

Absorptive Capacity in Action? R & D, Foreign-Company Technology Licensing, and Product Innovation in Ghana

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ABSTRACT

Foreign technology licensing can give firms rapid access to knowledge that would be costly to develop internally. However, absorptive-capacity theory argues that external knowledge creates value only when firms possess the internal ability to recognize, assimilate and use it. This study examined whether the use of technology licensed from a foreign-owned company was associated with product innovation in Ghana and whether research and development (R&D) engagement strengthened that relationship. The analysis used the Ghana World Bank Enterprise Survey 2023. After removing negative response codes and incomplete controls, the weighted analytical sample contained 682 formal establishments. Product innovation, foreign-company technology licensing and R&D engagement were measured directly from the survey. Hierarchical weighted logistic regression controlled for logged firm age, employment size, foreign ownership, top-manager sector experience, realized industry and region. Average predicted probabilities, alternative survey weights, a domestic-owned subsample, workforce-education controls, six-sector models, influence analysis, cross-validation and 1,000 stratified bootstrap replications were used. The weighted product-innovation rate was 19.0%, 17.4% of firms used licensed technology from a foreign-owned company, and 8.1% engaged in R&D. Licensing had a positive but statistically uncertain association before R&D was included (odds ratio = 1.55, 95% confidence interval [0.95, 2.53], $p = .081$). In the full interaction model, licensing was not significant among firms without R&D (odds ratio = 0.64, 95% confidence interval [0.31, 1.33], $p = .232$). R&D was strongly associated with product innovation (odds ratio = 11.26, 95% confidence interval [4.15, 30.54], $p < .001$). The licensing-by-R&D interaction was not significant (odds ratio = 1.63, 95% confidence interval [0.39, 6.78], $p = .503$). Adjusted innovation probabilities were 15.5% for firms with neither practice, 10.7% for licensing without R&D, 62.7% for R&D without licensing and 63.6% for firms using both. The findings support the importance of internal R&D capability but do not show that R&D converts foreign-company licensing into a stronger product-innovation advantage. Technology-transfer policy should therefore build internal learning systems and evaluate the depth, relevance and integration of licensed knowledge rather than treating license possession as sufficient.

Keywords: absorptive capacity, foreign technology licensing, research and development, product innovation, Ghana, Enterprise Survey

INTRODUCTION

Firms do not create every useful technology by themselves. They obtain knowledge from suppliers, universities, consultants, competitors, parent companies and technology owners in other countries. Licensing is one formal way to obtain external technology. It can reduce development time, lower technical uncertainty and give a firm access to designs, processes, software, patents or know-how that would otherwise be unavailable. For firms in developing economies, licensing may offer a direct route into technologies already tested elsewhere.

External technology is not automatically productive. A license gives legal or contractual access, but access is different from understanding and commercial use. The receiving firm must recognize which parts of the technology matter, connect them with existing knowledge, adapt them to local production and customer

conditions, and organize employees around the new routines. These requirements form the central argument of absorptive-capacity theory (Cohen & Levinthal, 1990).

Cohen and Levinthal (1990) defined absorptive capacity as the ability to recognize the value of external information, assimilate it and apply it commercially. Their argument made internal R&D important for two reasons. R&D can produce new knowledge directly, and it can also build the prior knowledge that enables a firm to learn from external sources. This dual role has shaped a large strategic-management literature on external search, alliances, licensing and open innovation (Cassiman & Veugelers, 2006; Escribano et al., 2009; Laursen & Salter, 2006).

The complementarity proposition is particularly relevant to foreign technology. Meta-analytic evidence confirms that absorptive capacity is generally associated with innovation, while also showing substantial variation across measures and contexts (Zou et al., 2018). Knowledge created in another institutional, technical and market setting may be difficult to interpret. Equipment standards, input quality, worker skills, customer preferences and regulation may differ. A firm with internal R&D staff or routines may be better able to translate a foreign technology into a product that works in its own environment. Evidence from Chinese high-technology industries indicates that importing foreign technology does not necessarily improve innovation unless internal R&D is also present (Li, 2011). Research on Korea likewise shows that different forms of foreign licensing interact differently with the development of absorptive capacity (Chung & Lee, 2015).

