional partners (the first tier of its transactional networks) were located in the earthquake-stricken area. For n=2, 3, 4, Tier n means that a firm was connected to another firm in the earthquake-stricken area by the n-th tier apart in its transactional networks. ("No Connection" means that we did not find any transactional connections to the earthquake-stricken area.) As we can see, the average number of new customers/suppliers is high for firms whose direct customers/suppliers were in the earthquake-stricken area (Tier 1), while this number is also generally higher for firms with above-average management scores than for firms with below-average management scores.

Panel B of Figure 2 shows a similar picture for the average number of terminated transactional partners. There is some statistically significant difference in the average number of terminated transactional partners between firms with high management scores and firms with low management scores across all the tiers but firms with transaction partners in Tier 1 stand out in terms of the magnitudes. These summary statistics do not indicate that negative shocks on transactional relationships from the Great East Earthquake affected firms uniformly regardless of the level of their management scores.

(Figure 2 here)

We now conduct a formal analysis examining the role of management in the restructuring process by running a two-stage least squares regression as explained in Section 3.3. In the first stage regression, the dependent variable is the logarithm of the

[16] We obtain similar results when the median of management scores are used.

number of terminated transaction partners. To count as an incidence, such terminations must have occurred between 2011 and 2012. The main independent variables are a dummy variable (Tier 0 shock) indicating whether a firm was located in the earthquake-stricken area, as of January 2011, and a dummy variable (Tier 1 shock) indicating whether a firm's direct transaction partners were located in the earthquake-stricken area. In the second stage regression, predicted values of the logarithm of the number of terminated partners from the first stage are regressed on the logarithm of the number of new transaction partners along with management scores and TFP in 2010, that is before the earthquake struck.

Estimation results from the first stage regression are reported in Panel A of Table 4. Regarding column (1) of terminated customers, the coefficients on the tier shock variables are positive and statistically significant at the one percent significance level. Thus, the number of terminated transactional relationship increased if a firm itself or its direct transactional partners were located in the earthquake-stricken area. It is also noteworthy that the coefficients on management scores and TFP are not statistically significant at conventional levels when the impacts of the earthquake on transactional networks are controlled for. The effects of the March 2011 earthquake appear to a dominant factor in the terminations of transactional relationships in 2011-2012. We have similar results for terminated suppliers in column (2), though the coefficients on management scores and TFP are negative.

Panel B of Table 4 reports estimation results from the second stage regression, using the number of terminated customers due to the earthquake as an instrument. According to column (1), while the coefficient on the predicted value of the number of terminated customers is positive and statistically significant, the coefficient on management scores is not statistically significant at conventional significance levels while the coefficient on TFP is even negative. Our main variable of interest in the second stage regression is the interaction term of the number of terminated customers with management scores in column (2) that summarizes the role of managerial efficiency during the restructuring process of transactional networks caused by the Great East Japan earthquake. The estimation result shows that the coefficient on the interaction term is 0.477 and statistically significant at the one percent significance level.[17] It indicates that the number of new customers increases with the number of terminated customers and this effect becomes larger as management scores get higher. We interpret this finding as follows: Firms lost their customers and needed to fill the void when they were affected by the Great East Japan Earthquake directly or indirectly through their transactional

[17] This result remains unchanged qualitatively in various specifications, though we do not report here.

networks. Firms with high managerial efficiency were able to establish new transactional relationships whereas firms with low managerial efficiency struggled to find new customers. This statement also applies to TFP because the coefficient on the interaction term of TFP and the number of terminated customers is estimated to be positive. We obtain similar results for the number of new suppliers (See columns (3) and (4)).

(Table 4 here)

5. Further examination of the role of structured management in transactional networks

Our estimation results in the previous section suggest that a range of transactional partners increases with managerial efficiency. Although a range of transactional partners is a defining characteristic of transactional relationships, we extend our analysis about structured management to other dimensions of transactional relationships.

5.1. Does more efficient management lead to more churn of transactional partners?

In this section, we shed light on the impact of managerial efficiency on the ability to change transactional partners by investigating how management scores are related to addition to or deletion from the set of transactional partners. To investigate how a firm adds new transactional partners, we first identify a transactional partner that is not in a firm's set of transactional partners in the year 2015 but is in that set in the year 2018.[18] We then define such transactional partners as newly added transactional partners to count the number of added transactional partners for each firm. A similar procedure is applied to count the number of dropped transactional partners.

Figure 3A displays a bins-scatter plot between addition and deletion of transactional partners. The number of added transactional partners is positively associated with the number of dropped transactional partners. This indicates that firms churn transactional partners. Figure 3B shows a bins-scatter plot between management scores and addition and deletion of transactional partners. As we can see from Figures 3.B(a) and 3.B(b), both the numbers of added and dropped transactional partners are positively associated with management scores. Consistent with Tables 2, 3 and 4, Figure 3.B(c) shows that a net change (the number of added transactional partners less the number of dropped transactional partners) is also positively associated with management scores. The figures thus appear to suggest that firms with higher management scores not only add more transactional partners but also drop them more. Figure 3C displays the same

[18] We used different years as a reference year, but our main results remain unchanged qualitatively.

relationships for TFP. As in the case of management scores, both addition and deletion of transactional partners are positively associated with TFP.

