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Paired but separately persistent: contractual obligations and supplier technology transfer in Vietnamese manufacturing

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Abstract

Supplier relationships transmit technology to manufacturers in developing economies. Contracts with international input suppliers often pair an obligation on the buyer to invest in equipment, information systems or staff training with technical assistance from the supplier. Firm surveys that record both can be used to identify knowledge-transfer linkages, yet whether such reports signal continuing support, rather than a one-off arrangement, has received little attention. We develop a framework in which obligations and assistance can be paired because adaptation raises the value of support or because high-value transactions attract both. We examine its implications using Vietnam's Technology and Competitiveness Survey linked to enterprise accounts for 1,867 manufacturers. Within a year, obligations and assistance are strongly paired: firms reporting an investment obligation are 45–50 percentage points more likely to report receiving technology transfer, mostly through intentional, contract-based support. Over time, the two reports follow separate paths. Each recurs on its own, and a model allowing separate persistence fits the data better than the stationary shared-state benchmark. Once past assistance is known, an earlier obligation adds little reliable information about later assistance, and this small association is sensitive to modest reporting error. Subsequent research and development and process-modification outcomes are too imprecise to resolve meaningful differences. Co-reported obligations and support describe how technology sourcing is organised in a given year; they do not establish a continuing learning relationship. Buyers should specify continuing support directly, linkage programmes should track repeat assistance, and surveys should record supplier identity and timing.

Keywords: technology transfer; supplier relationships; contractual obligations; survey measurement; Vietnamese manufacturing.

JEL classification: D22; F14; O14; O33.

1. Introduction

Manufacturers in developing economies acquire much of their production knowledge from the firms they trade with. Theory explains why a trading partner would part with knowledge: when better production by one firm raises the value of the exchange to the other, transferring know-how can pay (Pack & Saggi, 2001). The empirical record agrees. Domestic firms linked to foreign affiliates through supply chains show productivity gains (Javorcik, 2004; Blalock & Gertler, 2008), and firm-to-firm transaction data show lasting improvements in performance after domestic suppliers begin selling to multinationals (Alfaro-Ureña et al., 2022). Most of this evidence follows knowledge from buyers to suppliers. Knowledge also travels the other way, from an input supplier to the manufacturer that uses the input, when machinery, components or materials arrive with installation advice, operating instructions or training.

Direct evidence on such flows comes mainly from firm surveys. Survey responses can classify a firm as linked to a supplier and as receiving technology through that link, which allows direct transfers to be separated from spillovers inferred from foreign presence in an industry (Newman et al., 2015). Interviews with linked firms identify recognised knowledge transfers as one channel through which international relationships support learning (Newman et al., 2020). The same instruments often record the terms of the exchange, including whether a supplier contract obliges the buyer to invest. An annual report of this kind describes a relationship at one point in time. Whether it also signals assistance that continues into later years is a different question, and it matters to anyone who treats a reported link as evidence of an ongoing learning relationship. This paper asks what co-reported supplier obligations and technology transfer reveal beyond the year in which they are reported: whether they signal continuing assistance and, with the precision the data allow, whether they precede the buyer's own technological activity.

An investment obligation and supplier assistance can appear together in the same year for several reasons. Adaptation by the buyer may make assistance more valuable to the supplier. Firms may select transactions in which both investment and support pay off. An enterprise may also report an obligation from one supplier and assistance from another. Each account can produce a positive same-year association, but the accounts differ in what they imply for later years. Adapted equipment can keep its value in a continuing exchange, transaction opportunities can change, and suppliers enter and leave the portfolio. Once a firm's previous receipt of assistance is known, the relevant question is how much more an earlier obligation says about later assistance. A transfer report can recur year after year while the obligation adds little to its prediction. Because the survey covers the enterprise's whole portfolio of international suppliers, recurrence means repeated receipt by the manufacturer, possibly from different suppliers.

Vietnamese manufacturing is a useful setting for this question. Links to foreign-owned suppliers are associated with productivity gains among domestic manufacturers (Newman et al., 2015), and import competition improves domestically supplied inputs and raises productivity downstream (Newman et al., 2023). Earlier work on Vietnam shows that the history of a trading relationship carries information about cooperation between firms, through its connection with trade credit (McMillan & Woodruff, 1999). For the manufacturers we study, imported inputs average 60.5 percent of all inputs (Table 1), so international supplier relationships are a large part of how they produce.

We use Vietnam's Technology and Competitiveness Survey (TCS), linked to enterprise accounts from the Vietnam Enterprise Survey (VES). TCS asks separately about investment obligations and inward technology transfer, and records supplier numbers, source countries, contract duration and the share of imported inputs. Comparable questions in 2010 and 2011 let us follow

both reports for the same 1,867 enterprises in 40 provinces. The accounts supply size controls and later measures of capital stock, revenue and employment, and the technology module records research and development (R&D) and modification of production technology. Later rounds change the questions, and we analyse them under their own definitions.

Within each original year we compare transfer between enterprises that do and do not report an obligation. We then relate the earlier obligation to later transfer, first on its own and then with previous transfer added, on the same enterprises. Two exercises ask how much the remaining association depends on how well previous transfer is measured: one imposes reporting error on that history and the other calibrates an omitted factor to it. A held-out prediction exercise asks whether the obligation improves forecasts of later transfer. We also examine all sixteen combinations of the two reports across the two years, estimate how each original report predicts each later one, and compare two models of their joint movement. In the first, a single shared opportunity drives both reports; in the second, each report persists on its own. For R&D and production modification we report base rates and minimum detectable effects (MDEs) next to the estimates.

Same-year pairing is strong. Firms reporting an obligation are 44.8 percentage points more likely to report transfer in 2010 and 50.5 points more likely in 2011, and most of the paired assistance is described as intentional (Table 2; Supplement S3). The association between the 2010 obligation and 2011 transfer is 29.2 points, and it falls to 11.2 points once 2010 transfer is controlled on the same enterprises. What remains is fragile. With 2.5 percent symmetric error imposed on previous transfer, the estimate falls to 7.3 points with an interval of −0.5 to 15.1; at 5 percent it is 1.6 points (Table 5). Adding the obligation barely improves out-of-sample prediction of later transfer.

Each report, by contrast, recurs strongly. Holding the other report fixed, an earlier obligation report is associated with a 38.4-point higher probability of a later one, and earlier transfer with a 39.8-point higher probability of later transfer (Table 4). A model in which one shared state drives both reports fits the joint transitions poorly, and a model in which each report persists separately fits them much better (Appendix B). Enterprises repeat the obligation alone, transfer alone or both more often than a single shared process allows, and they switch one report while keeping the other less often. The later questionnaire tells a consistent story. Realised investment reported for 2012 has an association of −1.0 point with transfer in 2013 across 7,379 enterprises. The original 2010 obligation retains a 7.5-point association with 2013 transfer after 2010 transfer is controlled, which fits stable enterprise characteristics that a single year of transfer history captures only in part (Table 6). Estimates for later R&D and modification are imprecise relative to base rates of 8.7–15.1 percent and 5.3–7.0 percent (Table 7).

The paper contributes to three literatures. First, it identifies the additional temporal information in supplier-obligation reports once previous receipt is observed. Existing production-link research separates knowledge received from trading partners from spillovers of foreign presence (Newman et al., 2015) and documents gains after firms join multinational supply chains (Alfaro-Ureña et al., 2022). We show that, once previous receipt is known, a reported obligation says much less about subsequent assistance than its same-year pairing suggests.

Second, the paper relates the governance of knowledge sharing between firms to how arrangements evolve. The relational view treats specific investment and knowledge-sharing routines as sources of rents between firms (Dyer & Singh, 1998). Buyer–supplier evidence links contracts, specific investment and trust to the amount and credibility of transferred knowledge (Liu et al., 2017), and the age of a relationship affects the value and conduct of exchange

(Macchiavello & Morjaria, 2015). We separate the co-occurrence of obligations and assistance from their joint evolution. Our framework shows how complementarity or transaction selection can produce same-year pairing, and the transition evidence favours separate persistence of the reports over the stationary shared-state benchmark.

Third, the paper bears on how technology transfer is measured in enterprise surveys. A report that combines an investment obligation with support describes how sourcing is organised in a given year. Continued support is a separate object, and measuring it requires questions tied to an identified supplier and dated. Section 6.4 sets out what buyers, linkage programmes and survey designers would need to record.

Section 2 develops the framework and hypotheses. Section 3 describes the data and Section 4 the empirical approach. Section 5 presents the results, Section 6 discusses them and Section 7 concludes.

2. Conceptual framework and hypotheses

2.1. Framework

Specific investment changes the value of an exchange and the terms on which firms can sustain it. Transaction-cost theory relates contractual governance to specialised assets and repeated transactions (Williamson, 1979). An investment whose value depends on a particular counterparty creates returns that are exposed to renegotiation once the investment is sunk (Klein et al., 1978). Relational contracting ties cooperation to the value of future business when parts of performance cannot be specified or enforced (Baker et al., 2002), and the information parties hold about a relationship's value can change over time, affecting whether it continues (Halac, 2012). In global value chains, incomplete contracts link suppliers' investment incentives to how

ownership is allocated across stages of production (Antràs & Chor, 2013). Vertical-transfer models give trading partners a reason to share knowledge when one party's better production benefits the other (Pack & Saggi, 2001). We apply these ideas to a manufacturer that receives assistance from an input supplier. Appendix A gives the formal statements and proofs.

The framework separates two decisions. The buyer decides whether to accept an investment obligation, and the supplier later decides whether to provide support. A contract offers the buyer a direct benefit, requires costly adaptation and may attract technical assistance. The buyer accepts when the direct benefit and the expected value of assistance cover the cost of adaptation. Once adaptation is in place it can raise the value that support generates, and a supplier who shares in that value will then provide assistance over a wider range of support costs. Acceptance anticipates assistance, and assistance responds to adaptation (Appendix A1–A2). This complementarity links the two decisions within one occasion of exchange. The survey observes the contractual requirement; the amount of adaptation actually carried out is a separate object in the model.

Selection offers a second route to same-year pairing. Transactions differ in product fit and in the returns they offer each party. If more valuable opportunities raise both the buyer's direct benefit from accepting and the supplier's return to assistance, obligations and support will occur together more often across transactions. This happens even when adaptation has no effect on the supplier's return, provided acceptance and support costs are independent (Appendix Proposition A3). Complementarity changes assistance for a given transaction; selection changes which transactions involve both decisions. Both produce the same positive association.