However, complementarity is not guaranteed. Technology licences differ in novelty, complexity, exclusivity and the amount of technical assistance supplied by the licensor. Some technologies are highly codified and can be adopted without extensive internal research. Others are mature technologies obtained mainly to improve efficiency rather than to create new products. Internal R&D may also substitute for licensing when firms prefer to develop their own solutions. Cassiman and Veugelers (2006) found complementarity between internal R&D and external knowledge acquisition, but they also showed that complementarity depends on the firm's strategic context.

The question is important for Ghana. Ghanaian firms operate in an economy where innovation is needed to increase productivity, diversify production and compete in domestic and international markets. Previous research shows that both formal and informal Ghanaian firms innovate, but the type and intensity of innovation vary greatly (Fu et al., 2018; Robson et al., 2009). Wider sub-Saharan African evidence also shows that external knowledge channels differ in their value for innovation (Medase & Abdul-Basit, 2020). External knowledge can support this process, yet firms may differ in their capacity to absorb it. The costs of R&D, weak research-industry links, limited specialist skills and financing constraints may prevent firms from developing internal learning capability.

This article examines whether Ghanaian establishments that use technology licensed from a foreign-owned company are more likely to introduce new or significantly improved products or services. It then tests whether R&D engagement strengthens that association. The study uses direct variables in the Ghana World Bank Enterprise Survey 2023 rather than broad indexes or substitute measures. Licensing is based on the establishment's reported use of technology licensed from a foreign-owned company. R&D refers to expenditure on research and development during the previous fiscal year. Product innovation refers to the introduction of a new or significantly improved product or service during the previous three years.

The study contributes in four ways. First, it provides current firm-level evidence from Ghana, where empirical work on licensing and absorptive capacity is limited. Second, it examines a clear strategic combination: external technology access and internal R&D. Third, it distinguishes the direct association of R&D from the interaction required by the complementarity argument. Fourth, it follows the World Bank survey methodology by applying sampling weights, using realized industry, inspecting negative response codes and conducting sensitivity analyses under alternative eligibility assumptions.

The results are theoretically informative because they do not support the expected interaction. R&D is strongly associated with product innovation, but licensing is not significant after R&D is included, and the interaction

remains statistically uncertain. This pattern shows why strategic complementarity must be tested rather than assumed. It also suggests that a binary licensing measure may represent very different technology-transfer arrangements, only some of which require or benefit from internal R&D.

The remainder of the article develops the theoretical arguments and hypotheses, explains the data and methods, reports the weighted results, and discusses implications for managers, policymakers, and future research.

THEORETICAL BACKGROUND AND HYPOTHESES

Foreign Technology Licensing and Product Innovation

Technology licensing allows a firm to use knowledge owned by another organization under agreed conditions. The agreement may concern patents, production designs, software, formulas, trademarks, technical documentation or know-how. From a resource-based perspective, licensing can give the firm access to resources that are valuable but difficult or slow to create internally. From a transaction-cost perspective, licensing can be more efficient than acquiring a technology owner or undertaking uncertain research from the beginning.

Licensing can support product innovation through speed. A firm may introduce a new product sooner when it starts from an established technology platform. It can also reduce technical risk because the licensed knowledge has already been developed or tested. Foreign licensing may expose a firm to designs, standards and technical possibilities that are not widely available in the domestic market. These advantages can enlarge the set of product opportunities available to managers.

Licensing can also support recombination. Product innovation rarely comes from one isolated idea. Firms combine external technology with local market knowledge, existing production skills, supplier relationships and customer information. Open-innovation research shows that firms often obtain superior innovation results when they search beyond their organizational boundaries (Laursen & Salter, 2006). Knowledge-transfer studies further show that absorptive capacity helps organizational units turn access to knowledge into innovation and performance (Tsai, 2001). Technology licensing is a formal and focused form of such external search.