(Figure 3)

We subject these relationships to a more formal test in a regression, where we include both management scores and TFP as our key explanatory variables. The results are presented in Table 5 and they confirm the relationships we observe in Figure 3 as well as the presence of management score effects that are independent of TFP. According to Table 5, both management scores and TFP are positively associated with the number of added transactional partners even after several variables such as uncertainty and specialization measures are controlled for. This result holds regardless of whether we estimate the relationship by OLS or a count-data model (compare columns (1) and (3)).[19] We obtain similar results with the number of dropped transactional partners and the net change, as the dependent variables: both management scores and TFP are positively associated with the outcome variables.

In terms of economic magnitudes, the results show that while a change in management scores from the first to the third quartile is associated with an addition of 0.7 transactional partners and deletion of 0.4 transactional partners, the same change in TFP is associated with an addition of 2.2 transactional partners and deletion of 1.2 transactional partners. Overall, estimation results show that firms with higher management scores and higher TFP expand the range of transactional partners by churning them at a higher rate.

(Table 5 here)

5.2. Does more efficient management attract more productive and larger transactional partners?

We next examine whether more efficient management attracts more productive and larger transactional partners. Cross-sectional data are used to obtain insights regarding the relationship between management scores, the average characteristic of transactional partners, and the number of transactional partners.

Table 6 report estimation results in which the dependent variable is the average labor productivity of transactional partners[20] or the average size of transactional partners.

[19] This result is also robust with respect to zero-inflated estimation models.

[20] Transactional partners in non-manufacturing sectors are also included in this analysis. While limiting

According to column (1) of Table 6 in which the number of transaction partners is not controlled for, the coefficient on TFP is positive and statistically significant at the one percent significance level. This result indicates that firms with high productivity form transactional relationships with high productivity firms, which is basically consistent with Figure 1C. On the other hand, the coefficient on management scores is -0.076 and statistically insignificant at conventional significance level. Thus, the matching on labor productivity is not related to management scores.

In contrast, columns (3) of Table 6 shows that management scores are positively correlated with the average size of transactional partners. Given that a range of transactional partners increases with management scores, this result does not necessarily mean that a "marginal" transactional partner a firm adds when expanding its set of transactional partners is large. To examine this part of the story, we include the number of transactional partners as a separate control variable in column (4) of Table 6. The estimation results show that, while the coefficient on management scores is still positive, the coefficient on the number of transactional partners is negative and statistically significant at the one percent significance level. This leads to the following two observations. First, since the average size of transactional partners decreases with the number of transactional partners for a given level of management scores, the "marginal" new added transactional partner tends to be smaller than the average when a firm expands its set of transactional partners. Second, and in contrast to the above, the average size of transactional partners rises with management scores when the number of transactional partners is controlled for. That is, given the number of transactional partners, firms with higher management scores transact with larger firms.

It is well documented that management scores increase with the size of establishment and firm (Bloom et al., 2019; Kambayashi et al., 2021). This fact leads us to infer that the average firm size of transactional partners at least partially reflects their managerial efficiency and that well managed firms are matched with other well managed firms in transactional networks. Investigating this inference requires a dataset from which we can calculate management scores for all transactional partners, but our dataset allows us to calculate management scores only if a transactional partner is a firm in the JP MOPS data. With this limitation in mind, we provide suggestive evidence in column (5) and (6) of Table 6 where the dependent variable is the average management score of customers. Our estimation result shows that the coefficient on a supplier’s management score is

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our analysis to the manufacturing sector leads to measure the number of transactional partners inaccurately, data for estimating TFP are not available in the non-manufacturing sector.

positive, indicating that better managed suppliers are matched with better managed customers.

(Table 6 here)

The two observations above lead us to infer that high managerial efficiency allows firms to form transactional relationships with large firms, but this effect of managerial efficiency exhibits diminishing returns to the size of transactional partners. To probe this relationship further, we exploit panel aspects of our data. Again, we compare the set of transactional partners in the year 2015 with that in the year 2018. More specifically, to measure relative levels of labor productivity or size for added transactional partners, a firm's set of transactional partners that remains in both 2015 and 2018 is compared with the set of transactional partners that appears only in 2018. The "add" dummy variable is created and assigned to be equal to one in the latter category of transaction partners, zero otherwise. Similarly, to measure relative levels of labor productivity or size for dropped transactional partners, a firm's set of transactional partners that remains in both 2015 and 2018 is compared with the set of transactional partners that appears only in 2015. The "drop" dummy variable is created accordingly.

Table 7 reports estimation results in which the dependent variable is the average labor productivity or size of transactional partners (the same as in Table 6), and the main independent variables are add and drop dummies constructed as above, and their interaction terms with management scores and TFP. According to the results presented in column (1) and (3), the coefficient on the "add" dummy is negative and statistically significant at the one percent significance level. We observe similar results for the "drop" dummy in column (2) and (4). This implies that firms keep transactional partners with relatively high productivity and large size, while they tend to add and drop "marginal" transactional partners with relatively low productivity and small size.

Regarding the average labor productivity, the interaction term of the "add" dummy with TFP is positive and statistically significant but the interaction term of the "add" dummy with management scores is small in magnitude and statistically insignificant at the conventional levels (similar for the "drop" dummy). These results appear to suggest that while an added or dropped transactional partner tends to be less productive relative to existing transactional partners, higher productivity of the focal firm mitigates this effect. Consistent with what we saw in Table 6, the roles of TFP and structured management are reversed when looking at the size of transactional partners,

although the estimated coefficient on the interaction term between the "add" dummy and management score in column (3) is statistically not significant at the conventional levels.