A persistent opportunity state connects the original occasion to later support. A higher state makes both acceptance and support more likely, and the persistence of the state determines how

much of the original opportunity still matters later. If opportunities persist, an earlier obligation carries information about later assistance through its link to the original state. Previous transfer also reveals that state. After conditioning on receipt, the obligation remains informative only to the extent that the state is still uncertain (Appendix Proposition A4). If the next opportunity is independent of the first, the later contrast is zero even though current pairing is positive. If previous receipt nearly reveals the state, the additional contrast can be small even when opportunities persist. Recurrence of transfer and the extra information in an obligation therefore depend on different features of a firm's history.

Adaptation can also keep its value across occasions. Compatible equipment or skills acquired for one contract may continue to raise the return to support in a continuing exchange. Appendix A3 holds the support environment fixed and lets part of the original adaptation stay useful, which gives a second channel from earlier adaptation to later assistance. How much this channel matters depends on whether adaptation was carried out and remains useful. The survey item, by contrast, records a demand for investment and is partly retrospective in its wording, and later reports also depend on how sourcing arrangements change.

Two features of the data stand between these relationship-level mechanisms and the enterprise reports (Appendix A4–A5). The first is reporting error. Independent errors that do not depend on the other report shrink same-year covariance, while a reporting component shared by both items can add to it. Error in previous transfer matters differently, because it affects the history on which the obligation coefficient is conditioned. The second is aggregation. A manufacturer can face an obligation from one supplier and receive assistance from another. Under an illustrative rule in which a firm reports yes if any relationship qualifies, larger portfolios make both reports more likely even when the two features are unrelated within each relationship. We use supplier-

count controls and a single-supplier comparison to address this composition channel. The later question, which asks about transfer in most contracts, aggregates with a different threshold.

2.2. Hypotheses

We state the research questions as two null hypotheses of no conditional association. The framework supplies positive alternatives under the stated conditions.

Complementarity and selection both predict positive same-year pairing under their maintained conditions. Adaptation raises the supplier's return to support in Proposition A1, and transaction selection produces positive covariance in Proposition A3. Informative reporting with independent errors preserves the sign, and portfolio composition can add to the association at the enterprise level.

Hypothesis 1 (H1, null): There is no contemporaneous association between reported supplier-imposed investment obligations and reported inward technology transfer, conditional on enterprise size, sourcing characteristics, province and industry.

The comparable models for 2010 and 2011 test this association with those adjustments (Table 2). The transfer classifications show whether the assistance paired with an obligation is provided within or outside the legal contract (Supplement S3).

Persistent opportunities imply information over time in addition to current pairing. In Proposition A4, a higher original state raises acceptance and support, and a persistent state carries that information to the next occasion. As long as previous transfer leaves some uncertainty about the state, the obligation has a positive association with later support conditional on previous transfer.

Hypothesis 2 (H2, null): There is no association between supplier-imposed investment obligations reported for 2010 and inward technology transfer reported for 2011, conditional on 2010 transfer and the enterprise controls and fixed effects.

The positive alternative follows from persistence and from acceptance and support probabilities that rise with the state. Its size depends on how persistent opportunities are and how much previous receipt already reveals.

We test H2 by adding previous transfer to the longitudinal model on the same enterprises (Table 2). Models that predict each later report from both original reports separate this cross-item association from the persistence of each report (Table 4). Reporting-error scenarios, omitted-factor calibrations and held-out prediction show how far the association depends on the measured history and whether it improves forecasts (Table 5). The full transition table tests the shared-state restriction using both items in both years (Appendix B). Comparisons in later years keep the later questionnaire's definitions (Table 6). R&D and modification address the second part of the research question, with base rates, intervals and MDEs to show what the data can detect (Table 7).

3. Data and measurement

3.1. Survey setting and coverage

TCS is a manufacturing module attached to the annual enterprise survey conducted by Vietnam's General Statistics Office (GSO). The enterprise survey supplies enterprise characteristics, employment, production and financial accounts, and covers larger enterprises fully while sampling smaller ones (Newman et al., 2017). The GSO, the Central Institute for Economic Management and the Development Economics Research Group at the University of Copenhagen

developed TCS together (Newman et al., 2011). The module covers technology, investment, innovation and relationships with suppliers and customers (UNU-WIDER, n.d.).

Our main analysis uses the questionnaires covering activities in 2010 and 2011, which ask comparable questions about obligations and transfer in international supplier relationships. Throughout the paper, years refer to the activities a questionnaire covers, not the year it was administered. These are the only adjacent rounds in which the original obligation question and the any-transfer question are asked in comparable form. The distinction between current receipt and its recurrence applies beyond these years, although the magnitudes we estimate are specific to them. The cleaned supplier files contain 8,175 enterprises in 2010 and 8,652 in 2011, of which 2,584 and 2,706 name at least one international supplier country. We analyse enterprises that report international sourcing and restrict the sample to those with usable survey answers, account links and covariates. The main estimates describe this selected sample and are unweighted. Supplement S15 reweights the main estimate for inclusion in the panel.

We link the supplier files across years and to the enterprise accounts using province and establishment identifiers. We drop records with missing identifiers, every record sharing a duplicated identifier, and ambiguous account matches. The main longitudinal sample has 1,867 enterprises in 40 provinces. Two of them carry a non-manufacturing main-industry code in the linked accounts; they are not the sample's two state enterprises, and the supplement reports results without them. Tax identifiers agree in 1,859 of the 1,864 linked pairs that have identifiers in both account files. The supplement reports this check together with checks on enterprise names and administrative locations. Which linked enterprises enter the analysis is determined by survey retention and the availability of complete data.

All four original reports are observed for every enterprise in the panel, allowing the common-panel comparisons in Supplement S9 to hold membership fixed. Table 2's larger same-year samples use each year's available respondents. The models that predict each later report use the same baseline controls and the same province and industry effects. The larger same-year samples describe everyone who answered in that year; the panel estimates hold the population fixed for comparisons over time. This matters because retention and missing data can change which enterprises are observed in both years.

Table 1 describes the panel. In 2010, 13.8 percent of enterprises report an obligation and 22.4 percent report transfer; in 2011, 20.8 percent report transfer. The average enterprise has 6.7 international suppliers, but the median has three. Mean contract duration is 8.1 months and the median six. Employment is also widely dispersed, which is why the models control for size and use logged account measures.

The pooled comparisons include state enterprises alongside domestic private and foreign-invested enterprises; the panel contains two state enterprises. Later samples follow the same rule, with coverage set by each questionnaire, the outcomes available and complete data. The ownership comparisons in the supplement drop the state enterprises and compare domestic private with foreign-invested enterprises.

3.2. Obligation and transfer reports

The obligation question asks whether contracts with international suppliers require special investment in production or information technology, infrastructure or staff training. We code yes as one and no as zero, and treat other answers as missing. The question records an obligation. It does not record the amount spent or when. Its wording, "did or do", also admits obligations from

earlier contracts. Even so, 132 of the 257 enterprises that report an obligation in 2010 do not report one in 2011. Changes in the contract portfolio and inconsistent reporting can both produce this turnover.

The transfer question asks whether a relationship with an international supplier results in technology transfer from the supplier to the enterprise. It records receipt of assistance across the enterprise's portfolio of suppliers. Recipients say whether the transfer was intentional and part of the legal contract, intentional but outside the contract, or unintentional. For each type we code receipt as one and no transfer as zero. Recipients who give no type are left missing, which keeps unclassified transfer distinct from no transfer.

The two reports may refer to different suppliers. An enterprise can accept an obligation from one supplier and receive assistance from another, and the transfer question says nothing about the content, quality or amount of assistance. Studies of a single supplier's customers (Balboni et al., 2017) or of matched manufacturer–distributor dyads (Li et al., 2017) observe the exchange itself. Our data instead observe obligations and assistance across a portfolio, together with measures that describe its composition.

The baseline sourcing measures are the share of imported inputs, the number of international suppliers, the number of named source countries and average contract duration. Source countries show where inputs come from. A measure of sourcing history records the time since imports from a named country began, which may span several suppliers. These measures describe the portfolio and its history. They do not show whether a particular supplier contract continued.

A same-year accounting check gives weak, positive support for reading the obligation item as investment-related (Supplement S14). It compares the 2011 reports with the change in machinery stock within 2011. The check concerns what the item measures; it does not validate the 2010

obligation that enters the main models. Enterprises reporting both items in 2011 have 4.8 log points higher growth in gross machinery stock than enterprises reporting neither (95% interval 0.6 to 9.1), and enterprises reporting only an obligation have 5.3 log points higher growth (−0.4 to 11.1). The Holm-adjusted p-values are .051 and .067. Obligations appear to accompany some real capital accumulation, but at the adjusted threshold the evidence is weak.

3.3. Later questionnaires

The later questionnaires change both the investment question and the transfer threshold. The 2009 questionnaire, which we use for earlier history, asks whether most long-term supplier contracts include transfer, without distinguishing domestic from international suppliers. The 2012 and 2013 questionnaires ask whether the enterprise makes specific investments for a long-term contractor, again pooling domestic and international suppliers, and whether most contracts with international or foreign suppliers include transfer. Investment therefore changes from an obligation to an investment actually made, and transfer changes from any international relationship to most contracts.

We follow the 2010 obligation into the later transfer reports for 1,757 enterprises in 2012 and 1,730 in 2013. A separate comparison relates investment in 2012 to transfer in 2013 for 7,379 enterprises, using the later questionnaire throughout. Table 6 reports each estimate with its sample and history control.

Supplement Tables S2b and S2c give the definitions, coding and exact wording of each item in the English versions of the questionnaires. The 2012 transfer question refers to "international suppliers" and the 2013 question to "foreign suppliers". A report of any transfer and a report of transfer in most contracts cannot be converted into each other, because enterprises differ in

supplier numbers and in the importance of each contract. An investment that was made can also differ from one that was required. We therefore treat the later estimates as investment–transfer comparisons under a related, not identical, questionnaire.

3.4. Technological activity

The surveys record R&D and modification of production technology separately in 2010–2013. R&D means undertaking research and development, and modification means adapting existing production or process technology. Each model of a later activity controls for the same activity in 2010.