Empirical evidence nevertheless presents a mixed picture. Moreira et al. (2020) found that licensing-in can increase a firm's capacity to innovate under competitive pressure, especially where cumulative R&D is present. Dohse et al. (2019) showed that firms with internal R&D are more likely to license foreign technologies. In developing-economy manufacturing, Adbi et al. (2021) found that foreign technology licensing may create short-run disruption even when it offers longer-term learning opportunities. The effect therefore depends on the outcome period and the complementary resources available to the firm.

The licensing measure in the present study does not reveal whether the licence is exclusive, whether technical support is included or whether the technology is new to the world. Even so, the basic strategic argument is that access to external technology expands the firm's knowledge options and may increase the likelihood of a new or improved product. This leads to the first hypothesis.

Hypothesis 1: The use of technology licensed from a foreign-owned company is positively associated with product innovation.

R&D as Absorptive Capacity

R&D is both an innovation input and a learning investment. It gives scientists, engineers and technical employees experience in defining problems, evaluating evidence, testing alternatives and translating knowledge into commercial outcomes. Through these activities, firms accumulate prior related knowledge. Cohen and Levinthal (1990) argued that this knowledge makes external information easier to recognise and understand.

Later research separated potential and realised absorptive capacity. Reviews of the field also stress that absorptive capacity is shaped by organizational routines, managerial action and the surrounding knowledge environment (Volberda et al., 2010). Potential capacity concerns acquisition and assimilation, while realized capacity concerns transformation and exploitation (Zahra & George, 2002). A firm may obtain a foreign licence and understand its basic technical content but still fail to transform it into a locally useful product. R&D routines can support experimentation, adaptation, redesign and testing. They can therefore help move the firm from access to commercial application.

Organizational arrangements also matter. Jansen et al. (2005) showed that different coordination and socialization mechanisms support different parts of absorptive capacity. Fosfuri and Tribó (2008) found that potential absorptive capacity can improve innovation performance, especially when internal knowledge flows are effective. Escribano et al. (2009) similarly showed that absorptive capacity helps firms manage external knowledge flows and stimulate innovation.

The expected relationship is complementarity. External licensing supplies knowledge that the firm does not possess, while R&D supplies the internal ability to evaluate and adapt that knowledge. Cassiman and Veugelers (2006) found that internal R&D and external knowledge acquisition can be complementary innovation strategies. Recent work also indicates that the value of technology purchasing may depend on R&D thresholds and the scale of external acquisition (Sun et al., 2023). Formal models likewise show that licensing benefits depend on the receiving firm's absorptive capacity and the technology owner's innovation capability (Hong et al., 2024).

However, R&D may not always strengthen licensing. A firm with strong R&D may prefer internally generated technology and use licensing only for standard inputs. The licensor may provide extensive technical support that reduces the need for internal R&D. The licence may concern a process technology rather than a product platform. In addition, R&D measured as a binary activity may not show whether the work is related to the licensed technology. The complementarity proposition is therefore an empirical question.

The strategic expectation remains that firms engaging in R&D are better placed to transform licensed foreign-company technology into new or significantly improved products. The second hypothesis states this moderation argument.

Hypothesis 2: R&D engagement positively moderates the relationship between foreign-company technology licensing and product innovation, such that the licensing association is stronger among firms that engage in R&D.

METHODS

Data Source and Survey Design

The study used the Ghana World Bank Enterprise Survey 2023 and followed the accompanying study documentation and global Enterprise Survey methodology (World Bank Group, 2025). Fieldwork was conducted from February 2023 to February 2024. The survey covered formal private establishments with at least five employees in eligible manufacturing and service activities. Cooperatives, public organizations, agricultural establishments and firms outside the eligible industry groups were not part of the universe of inference. The establishment was the unit of analysis.

The full public-use file contained 713 establishments and 355 variables. The World Bank used stratified random sampling based on establishment size, business sector, geographical region and panel status. The sampling design deliberately selected firms across important domains rather than taking a simple random sample. Population estimates therefore require the survey weights supplied with the dataset.

The primary analysis used the median-eligibility weight, median. This weight reflects the World Bank's median assumption about the eligibility of firms whose eligibility could not be determined during fieldwork.