(Table 7 here)

5.3. Does more efficient management reduce transaction-related uncertainty?

The estimation results in Table 2 indicated that productivity, structured management, and uncertainty jointly determine a range of transactional partners. In this section, we explore the inter-relatedness of these factors to advance our understanding of how observed transactional patterns arise. In particular, we focused on a mechanism through which managerial efficiency and productivity may contribute to lowering the degree of uncertainty and work as complements in expanding a range of transactional partners through this particular channel.

Figure 4 displays the inter-relatedness of management scores, TFP, and coefficient of variation of business expectation.[21] We can see from Figure 4(a) that TFP is positively correlated with management scores. This positive correlation is consistent with the existing empirical findings from management survey data conducted in various countries (e.g., Bloom et al. 2019). There is also evidence that this relationship is causal (e.g., Bloom et al. 2019; Giorcelli, 2019). Figure 4(b) shows that management scores are negatively correlated with our measure of uncertainty, the coefficient of variation of business expectation. This measure of uncertainty is a subjective perception of uncertainty (business expectation) formed by a firm. Thus, this negative correlation can be interpreted as implying that structured management plays a certain role in lowering a degree of uncertainty controllable by firms.[22] This relation is also found in the U.K. MOPS data (Bloom et al., 2021). Finally, we also see a negative correlation between TFP and our measure of uncertainty in Figure 4(c). Our regression results in Table A2 also confirm the inter-relatedness of these factors we see in Figure 4.

(Figure 4 here)

To examine how these correlations are transmitted to the formation of transactional relationships, Table 8 replicates the main estimation of Table 2 by including

[21] The figures are bin-scatter plot with controls. Our measure of uncertainty is included in the set of controls for a bin scatter plot of management scores and TFP. Figures 4.b and 4.c include TFP and management scores respectively.

[22] Similar results are obtained when we use our other measure of uncertainty, the coefficient of variation of return on sales.

the interaction term of uncertainty with each of TFP and management scores.[23] According to our estimation results, the coefficient on our uncertainty measure is negative, and both coefficients on the interaction term with TFP and with management scores are positive. Thus, the number of transactional partners decreases as our measure of uncertainty gets larger, but both productivity and managerial efficiency work as mitigating this negative effect. Putting our estimates in some perspective, a one unit change in our uncertainty measure is associated with a decrease by four transactional partners for a firm with 0 management score (possible lowest score) and an increase by three transactional partners for a firm with 1 management score (possible highest score).

(Table 8 here)

Combining the estimation results in Tables 2, A2 and 8 gives us a more comprehensive view regarding how the observed pattern of transactional relationships arises from firm heterogeneity with respect to managerial efficiency and productivity. For a given degree of uncertainty, firms with high productivity are likely to have more efficient management in place so that high levels of both contribute to a broader range of transactional partners. Furthermore, both management scores and TFP are negatively correlated with firms' subjective measure of uncertainty. This correlation helps to expand a range of transactional partners further. These are firm characteristics arising from the joint distribution of TFP, management scores and uncertainty, and these are critical sources for firm heterogeneities we find in relation to transactional networks.

5. Conclusion

We investigated several empirical relationships between managerial efficiency, production efficiency and the formation of transactional relationships. There are two key takeaways from the main findings of this paper. First, we found that managerial efficiency is at least as important in forming transactional relationships as production efficiency. This finding is novel, and it offers a fresh view regarding the roles of structured management and productivity in the formation of transactional relationships. Second, structured management plays multiple roles in the formation of transactional relationships. Our main finding suggests that well-managed firms expand a range of transactional partners. Furthermore, managerial efficiency is not limited to this role. A subset of our

[23] We also tried the specification in which an independent term of TFP or management scores are included in addition to their interaction terms with uncertainty. In this case, we did not find the negative interaction effect. However, we suspected severe multi-collinearity in this specification because VIF indicates about 60 for the interaction terms.

findings indicates that managerial efficiency is linked to a firm's capability to attract large transactional partners, to change transactional partners flexibly, and to deal with transaction-related uncertainty. We also documented a positive correlation between management scores and TFP as well as a negative correlation between management scores and the coefficient variation of business expectation. The joint distribution of these three variables indicate that well-managed firms are likely to have characteristics that expand a range of transactional partners further.

As most past studies, this study faced data limitations on exogenous variation in managerial efficiency. However, we utilized the exogenous shock to transaction networks from the Great East Japan Earthquake as a quasi-natural experiment and examined the role of managerial efficiency in the process of forced reorganization of transactional relationships following this exogenous shock. The results from this instrumental-variable estimation suggested a causal link from managerial efficiency to faster reorganization of the disrupted transactional relationship. Of course, those findings were established only for the firms affected by the earthquake directly or indirectly through transaction networks. Therefore, the results from this approach should still be considered as only suggestive, and need further empirical investigation to draw general insights on the management-transaction relationships.

We tried to open the black box of the determinants for the formation of transactional relationships by taking advantage of the availability for separate measures of production efficiency and managerial efficiency in Japanese data. Overall, this paper reveals that managerial efficiency is one of the critical factors determining the pattern of transactional relationships we observe.