The technology-transfer literature uses broader measures of acquired knowledge and its use. Hsiao et al. (2017) measure acquired knowledge by its contribution to technology, products, human resources and innovation time. Wang et al. (2013) follow innovation after knowledge is licensed. Adomako and Nguyen (2024) measure the intensity of technology transfer in Vietnamese collaborations with a broader scale that includes contact with university researchers. Our R&D and modification measures are narrower. We interpret them with their prevalence and the precision of the estimates in view.

4. Empirical approach

4.1. Same-year and longitudinal comparisons

We estimate linear probability models with province and two-digit industry fixed effects. The main longitudinal specification is

$$T_{i1} = \alpha + \beta R_{i0} + \rho T_{i0} + X_{i0}'\lambda + \mu_p + \eta_j + u_i. \qquad (1)$$

Here R_{i0} is the 2010 obligation report, T_{i0} is 2010 transfer and T_{i1} is 2011 transfer. The baseline controls are log sales, log employment, log(1 + contract duration), log(1 + number of

international suppliers), the number of named source countries and the imported-input percentage. The coefficient β is the association between the earlier obligation and later transfer, holding previous transfer and the observed characteristics fixed.

The same-year models relate the obligation to transfer reported in the same year. For the longitudinal comparison we first estimate equation (1) without previous transfer and then add it on the same sample, which isolates what the obligation adds once previous receipt is known. An extended specification adds ownership, exporter status and prior sales growth, and is compared with the base specification on the same observations so that the effect of the controls is not confused with a change in sample. Each later comparison uses the previous-transfer question and controls available in its questionnaire.

Coefficients are differences in the probability of reporting transfer, in percentage points: an 11.2-point estimate is a fitted difference of 0.112. Standard errors are clustered by province, and confidence intervals use degrees of freedom based on the number of clusters. The main panel has 40 provinces and the larger later samples have 63. Each table row reports its sample size and number of clusters.

The coefficients are conditional associations in observational data. As Appendix A shows, transaction quality can affect both obligations and assistance, and earlier transfer can itself reflect adaptation or selection. Conditioning on earlier transfer defines the comparison we report. Fixed effects, size and sourcing controls account for observed differences between enterprises; complementarity and selection both remain possible explanations of what is left.

4.2. Transitions, selection and prediction

Table 3 reports how each report changes between years and the 2011 transfer rate for each combination of 2010 reports, with province-bootstrap intervals. Supplement Table S8 reports all sixteen joint cells. These transitions describe change within enterprises, while the regressions adjust comparisons between enterprises for observed characteristics.

We examine selection through survey retention and the availability of complete data, and check the consistency of links using tax identifiers, normalised names and administrative locations. The supplement reports the restrictions and the comparisons on common samples.

To assess prediction, we compare a model containing previous transfer and the baseline controls with one that also includes the obligation, using five-fold cross-validation repeated twenty times. Folds are assigned by enterprise, and every training set contains each represented province and industry and has full rank. Both models predict transfer for the same held-out enterprises. We clip fitted probabilities to the unit interval and average each enterprise's losses across repetitions. The Brier score is the mean squared error of the predicted probabilities, so lower is better. A province bootstrap refits both models to measure uncertainty, holding the folds fixed.

The analysis is exploratory. The models in Table 4, the panel contrasts and four-state transitions in Supplement S9–S10, the subtype and prior-activity comparisons in Supplement S3 and S7c, and the accounting comparisons and coverage check in Supplement S11–S14 were added during the analysis. Holm adjustments apply within the stated families of tests. The three predictions about ownership were recorded after we had seen the original ownership split and the pooled models for later years.

4.3. Sensitivity to measurement and omitted information

A yes or no report of previous transfer may capture only part of an enterprise's sourcing history. If so, the obligation may pick up persistent features of its transactions that the report misses. We use the partial-R^2 framework of Cinelli and Hazlett (2020) to ask how strong an omitted factor would have to be to change the conclusion. The scenarios calibrate the omitted factor to the explanatory power of previous transfer, size or sourcing characteristics, and we report the strength that would reduce the main estimate to zero if the factor were equally associated with the obligation and with later transfer.

A second exercise imposes reporting error on previous transfer. We fix sensitivity and specificity, assume errors that are constant and unrelated to the other variables, and correct the regression moments accordingly, setting the second moment of each binary variable equal to its mean. We keep only scenarios that produce valid moment matrices and feasible corrected cell probabilities. Intervals use a province-clustered sandwich estimator. With no imposed error this estimator gives an interval slightly different from the main fixed-effects estimator; Table 5 shows the difference.

Where error enters matters. Under Appendix Proposition A5, independent errors shrink same-year covariance. Error in the previous-transfer control works differently: it can raise or lower the association attributed to the obligation, and there is no general attenuation result for that coefficient. The scenarios therefore concern how history is measured. A reporting component shared by the two items could affect same-year covariance, as the broader model in the appendix allows.

4.4. Later activities and the model check

Each model of a later activity includes the 2010 obligation, 2010 transfer, the same activity in 2010, the baseline controls and province and industry effects, so the obligation and transfer coefficients come from one specification. We report each activity's prevalence and confidence intervals together with approximate MDEs at 80 percent power. The MDEs use the clustered standard error and a two-sided 5 percent test, and describe the precision of the design. The supplement adds equivalence tests at margins of ±2 and ±5 points.

We fit the stationary two-state model of Appendix A to the sixteen-cell table of obligation and transfer reports. To use the obligation reports from both years, we add to Proposition A4 an obligation probability for the later year that is the same as in the first. The six parameters are the share of enterprises in the high state, two obligation probabilities, two transfer probabilities and the persistence of the state. We compare the model's likelihood with that of the saturated table and report the fitted persistence and the conditional contrasts it implies. Because the fit uses cell counts without covariates, it tests different restrictions from equation (1). We then fit a model in which each report follows its own transition process, with an association between the two reports in each year, and compare the two by the Akaike and Bayesian information criteria (AIC and BIC).

4.5. Persistence of each report

We compare each report's persistence with its association with the other report. The model for the later obligation mirrors equation (1):

$$R_{i1} = \alpha_R + \beta_R R_{i0} + \rho_R T_{i0} + X_{i0}'\lambda_R + \mu_{Rp} + \eta_{Rj} + v_i. \qquad (2)$$

Here β_R is the association between the earlier and later obligation, conditional on previous transfer and the controls, and ρ_R is the additional association with previous transfer. In equation (1), ρ is the persistence of transfer and β its association with the earlier obligation. We report the four coefficients together with province-clustered intervals and a Holm adjustment across the four tests. Because the two items differ in prevalence and meaning, the coefficients describe how reports carry over, not how reliable each report is.

Both models use the same panel, controls and fixed effects. We also re-estimate same-year pairing in each year on the panel with the baseline controls, and use paired province resamples to measure the difference between each same-year estimate and the longitudinal estimate. This holds the sample and controls fixed while comparing same-year and later information; conditioning on previous transfer remains part of the longitudinal comparison.

We summarise the joint reports in four states: neither, obligation only, transfer only and both. Each row of the transition matrix gives the probabilities of the 2011 states for enterprises in a given 2010 state. Intervals come from 1,999 province resamples that recompute each row's denominator; the paired contrasts use 1,999 resamples with the same province weights for every coefficient. To check whether the results depend on any one province, we drop each province in turn, and we repeat both models for manufacturing enterprises only.

An AI assistant supported manuscript development and analytical coding. The authors remain responsible for the analysis, interpretation and final text.

5. Results

5.1. Same-year pairing

Enterprises reporting an obligation are far more likely to report transfer in the same year: the adjusted differences are 44.8 points in 2010 and 50.5 in 2011 (Table 2). The province-clustered intervals rule out small differences. The samples have 2,284 and 2,672 enterprises, since an enterprise can answer in one year without appearing in the next. We reject the null of H1 in both years.

Most of the paired assistance is intentional. For transfer within the legal contract the adjusted differences are 31.2 points in 2010 and 35.5 in 2011, and for intentional transfer outside the contract they are 12.7 and 14.3. Estimates for unintentional transfer are below one point, with intervals that include zero (Supplement S3). Manufacturers that face obligations mostly describe the assistance they receive as deliberately provided, inside or outside the contract.

Complementarity and transaction selection in Appendix A can each produce this pattern. Adaptation can make support more valuable, and valuable transactions can attract both obligations and assistance. The enterprise reports show that the two occur together across the sourcing portfolio, not which mechanism is at work.

5.2. The association over time and turnover in reports

Controlling for previous transfer lowers the association between the 2010 obligation and 2011 transfer from 29.2 to 11.2 points on the same enterprises (Table 2), with an interval of 4.8 to 17.7. The extended controls give 10.7 points on 1,831 enterprises; the supplement reports the comparison on the same sample. Most of the initial association overlaps with what previous transfer already tells us.

Raw rates show how much previous receipt matters (Table 3). Among enterprises with no transfer in 2010, 10.0 percent report transfer in 2011 if they reported no obligation and 21.5 percent if they did. Among 2010 recipients the rates are 51.0 and 62.2 percent. The obligation separates later receipt within both groups, but previous transfer separates the groups by much more.

The share reporting an obligation barely changes between the years, yet individual reports change a great deal. Of 257 enterprises reporting an obligation in 2010, 125 report one again and 132 do not; another 133 report one for the first time. The 2011 total is 258, and 48.6 percent of 2010 reporters report again. For transfer, 232 of 419 recipients in 2010 report receipt again and 187 do not. Supplement Table S8 shows how these changes combine across the two items.

The gap between same-year and later information remains when the sample and controls are held fixed. On the panel, same-year pairing is 45.0 points in 2010 and 46.2 in 2011, with intervals of 37.5 to 52.5 and 41.9 to 50.6. These exceed the 11.2-point longitudinal estimate by 33.7 and 35.0 points, with paired bootstrap intervals of 23.7 to 45.8 and 27.3 to 41.6 (Supplement S9). The gap is therefore not an artefact of the larger same-year samples.

Table 4 shows where the persistence lies. The 2010 obligation is associated with a 38.4-point higher probability of reporting an obligation in 2011, conditional on 2010 transfer and the controls (interval 30.9 to 45.9). The 2010 transfer report is associated with a 39.8-point higher probability of transfer in 2011, conditional on the 2010 obligation (29.9 to 49.8). Both survive the four-test Holm adjustment. The associations across items are smaller: 2010 transfer is associated with a 3.7-point higher probability of a later obligation (1.1 to 6.3), and the 2010 obligation with the 11.2-point higher probability of later transfer reported above (4.8 to 17.7).