Regression weights were divided by their analytical-sample mean so that relative selection probabilities were preserved without treating the weighted population count as the model's effective sample size. The weak-eligibility weight was used in a sensitivity analysis.

The survey was answered mainly by owners and top managers, with assistance from finance, human-resource or technical staff where required. The overall response rate was 24.8%. Sampling weights address the known design and eligibility assumptions, but they cannot remove all possible nonresponse bias. Results should therefore be interpreted as weighted associations within the represented formal-firm population.

Data Inspection and Analytical Sample

Data inspection was completed before modelling. Establishment identifiers were checked for duplication, response categories were compared with the questionnaire, numerical variables were examined for impossible values, and skip patterns were reviewed. All 713 establishment identifiers were unique.

World Bank negative response codes were not treated as substantive values. A value of -9 represented a spontaneous "do not know" response in the focal variables and was recoded as missing. Product innovation had 711 valid yes-or-no responses, technology licensing had 706, and R&D engagement had 707. Foreign ownership was valid for 708 firms, and top-manager sector experience was valid for 695.

The primary adjusted model required complete values for product innovation, licensing, R&D, firm age, employment size, foreign ownership, manager experience, realized industry, region, both survey weights and sampling stratum. The final analytical sample contained 682 establishments, including 154 product innovators. This retained 95.7% of the full survey file and 96.1% of establishments with valid product-innovation responses.

Workforce education was considered as an additional control because employee knowledge can support absorptive capacity. However, the percentage of full-time workers completing high school was valid for only 517 establishments and reduced the fully adjusted sample to 497. It was therefore included in a sensitivity model rather than the primary specification. This decision preserved population coverage while still testing whether education changed the focal estimates.

Firm age was calculated as interview year minus the year operations began. The natural logarithm of age plus one was used because age was right-skewed. Permanent full-time employment was also log transformed. Foreign ownership was measured as the percentage owned by foreign individuals, companies or organizations and was entered in ten-percentage-point units. Continuous controls were centred on weighted means.

Measures

Product innovation. The dependent variable was h1, which asked whether the establishment had introduced a new or significantly improved product or service during the previous three years. "Yes" was coded one and "No" was coded zero. The measure identifies innovation reported by the establishment but does not distinguish between products new to the firm, new to Ghana or new to the world. This limitation is common in firm-level innovation surveys and requires careful interpretation of self-reported innovation indicators (Cirera & Muzi, 2020).

Foreign-company technology licensing. The independent variable was e6, which asked whether the establishment used technology licensed from a foreign-owned company. "Yes" was coded one and "No" was coded zero. The wording identifies the ownership of the technology source, but it does not report the country, licence type, age of the technology, payment arrangement, exclusivity or technical-assistance provisions.

R&D engagement. The moderator was h8, which asked whether the establishment spent on research and development during the previous fiscal year, excluding market research. "Yes" was coded one and "No" was coded zero. R&D is used as an observable indicator of internal knowledge-development and absorptive

capability. It is not treated as a complete measure of absorptive capacity, which also includes routines for knowledge recognition, assimilation, transformation and exploitation.

Control variables. The primary controls were logged firm age, logged permanent employment, foreign ownership percentage, top-manager sector experience, realized industry and region. These factors can influence innovation opportunities, technical resources and exposure to foreign knowledge. Four-digit ISIC Revision 4 activity codes were grouped into manufacturing, wholesale and retail, and other eligible sectors in the primary model. A six-sector specification x was used for sensitivity analysis.

Statistical Analysis

The analysis proceeded in stages. Weighted descriptive statistics first established the prevalence of product innovation, licensing and R&D. Innovation rates were then calculated for the four combinations of licensing and R&D. These comparisons were descriptive because firms chose their strategies rather than receiving them randomly.

Survey-weighted binary logistic regression was used because product innovation was dichotomous. Model 1 contained the controls. Model 2 added licensing. Model 3 added R&D. Model 4 added the licensing-by-R&D product term. Heteroskedasticity-consistent HC1 standard errors were used (White, 1980). Odds ratios and 95% confidence intervals were reported.