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Tables and Figures

Table 1: Summary Statistics on Key Variables

	mean	standard deviation	25th	50th	75th	no. of obs
Management score	0.483	0.172	0.359	0.492	0.613	8,905
log of TFP	4.403	0.579	4.004	4.373	4.818	8,030
CV of business expectation	0.112	0.085	0.039	0.087	0.174	6,120
Degree centrality (suppliers)	28	108.8	5	8	17	8,571
Degree centrality (customers)	26.6	115.6	4	7	14	8,664
Page rank centrality ($x10^5$)	1.14	7.19	0.09	0.19	0.48	8,841

Table 2A: The Relationship between Degree (No. of Partners) Centrality Measure, Management Scores and TFP

	(1)	(2)	(3)	(4)	(5)	(6)
Management score	1.402 ***				0.644 ***	0.681 ***
	(0.080)				(0.079)	(0.071)
TFP		0.846 ***			0.853 ***	0.772 ***
		(0.035)			(0.037)	(0.034)
Coefficient of Variation of			-2.280 ***		-0.685 **	
Business Expectation			(0.382)		(0.346)	
Coefficient of Variation of				-0.0002 ***		-0.00001
Return on Sales				(0.00003)		(0.00004)
Specialization Ratio	-0.772 ***	-0.626 ***	-0.802 ***	-0.773 ***	-0.641 ***	-0.618 ***
	(0.042)	(0.041)	(0.055)	(0.045)	(0.0001)	(0.048)
Number of Employees	0.0003 ***	0.0002 ***	0.0002 ***	0.0003 ***	0.0002 ***	0.0002 ***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Firm Age	0.019 ***	0.017 ***	0.018 ***	0.019 ***	0.016 ***	0.017 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Noise Control			0.117 **		0.165 ***	
			(0.047)		(0.040)	
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
No of observations	8,520	7,303	5,238	7,641	5,060	6,614
Adjusted R_squared	0.46	0.53	0.42	0.43	0.472	0.531

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Coefficients are estimated by OLS. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.

Table 2B: The Relationship between Page-Rank Centrality Measure, Management Scores and TFP

	(1)	(2)	(3)	(4)	(5)	(6)
Management score	1.014 ***				0.462 ***	0.482 ***
	(0.077)				(0.091)	(0.081)
TFP		0.622 ***			0.660 ***	0.578 ***
		(0.032)			(0.037)	(0.033)
Coefficient of Variation of			-2.453 ***		-1.343 ***	
Business Expectation			(0.418)		(0.407)	
Coefficient of Variation of				-0.0001 ***		-0.00002
CV of Return on Sales				(0.00004)		(0.0001)
Specialization Ratio	-1.011 ***	-0.909 ***	-1.080 ***	-1.031 ***	-0.954 ***	-0.927 ***
	(0.045	(0.047)	(0.059)	(0.048)	(0.056)	(0.049)
Number of Employees	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***
	(0.00005)	(0.00004)	(0.00005)	(0.00005)	(0.00004)	(0.00004)
Firm Age	0.018 ***	0.016 ***	0.017 ***	0.018 ***	0.015 ***	0.016 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Noise Control			0.080 *		0.119 **	
			(0.048)		(0.044)	
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
No of observations	8,520	7,303	5,238	7,641	5,060	6,614
Adjusted R_squared	0.46	0.47	0.42	0.43	0.48	0.47

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Coefficients are estimated by OLS. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.

Table 3: The Relationship between Centrality Measures, Management Scores and TFP (Panel Estimation)

	Dependent variable: Degree Centrality Measure			Dependent variable: Page Rank Centrality Measure		
	(1)	(2)	(3)	(4)	(5)	(6)
Management score	0.700 ***	0.353 ***	0.45 ***	0.469 ***	0.141 ***	0.048
	(0.068)	(0.041)	(0.045)	(0.077)	(0.056)	(0.068)
TFP	0.79 ***	0.266 ***	0.053 ***	0.595 ***	0.262 ***	0.007
	(0.03)5	(0.017)	(0.014)	(0.033)	(0.020)	(0.020)
Coefficient of Variation of	-0.0002	-0.00002	-0.00001	0.00001	-0.00001	0.00001
Return on Sales	(0.00003)	(0.0001)	(0.00001)	(0.00004)	(0.00002)	(0.00002)
Specialization Ratio	-0.624 ***	-0.106 ***	-0.009	-0.938 ***	-0.209 ***	0.0001 ***
	(0.037)	(0.016)	(0.017)	(0.044)	(0.024)	(0.00001)
Number of Employees	0.0002 ***	0.0002 ***	0.0001 ***	0.0002 ***	0.0002 ***	0.005
	(0.0001)	(0.00005)	(0.00002)	(0.00004)	(0.00004)	(0.025)
Firm Age	0.017 ***	0.017 ***		0.016 ***	0.014 ***	
	(0.001)	(0.001)		(0.001	(0.001)	
Specification	Pooled OLS	Random Effect	Fixed Effect	Pooled OLS	Random Effect	Fixed Effect
Year and Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
No of observations	11,812	11,812	11,812	11,812	11,812	11,812
R_squared	0.55	0.31	0.03	0.49	0.71	0.003

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Numbers in parentheses are robust standard errors. (iii) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.