Both are positive and survive the adjustment. Each report persists strongly; each adds much less to the prediction of the other.

Figure 2 shows the four-state transitions. Of the 164 enterprises reporting both items in 2010, 74 report both again, a retention rate of 45.1 percent (interval 36.6 to 52.9). Of the rest, 28 report transfer only, seven an obligation only and 55 neither, so the joint state leads to several different later arrangements. Of the 93 enterprises reporting only an obligation, 34 stay in that state; of the 255 reporting only transfer, 108 do. These retention rates of 36.6 and 42.4 percent (intervals 28.6 to 46.9 and 35.6 to 49.6) are the repeated single-item states that the shared-state model underpredicts.

Continuing a report is much more common than starting one. An obligation recurs for 48.6 percent of 2010 reporters, while 8.3 percent of non-reporters begin reporting one. Transfer recurs for 55.4 percent of 2010 recipients, while 10.8 percent of non-recipients begin receiving it (Supplement S10). Stable overall prevalence is thus the sum of many recurring reports and a smaller flow of changes.

No single province drives these estimates. Dropping one province at a time, the persistence coefficient for the obligation ranges from 35.8 to 40.6 points and that for transfer from 37.3 to 44.8. The cross-item coefficients stay positive in every case, between 9.6 and 14.0 points for obligation to transfer and between 3.1 and 4.2 for transfer to obligation. Dropping the two enterprises with non-manufacturing industry codes changes no coefficient by more than 0.1 point (Supplement S10).

Two further checks leave the picture unchanged. An exploratory comparison of contractual and extra-contractual transfer finds no reliable difference in how the obligation predicts each (Supplement S3). Reweighting the panel by the inverse probability of inclusion, predicted from

observed baseline characteristics, gives an obligation coefficient of 11.0 points, close to the unweighted estimate (Supplement S15).

5.3. How much the obligation adds

The remaining association depends heavily on how previous transfer is measured (Table 5). With 1 percent symmetric error imposed on previous transfer, the estimate is 9.8 points. With 2.5 percent error it is 7.3 points, with an interval of −0.5 to 15.1, and with 5 percent error it is 1.6 points, with an interval of −8.4 to 11.6.

The omitted-factor calibrations point the same way. A factor as strong as previous transfer gives −6.6 points, with an interval that includes zero, whereas factors as strong as size or sourcing leave 11.0 and 10.8 points. A factor explaining 9.4 percent of the residual variation in both the obligation and later transfer would remove the estimate. Adding the 2009 transfer report barely changes the estimate on the smaller sample for which it is available. The association survives adjustment for observed characteristics but not stronger assumptions about unobserved history.

The obligation also adds little to prediction. Including it lowers the held-out Brier score from 0.13312 to 0.13176. The improvement of 0.00136 has a bootstrap interval of −0.00006 to 0.00329. A positive coefficient in the estimation sample thus coexists with a small and uncertain gain for enterprises outside it. Figure 1 places the same-year estimates, the longitudinal estimates and the measurement scenarios side by side.

We therefore reject the null of H2 in the main specification, but the rejection is fragile. The 11.2-point association is no longer statistically significant once 2.5 percent symmetric error is allowed in previous transfer, and it does not reliably improve prediction.

The stationary two-state model with a single shared process fits the sixteen joint cells poorly, with a likelihood-ratio (LR) statistic of 162.4 on nine nominal degrees of freedom. It predicts too few repeated reports of the obligation alone, of transfer alone and of both items, and too many switches of one item while the other stays positive. Appendix B reports the full fit and the contrasts it implies. Given the poor fit, the model cannot serve as an account of the observed transitions.

A model in which each report follows its own transitions does much better (Appendix Table B2). With seven parameters, it lets each report have its own transition probabilities and allows the two reports to be associated within each year. Its LR statistic against the saturated table is 60.3, compared with 162.4 for the shared-state model. Its AIC is lower by 100.1 points, with a province-bootstrap interval of 17.8 to 221.4, and it is lower in 998 of 999 resamples. The model reproduces the repeated single-item states and the switches of one item, although it still predicts too few enterprises that report both items in both years. The data thus support separate persistence of the two reports over a single shared process, with some departures from this simple model remaining.

5.4. Later questionnaires

Same-year associations remain large in the later questionnaires, at 33.5 points in 2012 and 27.3 in 2013 (Table 6). The association between investment in 2012 and transfer in 2013, conditional on 2012 transfer, is −1.0 point, with an interval of −5.6 to 3.7, across 7,379 enterprises in 63 provinces. In this comparison, investment reported under the later question carries little detectable information about next-year transfer. The supplement reports smaller samples restricted to enterprises with long-term international suppliers.

The 2010 obligation is associated with a 5.4-point higher probability of transfer in 2012 (interval −0.3 to 11.1) and a 7.5-point higher probability in 2013 (3.5 to 11.5; Holm p = .002). The positive 2013 estimate and the near-zero 2012–2013 estimate use different investment questions and condition on transfer histories from different years.

The ownership interaction in the original comparison is 14.2 points among domestic private and foreign-invested enterprises, with a Holm p-value of .238. None of the three recorded predictions of a larger association among foreign-invested enterprises is supported, with Holm p-values of 1.000 (Supplement S4).

5.5. Later technological activity

All twelve intervals in the activity models include zero (Table 7). R&D prevalence ranges from 8.7 to 15.1 percent and production modification from 5.3 to 7.0 percent, so uncertainty of a few percentage points is large relative to how often these activities occur.

For R&D in 2011, the obligation coefficient is 2.5 points, with an interval of −2.3 to 7.4 and an MDE of 6.9 points; the upper end of the interval is almost half the 15.1 percent base rate. For modification, the estimate is 1.6 points with an interval of −1.5 to 4.6, against a base rate of 7.0 percent. Neither comparison can rule out increases that would matter economically.

In later years the MDEs for the obligation are 3.6 to 5.3 points for R&D and 3.7 to 3.9 for modification, and the transfer coefficients are similarly imprecise. The equivalence tests generally fail at the narrow margin and sometimes pass at the wide one (Supplement S7); since the wide margin is large relative to the activities' prevalence, these tests describe precision rather than show the absence of an effect. The data say little about whether obligations or assistance are followed by more R&D or modification.

Interactions between previous transfer and prior activity give no reliable evidence that assistance matters more for firms already doing R&D or modification (Supplement S7c). Capital stock, revenue and employment outcomes are also imprecise (Supplement S11).

6. Discussion

6.1. Pairing and the organisation of exchange

Strong same-year pairing describes how sourcing is organised across enterprises, and its concentration in intentional assistance ties the reported obligations to support that suppliers provide deliberately. The relational view distinguishes specific investment from knowledge sharing (Dyer & Singh, 1998), and research on buyer–supplier governance studies how the two are coordinated (Liu et al., 2017). Our evidence shows them occurring together at the enterprise level and follows assistance into later years. The model explains how complementarity or transaction selection could produce the pairing. Work on early supplier involvement treats cooperation between buyers and suppliers as suppliers' participation in manufacturers' product development and innovation (Bidault et al., 1998), which places assistance within the organisation of production knowledge across firm boundaries.

Supplier-level studies observe the exchange directly. Balboni et al. (2017) examine knowledge acquisition among the customers of one identified supplier, and Liu et al. (2017) use matched reports from buyers and suppliers to separate contractual from relational governance and to measure the amount and credibility of transferred knowledge. TCS instead records the receiving enterprise's answers across all its input suppliers, so an obligation from one supplier can sit alongside assistance from another. The aggregation example in Appendix A5 shows that variation in the number of relationships alone can produce a positive association at the enterprise

level. Reading the pairing as a feature of single transactions would require linking each obligation and each instance of assistance to the same exchange.

The intentional-transfer categories help with interpretation. Most of the same-year association concerns assistance described as provided within or outside the legal contract, which tells us how manufacturers see the provision of assistance. These categories are consistent with the model's support decision, in which the supplier's return can rise with adaptation or with transaction value. Liu et al. (2017) measure governance instruments and knowledge outcomes separately; the categories here describe the arrangement through which assistance arrives. The coexistence of obligations and intentional assistance gives the association economic content without telling us which of the model's channels produces it.

6.2. Transitions and information over time

The joint transitions show why a same-year association is a poor summary of persistence. The shared-state model predicts too few repeated reports of the obligation alone, of transfer alone and of both, and too many switches of one item while the other stays positive. How strongly an item persists is a different matter from how much its pairing with the other item reveals. The longitudinal regressions measure the association between the obligation and later transfer given previous transfer; held-out prediction asks whether the obligation improves forecasts for other enterprises.

The age of a relationship can matter for its value. In Kenyan rose exports, older relationships were more valuable and suppliers in them responded differently to a supply shock (Macchiavello & Morjaria, 2015). Our evidence concerns reports, not relationships. Each report is strongly predicted by its own history, and each adds less to the prediction of the other. The cross-item

coefficients remain positive, so there is some information across items over time, and they measure how much one yes or no history adds once the other is known.

The four-state transitions concentrate continuity in repeated single-item and joint states, more than the shared-state model allows (Appendix B). Three explanations fit this pattern to different degrees. The framework allows retained adaptation to raise the return to later support. The retrospective obligation item leaves the persistence of implemented adaptation unobserved; the conditional association with later transfer is smaller than current pairing and sensitive to assumed reporting error (Tables 4 and 5). If supplier portfolios are stable, both reports should recur, and larger portfolios allow obligations and assistance to arise in different exchanges. The positive association among single-supplier enterprises and the uncertain interaction with diversification suggest that portfolio size is not the whole story (Supplement S5). If respondents interpret each question consistently from year to year, answers to each item should repeat, which also fits the persistence of each report and the repeated single-item states (Table 4; Supplement S10).

The positive association between the 2010 obligation and 2013 transfer belongs to the same pattern: an early obligation report still says something about a later transfer report once early transfer is controlled. The near-zero 2012–2013 comparison answers a different question, with investment actually made, a most-contracts threshold for transfer and a more recent history. Taken together, the estimates show that the conditioning history and the wording of the questions shape the answer. Over one year, the obligation carries less additional information once previous transfer is controlled; the three-year comparison also retains a positive conditional association.