Interaction effects in logistic models cannot be interpreted adequately from the product coefficient alone (Ai & Norton, 2003; Brambor et al., 2006). Average adjusted probabilities were therefore estimated for the four licensing-R&D combinations while averaging over the observed controls. Five thousand simulations from the coefficient covariance matrix produced confidence intervals and probability-scale contrasts.

Robustness tests used the weak-eligibility weight, an unweighted model, all six realised sectors, workforce education, a binary foreign-ownership control, a domestic-owned subsample and quadratic continuous controls. Variance inflation factors assessed collinearity. Cook's distance identified observations with unusual influence. A stratified bootstrap resampled establishments within World Bank strata for 1,000 replications.

Ten-fold cross-validation provided a descriptive assessment of discrimination and calibration. The model was developed to examine theoretical associations, not to make high-stakes predictions for individual firms. All tests were two-sided, and $p < .05$ was used as the conventional significance threshold. Statistical uncertainty and confidence intervals were considered alongside p values.

Ethical and Data Management Considerations

The study analysed anonymised secondary establishment data. No respondent was contacted, and no attempt was made to identify any individual or firm. The data were used under the World Bank Enterprise Surveys access conditions. Only aggregated descriptive and model results were reported.

RESULTS

Sample Characteristics

The analytical sample contained 682 establishments. The weighted product-innovation rate was 19.0%. A total of 118 sampled establishments used technology licensed from a foreign-owned company, corresponding to a weighted rate of 17.4%. Eighty-one establishments engaged in R&D, corresponding to 8.1% of the weighted population.

The weighted mean firm age was 14.12 years, and the mean number of permanent full-time employees was 27.95. The average top manager had 15.82 years of sector experience. Foreign investors owned an average of 6.74% of equity, although most establishments had no foreign ownership.

Wholesale and retail represented 40.9% of the weighted sample, followed by accommodation and food, manufacturing and other services. Product innovation was most common in manufacturing, accommodation and food, and other services. R&D was most common in other services and manufacturing. Licensing was especially common in other services, although the unweighted number of establishments in that category was modest.

Table 1 *Weighted Characteristics of the Analytical Sample*

Characteristic	Unweighted n	Weighted % or M	Weighted SD
Product innovation, yes	154	19	
Technology licensed from a foreign-owned company, yes	118	17.4	
R&D engagement, yes	81	8.1	
Foreign ownership share, percent	682	6.74	22.33
Top manager sector experience, years	682	15.82	9.81
Firm age, years	682	14.12	11.55
Permanent full-time employees	682	27.95	57.38
Realised sector			
Manufacturing	224	15.9	
Construction	41	7	
Wholesale and retail	198	40.9	
Transport and storage	20	6.5	
Accommodation and food	154	17.9	
Other services	45	11.9	
Region			
Region 1	278	69.3	
Region 2	168	16.1	
Region 3	123	11.1	
Region 4	113	3.6	

Note. N = 682. Percentages and means use the World Bank median-eligibility weight. The realised sector is based on the activity reported during the interview.

Product Innovation across Licensing and R&D Strategies

The descriptive results showed a large R&D difference and almost no licensing difference within R&D status. Among firms with neither licensing nor R&D, the weighted innovation rate was 15.3%. Firms using licensed technology without R&D had a lower weighted rate of 10.3%.

R&D firms had much higher innovation rates. The weighted rate was 67.3% among R&D firms without licensing and 67.7% among firms combining R&D and licensing. Thus, the descriptive increase associated with R&D exceeded 50 percentage points in both licensing groups, whereas licensing changed the innovation rate very little among R&D firms.

The smallest focal group contained 33 firms that combined licensing and R&D, including 19 innovators. The corresponding no-licensing R&D group contained 48 firms and 31 innovators. These counts permitted estimation but produced wide confidence intervals for the interaction.

Table 2 Product Innovation by Foreign-Company Technology Licensing and R&D Engagement

Licensed technology	R&D	n	Innovation n	Unweighted innovation %	Weighted innovation %	Weighted sample %
No	No	516	88	17.1	15.3	79.2
Yes	No	85	16	18.8	10.3	12.7
No	Yes	48	31	64.6	67.3	3.5
Yes	Yes	33	19	57.6	67.7	4.7

Note. The table is descriptive and does not adjust for firm characteristics. Licensed technology refers to technology licensed from a foreign-owned company.