Table 4A: The Relationship between Centrality Measures, Management Scores and TFP (1st stage)

	First Stage Regression			
	Terminated Customers		Terminated Suppliers	
Tier 0 shock	0.283	***	0.092	
	(0.109)		(0.111)	
Tier 1 customer shock	0.198	***	0.129	***
	(0.039)		(0.038)	
Tier 1 supplier shock	0.137	***	0.195	***
	(0.042)		(0.042)	
Management score	0.052		-0.159	**
	(0.066)		(0.007)	
TFP	-0.018		-0.06	**
	(0.025)		(0.024)	
Controls	Yes		Yes	
No of observations	3,933		3,933	
Adjusted R_squared	0.65		0.62	

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Numbers in parentheses are robust standard errors. (iii) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.

Table 4B: The Relationship between Centrality Measures, Management Scores and TFP (2nd stage)

Dependent variable: New Customers			Dependent variable: New Suppliers		
	1	2		3	4
Management score	-0.003	-0.214 **	Management score	-0.041	-0.207 ***
	(0.077)	(0.084)		(0.878)	(0.086)
No. of terminated customers		0.477 ***	No. of terminated suppliers		0.270 **
x Management Score		(0.121)	x Management Score		(0.106)
No. of terminated customers	0.724 ***	-0.316	No. of terminated suppliers	0.642 ***	-0.988 ***
	(0.151)	(0.239)		(0.158)	(0.210)
TFP	-0.085 ***	-0.220 ***	TFP	-0.062 **	-0.289 ***
	(0.029)	(0.032)		(0.027)	(0.033)
No. of terminated customers		0.161 ***	No. of terminated customers		0.252 ***
x TFP		(0.026)	x TFP		(0.022)
Controls	Yes	Yes	Controls	Yes	Yes
No of observations	3,933	3,933	No of observations	3,933	3,933
Adjusted R_squared	0.55	0.65	Adjusted R_squared	0.53	0.62

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Numbers in parentheses are robust standard errors. (iii) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.

Table 5: Adding and Dropping of Transactional Partners

	1. Add	2. Drop	3. Add	4. Drop	5.Net Change
Management score	2.767 ***	1.488 ***	0.595 ***	0.48 ***	1.279 ***
	(0.626)	(0.277)	(0.101)	(0.094)	(0.495)
TFP	3.301 ***	1.736 ***	0.508 ***	0.472 ***	1.565 ***
	(0.347)	(0.119)	(0.032)	(0.030)	(0.271)
Specification	OLS	OLS	Negative Binomial	Negative Binomial	OLS
Control variables	Yes	Yes	Yes	Yes	Yes
No of observations	5,872	5,872	5,872	5,872	5,872
Adjusted R_squared	0.36	0.36	NA	NA	0.26
AIC	NA	NA	26927.56	24470.89	NA

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Numbers in parentheses are robust standard errors. (iii) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.

Table 6: Management Scores and Characteristics of Transactional Partners

	Average LP of customers		Average size of customers		Average management scores of customers	
	(1)	(2)	(3)	(4)	(5)	(6)
Management score	-0.076	-0.064	0.835 ***	0.879 ***	0.071 ***	0.072 ***
	(0.066)	(0.066)	(0.162)	(0.160)	(0.015)	(0.015)
TFP	0.219 ***	0.0232 ***	0.085	0.130 **	-0.007	-0.006
	(0.021)	(0.021)	(0.052)	(0.052)	(0.005)	(0.005)
Coefficient of Variation of	1.116 ***	1.082 ***	2.851 ***	2.728 ***	0.078	0.075
Business Expectation	(0.292)	(0.291)	(0.714)	(0.705)	(0.060)	(0.060)
Coefficient of Variation of	-0.00001	-0.00001	-0.0001	-0.0001	0.0001	0.0001
Return on Sales	(0.00004)	(0.00003)	(0.0001)	(0.0001)	(0.00001)	(0.00001)
Number of customers		-0.001 ***		-0.002 ***		-0.00004 ***
		(0.0002)		(0.001)		(0.000002)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
No of observations	4,642	4,642	4,643	4,643	3,088	3,088
Adjusted R_squared	0.15	0.16	0.16	0.18	0.08	0.08

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Coefficients are estimated by OLS. (iii) Numbers in parentheses are standard errors. (iv) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.

Table 7: Characteristics and Churning of Transactional Partners

	Average LP of transactional customers		Average size of transactional partners customers	
	(1)	(2)	(3)	(4)
Add dummy	-0.609 ***		-1.560 ***	
	(0.094)		(0.264)	
Add dummy x management score	-0.017		0.201	
	(0.027)		(0.225)	
Add dummy x TFP	0.071 ***		0.067	
	(0.021)		(0.052)	
Drop dummy		-0.543 ***		-1.125 ***
		(0.100)		(0.245)
Drop dummy x management score		-0.021		0.425 **
		(0.082)		(0.204)
Drop dummy x TFP		0.074 ***		-0.018
		(0.023)		(0.056)
Control variables	Yes	Yes	Yes	Yes
No of observations	9,976	9,976	10,206	10,206
Adjusted R_squared	0.15	0.12	0.14	0.12

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Coefficients are estimated by OLS. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.

Table 8: Interaction Effects of Uncertainty with Management Scores and TFP

Dependent variable:	Degree Centrality Measure		Page Rank Centrality Measure	
	1	2	3	4
CV of Business Expectation	-4.137 ***	-40.673 ***	-3.689 ***	-32.086 ***
	(0.630)	(2.300)	(0.726)	(2.421)
Management score x	7.175 ***		4.484 ***	
CV of Business Expectation	(1.181)		(1.327)	
TFP x		8.941 ***		6.828 ***
CV of Business Expectation		(0.538)		(0.552)
Management score		0.920 ***		0.684 ***
		(0.091)		(0.099)
TFP	0.862 ***		0.675 ***	
	(0.039)		(0.039)	
Controls	Yes	Yes	Yes	Yes
No of observations	4,674	4,674	4,674	4,674
Adjusted R_squared	0.51	0.55	0.46	0.48

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Coefficients are estimated by OLS. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.