Technology-transfer research measures access, implementation and outcomes in different ways. Studies of transfer performance in alliances (Hsiao et al., 2017), of innovation after licensing (Wang et al., 2013) and of collaboration between organisations (Adomako & Nguyen, 2024)

concern different stages and channels. Connecting supplier reports to that research requires knowing who provides assistance, who receives it, when, and how the survey defines receipt. Our results show that these details change what the reports can tell us.

6.3. Assistance and its use

Receiving assistance, putting it into practice and undertaking new technological activity are different stages. Our activity estimates cannot rule out economically meaningful differences (Table 7). Direct knowledge links, better inputs and changes in the mix of inputs are associated with productivity gains (Newman et al., 2015, 2023), and recorded R&D captures only a narrow part of what assistance might change. Productive use of assistance is a separate outcome that needs its own measurement.

6.4. Implications for managers, policy and surveys

For buyers, an investment obligation is weak evidence that assistance will continue. Once previous receipt is controlled, the obligation adds 11.2 percentage points to the probability of transfer in the next year, and the interval includes zero under an assumed scenario with 2.5 percent symmetric reporting error in previous receipt (Tables 2 and 5). Buyers who need continuing support should specify its content and timing in the contract rather than infer it from the obligation.

Linkage programmes can distinguish enterprises newly reporting assistance from those reporting it again. Transfer recurs for 55.4 percent of earlier recipients, while 10.8 percent of earlier non-recipients begin receiving it (Supplement Table S10b). Counting these two groups separately would describe both the reach and the continuity of supplier support better than a single annual count of recipients.

Survey designers should keep separate, consistently worded questions on obligations and on assistance. Both reports persist strongly (Table 4), and the transition table contains repeated obligation-only, transfer-only and joint states (Table 3; Supplement S8). Dating each report and linking it to a named supplier would allow later rounds to tell an enterprise's history apart from continuity within a particular exchange.

The same point applies to the Community Innovation Survey and similar innovation surveys that summarise cooperation by partner category across the firm. The Oslo Manual recognises categories of suppliers and the need to identify a knowledgeable respondent to coordinate answers, while allowing information to come from several people in the firm (OECD/Eurostat, 2018). The distinction between current reporting across a portfolio and recurrence with the same supplier should carry over to such surveys, although our coefficients, the sensitivity to reporting error and the relative fit of the two models depend on item wording, reference periods and sourcing conditions in Vietnam. A minimal redesign would record a supplier identifier, the start date of the obligation and whether assistance recurred from the same supplier.

6.5. Scope and limitations

The estimates are conditional associations in selected survey samples from more than a decade ago. Linkage and the requirement of complete data determine coverage, and a repeated enterprise identifier does not show that the same suppliers continued. The association between the 2010 obligation and 2013 transfer may reflect stable enterprise characteristics or continuing relationships, and one year of transfer history cannot separate the two. The retrospective wording of the obligation question leaves its timing unclear, and both changes in relationships and inconsistent reporting may contribute to turnover. Later questionnaires change the investment question and the transfer threshold.

The two-state benchmark imposes stationarity and conditional independence together. Its residuals are consistent with persistence specific to each item, but they do not identify what produces it, and the chi-square reference for the LR statistic ignores clustering by province. The reporting-error rates and omitted-factor strengths are assumptions for sensitivity analysis, not estimates. The prediction exercise evaluates held-out enterprises from provinces and industries represented in the training data. R&D and modification are particular activities and leave wider assimilation and routine use of assistance unobserved.

Growth in gross machinery stock is an accounting measure of capital accumulation, not investment spending, since acquisitions, disposals and revaluations all change recorded stock. The obligation question neither dates implementation nor identifies spending for a particular supplier. The same-year check therefore offers weak corroboration of the item's meaning, not direct validation of adaptation.

The released files do not identify respondents or record changes of respondent between years. Consistent answering by the same respondent therefore remains an alternative explanation for the persistence of each report (Podsakoff et al., 2003).

7. Conclusion

Supplier obligations and technology transfer are strongly paired within a year in Vietnamese manufacturing, but the pairing says little about later assistance. Controlling for previous transfer cuts the association between an obligation and next-year transfer from 29.2 to 11.2 points, and what remains depends on how accurately previous transfer is reported and does not reliably improve prediction. Each report persists strongly on its own, and a model allowing separate persistence fits the joint transitions better than the stationary shared-state benchmark.

The later questionnaires give a near-zero association between investment in 2012 and transfer in 2013, while the 2010 obligation keeps a positive association with 2013 transfer. Estimates for later R&D and modification are too imprecise to rule out meaningful differences. Current pairing, the persistence of each report and the information one report adds about the other are different quantities, and studies that use supplier-transfer indicators should report them separately. Establishing whether supplier support continues, and whether it changes what manufacturers do, requires data that follow identified suppliers over time and measure the use of assistance directly.

Statements and Declarations

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This research received no external funding.

Competing interests

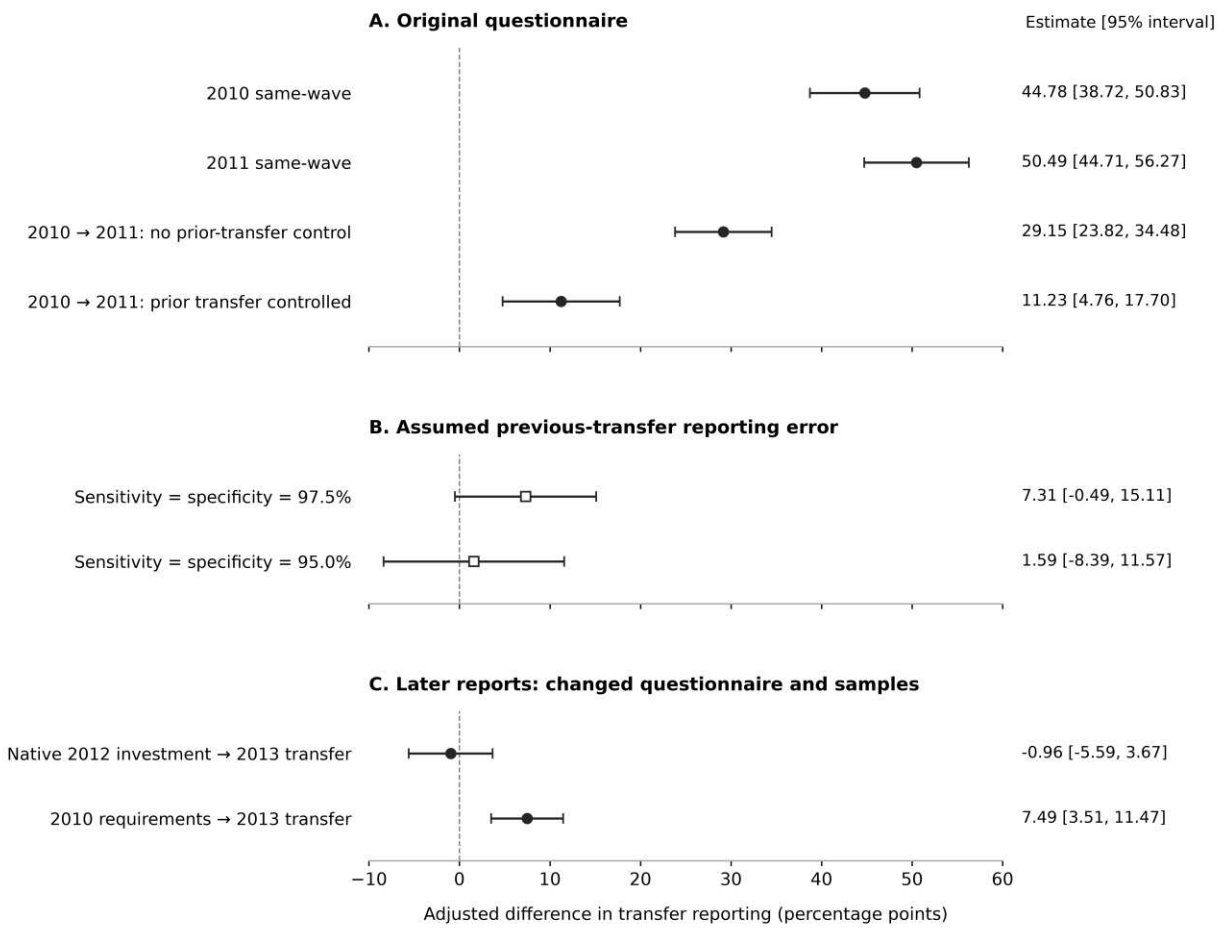
The authors declare no competing interests.

Data availability

Replication code, aggregate outputs and reproduction instructions will be supplied as Electronic Supplementary Material once accepted. Enterprise microdata and prepared enterprise panels are not redistributed due to contract and confidentiality. The UNU-WIDER Viet Nam data page (https://www.wider.unu.edu/database/viet-nam-data) provides TCS documentation and questionnaires and directs requests for TCS microdata to Vietnam's national statistical office. Enquiries about access to the VES accounts should also be directed to the National Statistics Office of Vietnam (https://www.nso.gov.vn/); access and permitted use are determined by the

data provider. Researchers with authorised access can reproduce the analysis using the supplied instructions. The latent-model fits use the aggregate transition table reported in the supplement.