Hierarchical Logistic Models

Model 1 contained firm and environmental controls. Older firms had significantly higher adjusted odds of product innovation. Employment size was positive but narrowly nonsignificant. Foreign ownership, manager experience, industry and region were not significant at the .05 level.

Model 2 added foreign-company technology licensing. Licensing was positively associated with product innovation, OR = 1.55, 95% CI [0.95, 2.53], $p = .081$. The coefficient was suggestive but did not meet the conventional significance threshold. The addition reduced AIC slightly from 635.99 to 635.22.

Model 3 added R&D. R&D had a large positive association, OR = 14.13, 95% CI [6.73, 29.66], $p < .001$. Once R&D was included, the licensing coefficient changed direction and was not significant, OR = 0.73, $p = .305$. Model fit improved substantially: AIC declined to 577.81 and weighted AUC increased from .688 to .761.

Model 4 added the interaction. Licensing was not significant among firms without R&D, OR = 0.64, 95% CI [0.31, 1.33], $p = .232$. R&D remained strongly associated with innovation among firms without licensing, OR = 11.26, 95% CI [4.15, 30.54], $p < .001$. The interaction was positive but imprecise, OR = 1.63, 95% CI [0.39, 6.78], $p = .503$. Adding the interaction increased AIC and produced almost no change in Brier score. Hypothesis 1 was not supported in the fully adjusted model, and Hypothesis 2 was not supported.

Table 3 Hierarchical Weighted Logistic Regression Models Predicting Product Innovation

Predictor	Model 1 OR [95% CI]	Model 2 OR [95% CI]	Model 3 OR [95% CI]	Model 4 OR [95% CI]
Logged firm age	1.98 [1.39, 2.81]***	2.05 [1.44, 2.92]***	2.22 [1.48, 3.33]***	2.23 [1.49, 3.34]***
Logged employment	1.19 [0.99, 1.44]	1.16 [0.95, 1.41]	1.14 [0.92, 1.41]	1.14 [0.92, 1.42]
Foreign ownership, per 10 points	1.07 [0.98, 1.17]	1.06 [0.98, 1.16]	1.03 [0.93, 1.14]	1.02 [0.92, 1.14]
Manager sector experience	1.01 [0.99, 1.03]	1.01 [0.99, 1.03]	1.00 [0.98, 1.03]	1.00 [0.98, 1.03]
Foreign-company technology licence		1.55 [0.95, 2.53]	0.73 [0.41, 1.33]	0.64 [0.31, 1.33]

R&D engagement			14.13 [6.73, 29.66]***	11.26 [4.15, 30.54]***
Licence × R&D				1.63 [0.39, 6.78]
AIC	635.99	635.22	577.81	579.35
Weighted AUC	0.687	0.688	0.761	0.763

Note. N = 682. Entries are odds ratios with HC1 robust 95% confidence intervals. All models include three realised-industry groups and four regions. Manufacturing and Region 1 are reference categories. *p < .05. **p < .01. ***p < .001.

Full Interaction Model and Conditional Effects

The conditional contrasts reinforced the main findings. Licensing was not significant when R&D was absent, OR = 0.64, p = .232, or present, OR = 1.04, p = .945. R&D was strongly associated with innovation in both licensing groups. Among firms without licensed technology, the conditional R&D odds ratio was 11.26. Among licensing firms, it was 18.33. Although the latter number was larger, the difference between the two R&D coefficients was not statistically significant, as shown by the interaction term.