Figure 1A: Transaction Patterns: Geographical Locations

Figure 1B: Transaction Patterns: Industries

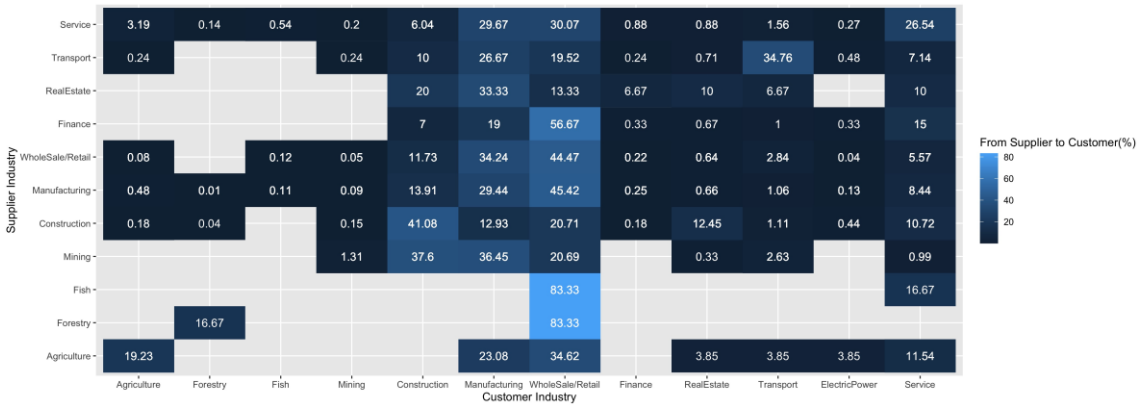


Figure 1C: Transaction Patterns: Size and Labor Productivity

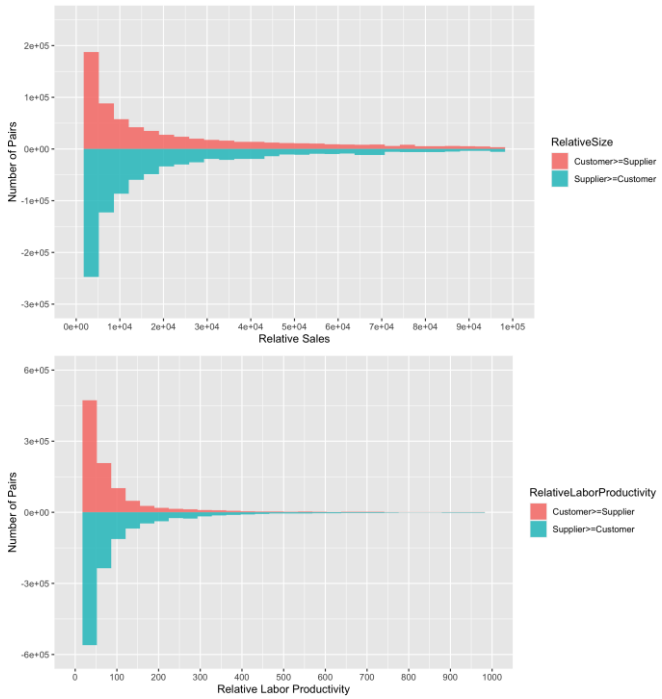
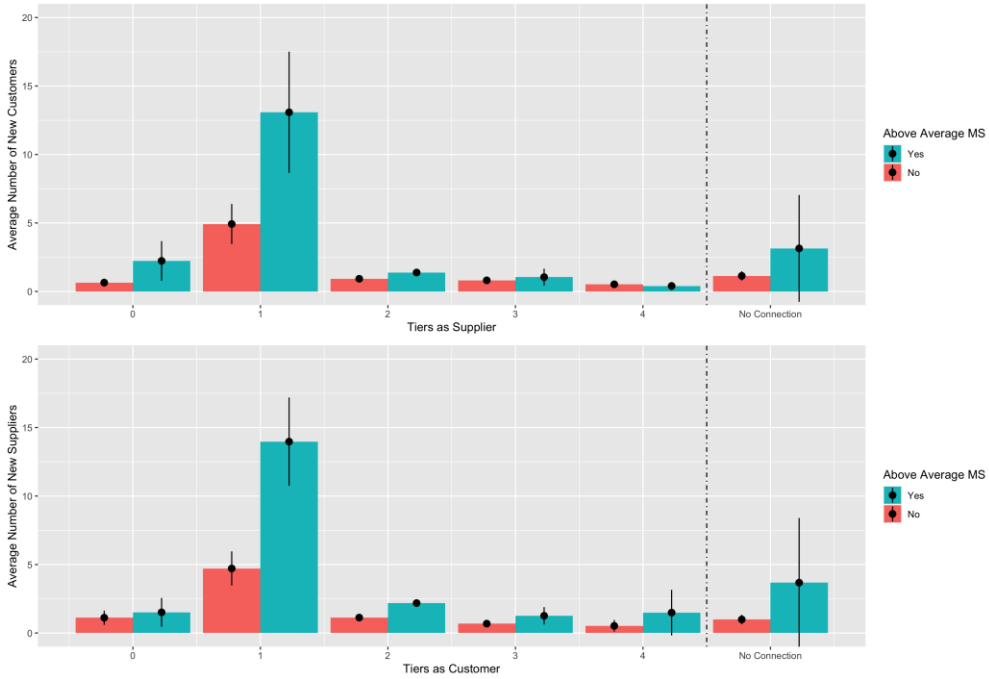