Figure 1. Coefficient profile

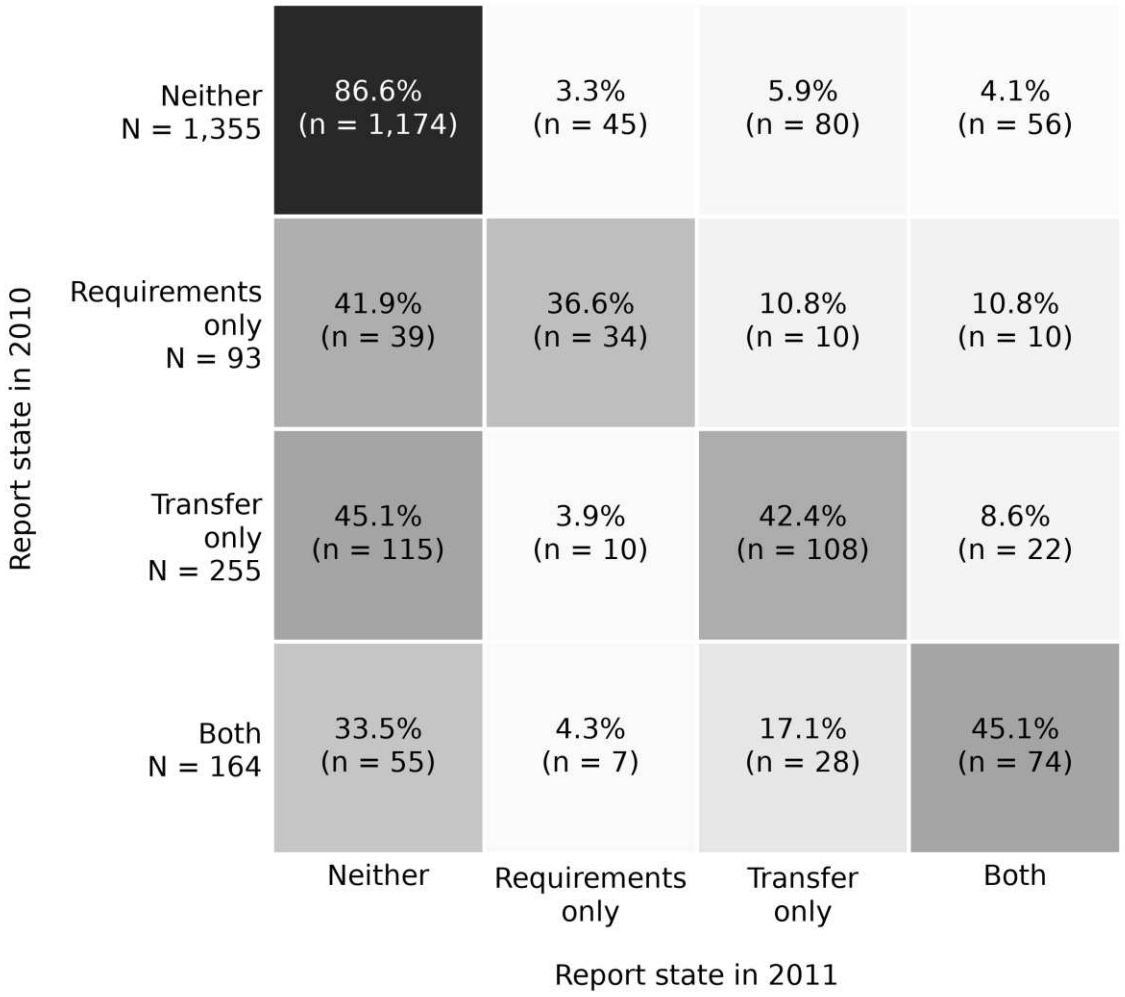


Same-wave, longitudinal and sensitivity estimates

Figure 1. Same-wave pairing, longitudinal associations and measurement scenarios.

Points are adjusted differences in supplier-transfer reporting, in percentage points. Filled circles show observational estimates; bars show 95% province-cluster confidence intervals. Open squares show model-based intervals under assumed independent nondifferential previous-transfer errors, with sensitivity and specificity fixed at the displayed values; these rates are not estimated. Panel A uses the original questionnaire: same-wave samples contain 2,284 and 2,672 enterprises, and the two longitudinal specifications use the same 1,867 enterprises. Panel B retains that longitudinal sample. Panel C uses 7,379 enterprises for the later-questionnaire 2012–2013 comparison and 1,730 for the original-requirements-to-2013 comparison, both controlling previous transfer. The later questionnaire measures realised contractor-specific investment and transfer for most contracts; the original items concern required investment and any international supplier transfer. All pooled samples retain eligible state enterprises. Specifications and source estimates are reported in Tables 2, 5 and 6.

Figure 2. Joint report-state transitions



Joint report-state transitions

Figure 2. Report-state transitions within the original enterprise panel. Rows show the original report state and columns the next-wave state. Each cell gives its share of the original-state row and its enterprise count. Row denominators are shown at left; percentages within each row sum to 100 apart from rounding. The same 1,867 enterprises are observed in both waves, including the two state enterprises. All sixteen cells are retained. Darker cells indicate larger row probabilities; the printed values make the display interpretable in grayscale. These are transitions between enterprise reports, without identifying continuity of a particular supplier. Supplement S10 reports province-bootstrap intervals for every cell.

Table 1. Pooled longitudinal-sample characteristics

Variable	N	Mean	SD	Median
Requirements, 2010	1867	13.77	34.46	0.00
Supplier transfer, 2010	1867	22.44	41.73	0.00
Supplier transfer, 2011	1867	20.78	40.59	0.00
Employment	1867	274.00	685.02	66.00
Contract duration (months)	1867	8.09	7.10	6.00
International suppliers	1867	6.68	21.82	3.00
Named sourcing countries	1867	2.12	0.88	2.00
Imported input share (%)	1867	60.47	30.33	65.00

Binary-item statistics are percentages; other statistics use the indicated units. The pooled sample includes eligible state enterprises as well as domestic non-state and foreign-invested enterprises.

Table 2. Same-wave pairing and the original longitudinal association

Comparison	Adjusted difference (pp) [95% CI]	N	Province clusters
2010 same-wave pairing	44.78 [38.72, 50.83]	2284	44
2011 same-wave pairing	50.49 [44.71, 56.27]	2672	43
2010 → 2011, without previous transfer	29.15 [23.82, 34.48]	1867	40
2010 → 2011, previous transfer controlled	11.23 [4.76, 17.70]	1867	40
2010 → 2011, extended controls	10.66 [3.96, 17.37]	1831	40

Province-cluster confidence intervals. Same-wave samples use each wave's available adjusted sample; longitudinal estimates use the indicated panel sample. Extended controls add ownership, exporter status and prior growth. State firms remain eligible throughout.

Table 3. Pooled report transitions, 2010–2011

Panel A. Marginal transitions

Report	0 → 0	0 → 1	1 → 0	1 → 1
Requirements	1477	133	132	125
Transfer	1292	156	187	232

Panel B. Later transfer conditional on baseline reports

Transfer, 2010	Requirement, 2010	N	Transfer reporters, 2011	Transfer rate, 2011 (%) [95% CI]
0	0	1355	136	10.04 [7.68, 12.29]
0	1	93	20	21.51 [11.63, 32.73]
1	0	255	130	50.98 [43.07, 60.17]
1	1	164	102	62.20 [56.96, 70.37]

Raw rates with province-bootstrap intervals. Among 257 baseline requirements reporters, 125 report requirements again and 132 switch off; 133 switch on. The next-wave total is 258, and positive-report retention is 48.64%. All 1867 pooled enterprises have the two requirement items. State enterprises are included.

Table 4. Own-report persistence and additional cross-item information

Later report	Original report	Adjusted difference (pp) [95% CI]	Holm p	N
Requirements, 2011	Requirements, 2010	38.39 [30.93, 45.85]	<.001	1867
Requirements, 2011	Transfer, 2010	3.70 [1.13, 6.28]	0.006	1867
Transfer, 2011	Requirements, 2010	11.23 [4.76, 17.70]	0.002	1867
Transfer, 2011	Transfer, 2010	39.85 [29.85, 49.84]	<.001	1867

Both models include both original reports, the six baseline size/sourcing covariates and province and two-digit industry effects. Each uses the same 1,867 enterprises in 40 provinces and retains eligible state enterprises. Intervals use province-cluster standard errors and cluster degrees of freedom. Holm adjustment covers the four displayed exploratory coefficients. Differences describe conditional report probabilities; the own-item and cross-item coefficients do not measure supplier survival or relative reporting reliability.

Table 5. Measurement, omitted-variable sensitivity and prediction

Diagnostic	Estimate [95% interval, where available]	Units / interval	N
Prior-transfer sensitivity = specificity = 1.000	11.23 [4.69, 17.77]	pp; model-based scenario interval	1,867
Prior-transfer sensitivity = specificity = 0.990	9.82 [2.86, 16.79]	pp; model-based scenario interval	1,867
Prior-transfer sensitivity = specificity = 0.975	7.31 [-0.49, 15.11]	pp; model-based scenario interval	1,867
Prior-transfer sensitivity = specificity = 0.950	1.59 [-8.39, 11.57]	pp; model-based scenario interval	1,867
Omitted factor calibrated to previous transfer	-6.58 [-18.54, 2.76]	pp; province-bootstrap interval	1867
Omitted factor calibrated to size	11.02 [4.65, 16.82]	pp; province-bootstrap interval	1867
Omitted factor calibrated to sourcing	10.79 [4.09, 16.67]	pp; province-bootstrap interval	1867
Equal-strength residual R^2 removing point estimate	9.40	Percent in each of requirement and outcome	1867
Brier prior transfer and controls	0.13312 [0.11798, 0.15258]	Squared-probability loss	1867
Brier add requirements	0.13176 [0.11788, 0.15032]	Squared-probability loss	1867
Brier improvement	0.00136 [-0.00006, 0.00329]	Squared-probability loss	1867

Misclassification scenarios assume independent nondifferential error in the previous-transfer item; they do not estimate error rates. The no-error scenario uses the sensitivity procedure's own covariance estimator, so its interval differs slightly from Table 2. Omitted-factor calibration uses the partial-R^2 sensitivity calculation of Cinelli and Hazlett (2020). Brier intervals use a 499-draw province-weight bootstrap refitting both models, conditional on the selected 20 repetitions of five folds. State enterprises are included.

Table 6. Pooled comparisons using later supplier reports

Comparison	Adjusted difference (pp) [95% CI]	N	Province clusters	Holm p
2012 same-wave realised investment and transfer	33.53 [27.57, 39.50]	7756	63	<.001
2013 same-wave realised investment and transfer	27.31 [22.69, 31.93]	7818	63	<.001
2010 requirements → 2012 international transfer	5.38 [-0.33, 11.09]	1757	40	0.128
2010 requirements → 2013 international transfer	7.49 [3.51, 11.47]	1730	39	0.002
Later questionnaire: 2012 investment → 2013 transfer	-0.96 [-5.59, 3.67]	7379	63	0.679

Longitudinal models control previous transfer. The later instrument measures realised contractor-specific investment across domestic/international contracts and transfer for most contracts; the 2010 instrument measures required investment in international sourcing and any international transfer. These comparisons therefore use changed definitions. Holm adjustment uses a seven-contrast later-wave family, including two international-long-term-supplier restrictions shown in the supplement. State enterprises remain eligible.

Table 7. Subsequent technological activities and the scale of uncertainty

Year	Activity	Predictor	Adjusted difference (pp) [95% CI]	Base rate (%)	Approx. 80% MDE (pp)	N	Province clusters	Holm p
2011	R&D	Previous requirements	2.52 [-2.32, 7.36]	15.10	6.86	1867	40	1.000
2011	R&D	Previous transfer	-0.22 [-2.92, 2.48]	15.10	3.82	1867	40	1.000
2011	Production-technology modification	Previous requirements	1.57 [-1.48, 4.62]	6.96	4.32	1867	40	1.000
2011	Production-technology modification	Previous transfer	1.39 [-2.12, 4.90]	6.96	4.97	1867	40	1.000
2012	R&D	Previous requirements	-1.09 [-3.62, 1.43]	9.20	3.57	1760	40	1.000
2012	R&D	Previous transfer	0.14 [-3.24, 3.52]	9.20	4.79	1760	40	1.000
2012	Production-technology modification	Previous requirements	-0.19 [-2.83, 2.45]	5.28	3.74	1760	40	1.000
2012	Production-technology modification	Previous transfer	1.05 [-1.04, 3.13]	5.28	2.95	1760	40	1.000
2013	R&D	Previous requirements	1.71 [-2.01, 5.43]	8.67	5.27	1731	39	1.000
2013	R&D	Previous transfer	0.03 [-3.94, 4.00]	8.67	5.62	1731	39	1.000
2013	Production-technology modification	Previous requirements	1.25 [-1.52, 4.01]	6.30	3.92	1731	39	1.000
2013	Production-technology modification	Previous transfer	-0.93 [-4.09, 2.23]	6.30	4.47	1731	39	1.000

Each additive model includes requirements, previous transfer, previous corresponding activity and the original controls/fixed effects. MDEs are approximate two-sided 5%-level, 80%-power differences from the fitted cluster standard error; they describe attainable precision rather than post-hoc observed power. The 12-term Holm family is retained. State enterprises remain eligible.

Appendix A. Contractual adaptation, supplier support and reported persistence

The model distinguishes specific adaptation and knowledge sharing (Dyer & Singh, 1998), and receipt from application (Cohen & Levinthal, 1990). Sections A1–A2 set out support and acceptance. Section A3 derives selection and prospective information; A4–A5 address observation and portfolio composition; A6 maps these objects to the empirical comparisons. Appendix B reports the aggregate stationary-model fit.

A1. Transaction and implementation

A manufacturer chooses a contract with requirement $r \in \{0,1\}$ at private cost kr, $k \geq 0$. Type q describes product fit and exchange value. Implemented adaptation is $x = gr$, $g \geq 0$; a survey obligation does not observe g. Support generates value $G(r,q) = a(q) + bgr$, where $a(q), b \geq 0$. The customer receives share $\theta \in (0,1)$ and direct benefit $v(q)r$; the supplier receives the remaining share and pays support cost c. Cost has a common cdf H across contracts and types, and is independent of k conditional on q. Expected customer payoff is

$$U(r,q) = [v(q) - k]r + \theta G(r,q)p(r,q). \qquad \text{(A1)}$$

These are contracting and support stages within an occasion, rather than survey dates.

A2. Support and requirement acceptance

Proposition A1. Complementarity. Supplier support probability is

$$p(r,q) = H((1-\theta)[a(q) + bgr]). \qquad \text{(A2)}$$

Hence $p(1,q) \geq p(0,q)$, strictly if $bg > 0$ and costs have positive mass between thresholds. **Proof:** support pays when $c \leq (1-\theta)G(r,q)$; integrate over H.

Proposition A2. Acceptance. The customer accepts the requirement if and only if

$$k \leq v(q) + \theta\{[a(q) + bg]p(1,q) - a(q)p(0,q)\}. \qquad \text{(A3)}$$

Proof: subtract $U(0,q)$ from $U(1,q)$. Expected assistance enters contract selection as well as responding to adaptation. The menu and return share are fixed; neither an offer mechanism nor bargaining is estimated.

A3. Pairing and information across support opportunities

Selection benchmark

Proposition A3. Pairing without complementarity. Set $b = 0$, let k be independent of scalar q with cdf J, and let $a(q)$ and $v(q)$ be nondecreasing. Then requirement acceptance and support have nonnegative covariance, strictly positive when both probabilities vary together over types. **Proof:** acceptance probability is $J(v(q))$, support probability $H((1-\theta)a(q))$, and their conditional covariance is zero by cost independence. For an independent copy q',

$$2\mathrm{Cov}(f(q), h(q)) = E[(f(q) - f(q'))(h(q) - h(q'))] \geq 0, \qquad \text{(A4)}$$

where $f = J \circ v$ and $h = H \circ [(1-\theta)a]$ are nondecreasing. This case generates pairing through transaction selection while leaving support unchanged by the requirement at a fixed type.

The subscripts 0 and 1 below identify original and subsequent support occasions, not the contracting and support stages within an occasion.

Let $Q_0 \in \{0,1\}$ denote the relationship opportunity state at the original survey date, with $P(Q_0 = 1) = \pi \in (0,1)$. The higher state offers greater direct value from accepting an investment obligation and greater value from supplier support. In the sorting benchmark of Proposition A3, these values yield

$$P(r_0 = 1 \mid Q_0 = q) = \alpha_q, \qquad P(s_0 = 1 \mid Q_0 = q) = \mu_q, \quad 0 < \alpha_0 < \alpha_1 < 1, \quad 0 < \mu_0 < \mu_1 < 1. \qquad \text{(D1)}$$

The requirement choice r_0 and original support s_0 are conditionally independent given Q_0. This follows from independent adaptation and support costs in the zero-complementarity benchmark. Write $\Delta\alpha = \alpha_1 - \alpha_0$ and $\Delta\mu = \mu_1 - \mu_0$. The opportunity state evolves according to

$$P(Q_1 = 1 \mid Q_0 = q) = \pi + \phi(q - \pi), \qquad 0 \leq \phi \leq 1. \qquad \text{(D2)}$$

The process has stationary marginal probability π. At $\phi = 1$ the original state is retained; at $\phi = 0$ the next state is an independent draw. Subsequent support satisfies $P(s_1 = 1 \mid Q_1 = q) = \mu_q$. Conditional on Q_0, the transition innovation is independent of original requirement and support choices, and conditional on Q_1, the subsequent support-cost innovation is independent of the original history. Thus

$$E[s_1 \mid Q_0 = q] = \mu_0 + \Delta\mu\{\pi + \phi(q - \pi)\}. \qquad \text{(D3)}$$

Proposition A4. Contemporaneous pairing and prospective support. Under (D1)–(D3),

$$\mathrm{Cov}(r_0, s_0) = \pi(1-\pi)\Delta\alpha\Delta\mu > 0, \qquad \mathrm{Cov}(r_0, s_1) = \phi\pi(1-\pi)\Delta\alpha\Delta\mu. \qquad \text{(D4)}$$

For an original support realization $t \in \{0,1\}$, define

$$\pi_t = P(Q_0 = 1 \mid s_0 = t) = \frac{\pi\mu_1^t(1-\mu_1)^{1-t}}{\pi\mu_1^t(1-\mu_1)^{1-t} + (1-\pi)\mu_0^t(1-\mu_0)^{1-t}}, \qquad A_t = \alpha_0 + \Delta\alpha\pi_t. \qquad \text{(D5)}$$

Then the subsequent-support contrast conditional on original support is

$$E[s_1 \mid r_0 = 1, s_0 = t] - E[s_1 \mid r_0 = 0, s_0 = t] = \phi\Delta\mu\,\frac{\pi_t(1-\pi_t)\Delta\alpha}{A_t(1-A_t)}. \qquad \text{(D6)}$$

Proof. Conditional independence in (D1) makes the conditional covariance of r_0 and s_0 zero. Their conditional means are $\alpha_0 + \Delta\alpha Q_0$ and $\mu_0 + \Delta\mu Q_0$. Taking their covariance proves the first expression in (D4). Equation (D3) and independence of the subsequent innovation give the second. Bayes' rule gives (D5). Given $s_0 = t$, the requirement remains a conditionally independent signal of Q_0, so

$$P(Q_0 = 1 \mid r_0 = 1, s_0 = t) = \frac{\pi_t\alpha_1}{A_t}, \quad P(Q_0 = 1 \mid r_0 = 0, s_0 = t) = \frac{\pi_t(1-\alpha_1)}{1-A_t}.$$

Subtracting gives $\pi_t(1-\pi_t)\Delta\alpha/[A_t(1-A_t)]$. The conditional mean in (D3) varies with Q_0 by $\phi\Delta\mu$, yielding (D6). ▫

The result separates original pairing from the persistence of opportunities. Requirements and support can be strongly paired at the original date while the requirement adds little information about subsequent support when the opportunity state changes rapidly. At $\phi = 0$, the subsequent contrast is zero even though the original covariance is strictly positive. When $\phi > 0$, an imperfectly informative original support realization leaves residual information about relationship type in the requirement choice. In the limiting case where original support perfectly reveals Q_0, π_t is zero or one and the conditional prospective contrast is zero. These are distinct routes to a weak prospective comparison: little persistence of opportunities, or little additional information once original support is known.

This benchmark imposes no sign reversal: with the stated monotonicity assumptions its population prospective contrasts are nonnegative. It therefore explains how positive contemporaneous pairing can coexist with weak prospective information, rather than explaining any negative estimate as a structural prediction. Changes in survey wording or relationship composition require a further observation model. The empirical comparison remains an enterprise-level projection, not a direct estimate of ϕ or equation (D6).

Retained implementation as a separate channel

The sorting benchmark isolates persistence of opportunities. Complementary adaptation can also retain value in a continuing exchange. If the originally implemented amount is $x_0 = gr_0$ and fraction $\delta_t \in [0,1]$ remains useful, then, holding the support environment fixed,

$$p_t(r_0, q) = H((1-\theta)[a(q) + b\delta_t g r_0]). \qquad \text{(D7)}$$

The support increment associated with $r_0 = 1$ weakly increases with δ_t. This follows directly from the monotonicity of H and $b, g \geq 0$. It is a conditional structural comparison: changes in supplier identity, baseline support value or support-cost distribution can change the surrounding environment, and conditioning on earlier support creates a different empirical comparison.