Figure 2

Panel A: Number of New Transaction Partners



Panel B: Number of Terminated Transaction Partners

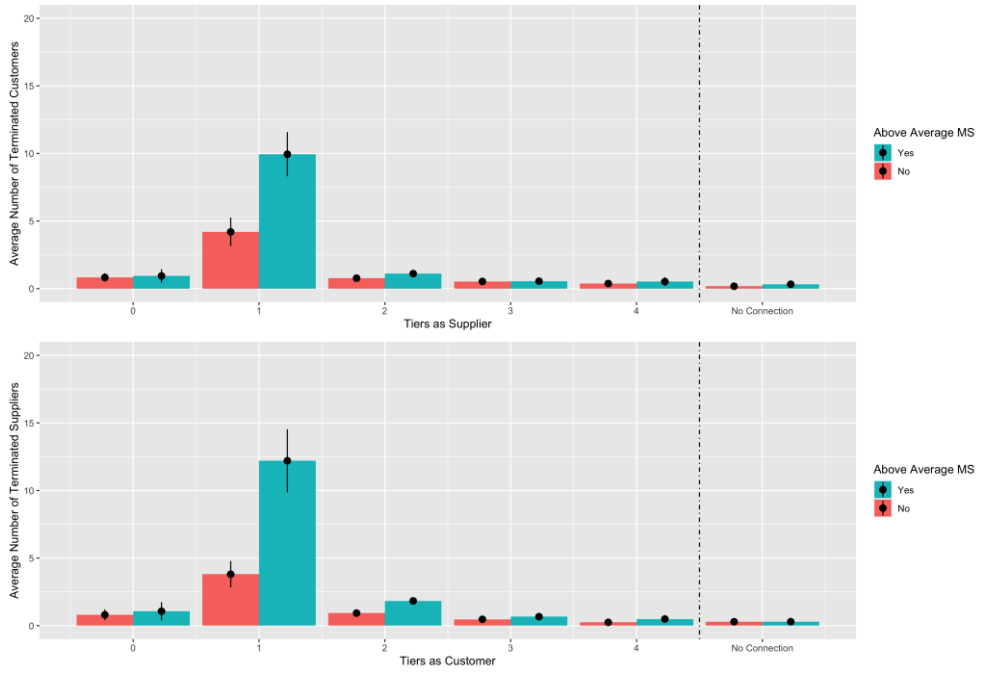


Figure 3A: Added and Dropped Products

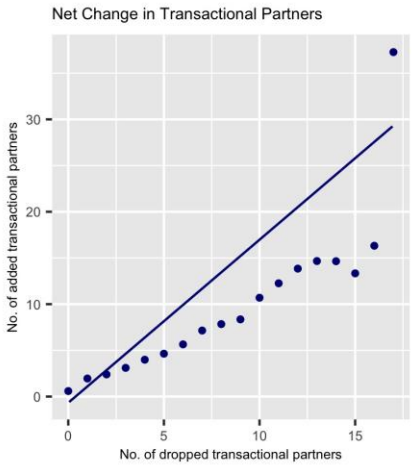


Figure 3B: Added and Dropped Products – Management Scores

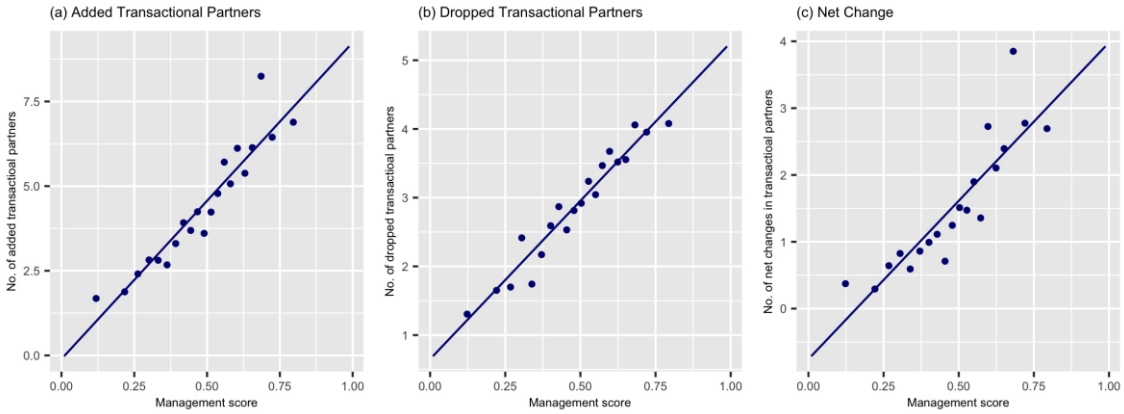


Figure 3C: Added and Dropped Products – TFP

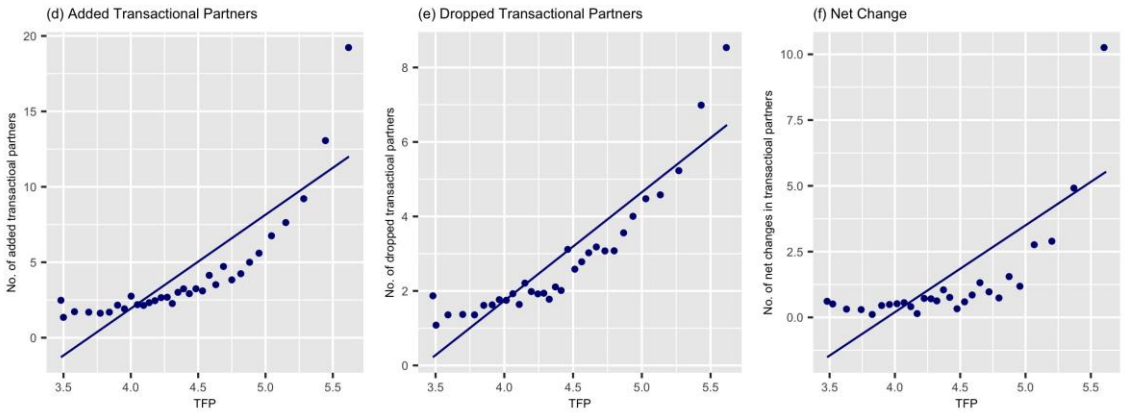
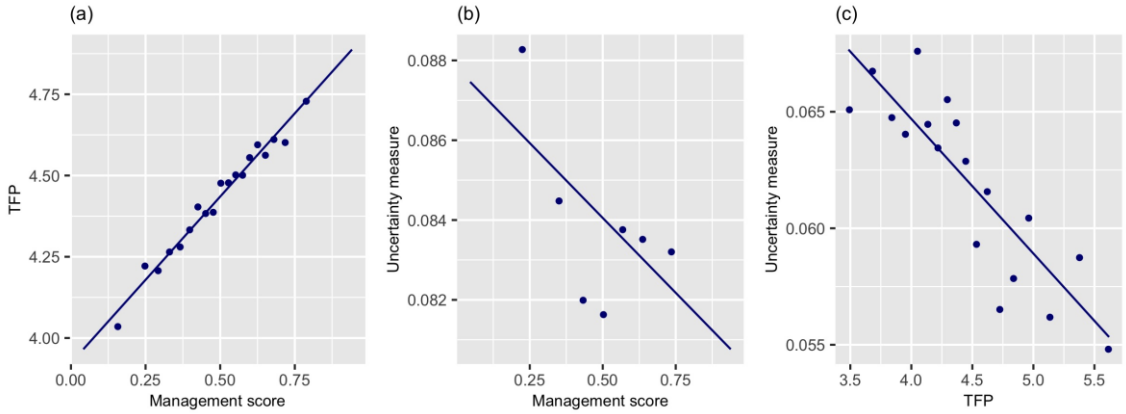


Figure 4: Management Scores, TFP, and Uncertainty



Appendix

Table A.1: Definition of Main Variables

Variable	***Description***
Management Score	Average of scores from the 16 management practice questions in MOPS.
TFP	Total factor productivity estimated using value-added, number of employees and fixed capital.
Coefficient of Variation of Business Expectation	Probability weighted average of each establishment's business expectation about its future values of shipments in 2018(Coefficient of Variation).
Coefficient of Variation of Return on Sales	Volatility of historical Return on Sales(Coefficient of Variation).
Specialization Ratio	Percentage of customers such that the focal firm does not trade within the same industry as the customer.
Number of Employees	Number of all employees.
Firm Age	Number of years established(If it is a missing value, use the number of years in business).
Degree centrality	Number of direct transaction partners.
Page rank centrality	Page rank centrality measure calculated from the transaction network in 2015.
Terminated Customers	Number of transactional customers in a firm's set of transactional partners in the year 2011 but not in that set in the year 2012.
Add	Number of transactional partners not in a firm's set of transactional partners in the year 2010 but in that set in the year 2018.
Drop	Number of transactional partners in a firm's set of transactional partners in the year 2015 but not in that set in the year 2018.
Net Change	Add minus Drop.
Average LP of customers	Average labor productivity of transactional customers.
Average size of customers	Average sales of transactional customers.
Tier 0 shock dummy	Dummy that takes on the value of one if the location of a firm's head office is one of the regions stricken by the earthquake and the value of zero otherwise.
Tier 1 supplier (customer) shock dummy	Dummy that takes on the value of one if at least one of firm's transactional supplier (customer) locates its headquarters in one of the regions stricken by the earthquake and zero otherwise.
Noise Control	Discrepancy in actual values of shipment reported between Japanese Manufacturing Census and JP MOPS

Table A2: Partial Correlation between Management Scores, TFP and Uncertainty

	1. CV of Business Expectation	2. TFP
Management score	-0.013 ***	0.884 ***
	(0.003)	(0.042)
TFP	-0.006 ***	
	(0.001)	
Coefficient of Variation of		-1.155 ***
Business Expectation		(0.191)
Control variables	Yes	Yes
No of observations	5,095	5,095
Adjusted R_squared	0.08	0.30

Notes: (i) JP MOPS and TDB transaction data are used. (ii) Coefficients are estimated by OLS. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in t-test for coefficients; *<10% , **<5% and ***<1%.