A4. Binary reporting and observed pairing

Proposition A5. Reporting and observed pairing. Distinguish true binary requirement and support states r, s from their reports R, S. Let $f_R = P(R = 1 \mid r = 0)$ and $u_R = P(R = 1 \mid r = 1)$ be the false-positive rate and sensitivity of requirement reporting. Define f_S, u_S analogously and $\kappa_R = u_R - f_R$, $\kappa_S = u_S - f_S$. Suppose each report's conditional distribution depends only on its corresponding true state, and the reports are independent conditional on (r, s). Then

$$E[R \mid r, s] = f_R + \kappa_R r, \qquad E[S \mid r, s] = f_S + \kappa_S s, \qquad \mathrm{Cov}(R, S) = \kappa_R \kappa_S \mathrm{Cov}(r, s). \qquad \text{(M1)}$$

Under independent nondifferential errors with informative reports, $0 < \kappa_R, \kappa_S \leq 1$, equation (M1) weakly attenuates same-wave covariance. It cannot inflate that covariance. Within this observation model, inflation requires a shared conditional reporting component, represented by (M2); differential reporting would instead violate the maintained affine conditional means. This statement concerns covariance, not the coefficient of a regression conditioning on an error-prone previous report.

Proof. The law of total covariance decomposes report covariance into covariance of the two conditional means and mean conditional covariance. Conditional report independence sets the latter to zero. Substituting the affine conditional means yields (M1). ▫

If the affine conditional means hold but report errors share a conditional component, the identity becomes

$$\mathrm{Cov}(R,S) = \kappa_R \kappa_S \mathrm{Cov}(r,s) + E[\mathrm{Cov}(R,S \mid r,s)]. \qquad \text{(M2)}$$

A common reporting component can therefore contribute to observed pairing. Differential reporting, whose conditional means depend on both true states or on ownership, requires a richer model. Equations (M1)–(M2) define assumptions under which reports map into the economic mechanism; they do not assign error rates to this survey. Agreement or positive-item retention across years combines changing true states with measurement and cannot identify sensitivities or false-positive rates without validation information.

A5. From relationships to enterprise portfolios

The original survey records enterprise-level reports of contractual requirements and transfer from international suppliers. To isolate portfolio composition, consider a stylised any-report aggregation example with N relationships: $R = \max_j r_j$ and $T = \max_j s_j$. This illustrative rule describes one possible way to aggregate relationship reports. Under this rule, co-occurrence does not require that the same relationship supplies both features.

Proposition A6. Portfolio composition can generate pairing. Portfolio size alone can generate positive covariance in a simple benchmark. Suppose requirements and support are independent within and across relationships conditional on N, with constant probabilities π_R and π_T, both strictly between zero and one. Then

$$E[R \mid N] = 1 - (1-\pi_R)^N, \qquad E[T \mid N] = 1 - (1-\pi_T)^N. \qquad \text{(P1)}$$

Conditional independence implies $\mathrm{Cov}(R,T \mid N) = 0$. Both probabilities in (P1) rise with N, so the same covariance identity used in Proposition A3 gives $\mathrm{Cov}(R,T) \geq 0$, with strict positivity when portfolio size varies. This benchmark isolates a composition effect without within-relationship complementarity.

Supplier-count adjustment addresses this observed component of composition. Unobserved supplier quality, input complexity and contract combinations can remain. A single-supplier comparison reduces the opportunities for cross-relationship pairing, although its enterprises can still select into different types and contracts. The later question about whether *most* supplier contracts include transfer uses a different portfolio threshold from the original any-transfer report. The questionnaire leaves the weighting of contracts of different importance unspecified. It therefore describes a different portfolio outcome even if relationship-level support probabilities remain unchanged.

A6. Model-to-evidence mapping

Table A1. Theoretical objects and empirical comparisons

Model object or implication	Empirical comparison	Interpretation
Contractual obligation and implemented adaptation	Original requirements report	Obligation is observed; implemented amount and compliance are not measured
Support choice, Proposition A1	Same-wave requirement–transfer association	Complementarity can generate pairing at a given transaction type
Contract selection, Propositions A2–A3	Same-wave pairing and sourcing controls	Selection also generates pairing without a direct adaptation effect
Opportunity persistence, Proposition A4	Earlier requirements and later transfer, with previous transfer controlled	Assesses additional information in an earlier report; does not estimate the state-persistence parameter
Binary reporting, Proposition A5	Prior-transfer misclassification scenarios and item transitions	Evaluates specified observation assumptions; turnover does not identify error rates
Portfolio composition, Proposition A6	Supplier-count controls and single-supplier comparisons	Addresses observable composition without reconstructing a matched supplier dyad
Changed observation rule	Later-questionnaire investment–transfer comparison	Exposure scope and transfer threshold change; this is not an identical repeated measure

The adjusted regression coefficients are enterprise-level projections. Proposition A4 describes a conditional transaction-level contrast under a specified state process, and Proposition A5 describes covariance under an observation process. Neither quantity equals the regression

coefficient generally. The main regressions do not estimate transition or reporting-error parameters. Appendix B fits the separately specified stationary aggregate benchmark and assesses its fit against the complete observed table.

Appendix B. Aggregate fit of the stationary two-state benchmark

The fit uses the 16 observed cells in Supplementary Table S8, N=1,867. To model both requirement occasions it adds stable requirement emissions to Proposition A4: conditional on latent state q, requirements have probability α_q and transfer probability μ_q at both occasions. Emissions are independent conditional on state; the transition follows (D2), with stationary state prevalence π. The six parameters are estimated by multinomial likelihood under $\alpha_1 \geq \alpha_0$, $\mu_1 \geq \mu_0$ and $0 \leq \varphi \leq 1$. The restrictions and original table were recorded before fitting.

Table B1. Fitted parameters and fit diagnostics

Quantity	Estimate
pi	0.287529
alpha_0	0.016613
alpha_1	0.438514
mu_0	0.024840
mu_1	0.690102
phi	0.718602
LR against saturated table	162.3763
Nominal degrees of freedom	9
Prior transfer = 0: implied D6 contrast (points)	33.6425
Prior transfer = 1: implied D6 contrast (points)	6.2979

The fitted persistence is .719, but the model fits the complete table poorly: LR=162.38 on nominal nine degrees of freedom. Under an iid multinomial chi-square reference, $p \approx 2.38 \times 10^{-30}$; this reference does not account for province clustering. Parameters are interior and the local probability map has rank six. All 104 optimizer starts reach the same solution. The implied D6 contrasts, 33.64 and 6.30 points, also match direct summation of the fitted cells.

The residuals show where the stationary shared-state benchmark fails to reproduce the table. Requirements at both occasions without transfer occur in 34 enterprises, against 8.72 fitted; transfer at both occasions without requirements occurs in 108, against 67.21. Repeated reports of both items occur in 74 enterprises, against 39.33 fitted. Requirement switches among continuing transfer recipients occur in 22 and 28 enterprises, against 51.15 fitted in each direction. Transfer switches among continuing requirements reporters occur in 10 and 7 enterprises, against 18.19

fitted in each direction. The benchmark therefore overpredicts switching of either item while the other remains positive. The two opposite-direction joint-switch cells each contain 10 enterprises, against 24.12 fitted. Repeat reporting is therefore concentrated in stable item patterns more strongly than this stationary conditional-independent benchmark permits. This is consistent with item-specific persistence beyond one common latent process; it does not identify whether reporting practices, distinct sourcing arrangements, heterogeneous firms or other departures generate the pattern.

The implied D6 contrasts are algebraic consequences of the rejected specification. We report them as model outputs only, without comparison to observed stratum differences or interpretation as a validated persistence mechanism. Table B2 compares this benchmark with the separately specified temporal-tracks model.

Table B2. Shared-state and separate-tracks model comparison

Panel A. Fit to the same 1,867 enterprises

Model	Log likelihood	Parameters	LR vs saturated	Nominal df	AIC	BIC
Shared state	-3001.26	6	162.38	9	6014.52	6047.71
Separate tracks	-2950.20	7	60.26	8	5914.40	5953.13
Saturated	-2920.07	15	0.00	0	5870.15	5953.13

Panel B. Province-cluster resampling uncertainty

Statistic	Point	Bootstrap 95% interval	Successful draws
LR shared	162.38	[64.32, 315.70]	999
LR tracks	60.26	[18.66, 154.40]	999
delta AIC shared minus tracks	100.12	[17.76, 221.36]	999

Panel C. Diagnostic cells: observed and fitted counts

Cell (R0 T0 R1 T1)	Observed	Shared state	Separate tracks	Pattern
0001	80	98.02	97.73	One item switches; other stays negative
0010	45	43.47	62.96	One item switches; other stays negative

Cell (R0 T0 R1 T1)	Observed	Shared state	Separate tracks	Pattern
0100	115	98.02	114.30	One item switches; other stays negative
0101	108	67.21	116.77	Transfer only, repeated
0111	22	51.15	19.64	One item switches; other stays positive
1000	39	43.47	49.06	One item switches; other stays negative
1010	34	8.72	31.53	Requirements only, repeated
1011	10	18.19	8.70	One item switches; other stays positive
1101	28	51.15	29.28	One item switches; other stays positive
1110	7	18.19	13.27	One item switches; other stays positive
1111	74	39.33	60.53	Both items, repeated

Note. R denotes requirements and T transfer; the four digits identify the two original reports and two later reports. Log likelihood omits the multinomial combinatorial constant. AIC = −2 log likelihood + 2k; BIC = −2 log likelihood + k log(1,867). The saturated model has 15 free probabilities. Degrees of freedom are nominal parameter-count differences. The three summary rows use 999 draws of 40 provinces with replacement, preserving all original firms and cells within each province; both models are refitted in every draw. All 999 paired fits converge. Percentile intervals describe province-resampling uncertainty, not null-calibrated goodness-of-fit p-values. Delta AIC is shared minus separate tracks; it is positive in 998 draws. Both models leave departures from saturation, and BIC places the separate-tracks and saturated fits almost exactly together.

The separate-tracks model has two initial marginal probabilities, two transition probabilities for each item and a common contemporaneous conditional log odds ratio. Its initial joint distribution has margins P(R0=1) and P(T0=1). Conditional on each original state (r,t), the later joint distribution has margins P(R1=1|R0=r) and P(T1=1|T0=t). The same log odds ratio applies to the initial joint table and all four conditional later tables. The items therefore have separate first-order Markov margins and correlated contemporaneous innovations; the common parameter refers to conditional association at the later occasion. It leaves unconditional same-wave odds ratios free to differ through the changing mix of original states. This seven-parameter specification was recorded before fitting, and both models use the identical original sixteen cells.

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