Table 4 Full Weighted Logistic Regression Model for Product Innovation

Predictor	B	SE	Adjusted OR	95% CI	p
Foreign-company technology licence	-0.445	0.372	0.64	[0.31, 1.33]	0.232
R&D engagement	2.421	0.509	11.26	[4.15, 30.54]	< .001
Licence × R&D	0.487	0.728	1.63	[0.39, 6.78]	0.503
Logged firm age	0.802	0.206	2.23	[1.49, 3.34]	< .001
Logged employment	0.134	0.111	1.14	[0.92, 1.42]	0.224
Foreign ownership, per 10 points	0.025	0.053	1.02	[0.92, 1.14]	0.643
Manager sector experience	0.003	0.012	1	[0.98, 1.03]	0.783
Other sectors	-0.022	0.314	0.98	[0.53, 1.81]	0.944
Wholesale and retail	-0.083	0.323	0.92	[0.49, 1.74]	0.798
Region 2	-0.626	0.371	0.53	[0.26, 1.11]	0.091
Region 3	-0.272	0.361	0.76	[0.38, 1.55]	0.452
Region 4	0.108	0.614	1.11	[0.33, 3.71]	0.86
Intercept	-1.679	0.287	0.19	[0.11, 0.33]	< .001

Note. Continuous variables are centred. B = log-odds coefficient; SE = robust standard error; OR = odds ratio.

Adjusted Probabilities

Average adjusted probabilities translated the logistic results into direct innovation rates. Firms with neither licensing nor R&D had a predicted probability of 15.5%, 95% CI [13.1%, 19.3%]. Licensing without R&D produced a predicted probability of 10.7%, 95% CI [5.9%, 19.0%]. The difference was -4.8 percentage points (95% CI [-11.1, 3.6]), $p = .225$.

R&D produced large probability increases. Firms with R&D but no licensing had a predicted probability of 62.7%, 95% CI [41.4%, 80.3%]. Firms combining licensing and R&D had a probability of 63.6%, 95% CI [46.9%, 77.3%]. The licensing difference among R&D firms was only 0.9 percentage points, 95% CI [-22.7, 25.6], $p = .933$.

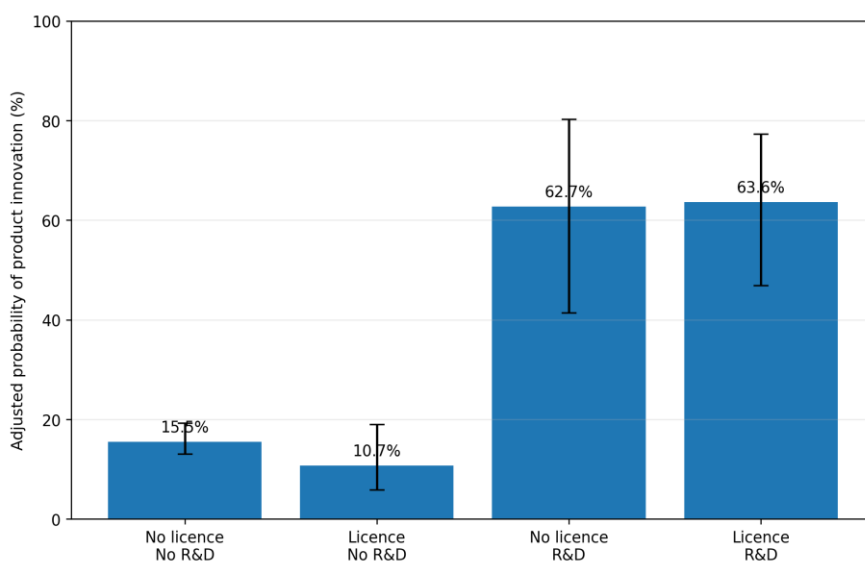
The probability-scale interaction was 5.7 percentage points, but its confidence interval ranged from -19.8 to 31.0 percentage points, $p = .668$. This wide interval means that moderate complementarity or substitution cannot be ruled out, but the observed data do not provide evidence for a positive interaction.

Table 5 *Adjusted Product-Innovation Probabilities and Conditional Contrasts*

Licensed technology	R&D	Predicted probability %	95% CI
No	No	15.5	[13.1, 19.3]
Yes	No	10.7	[5.9, 19.0]
No	Yes	62.7	[41.4, 80.3]
Yes	Yes	63.6	[46.9, 77.3]
Probability contrasts		Difference, pp	95% CI
Licensing effect when R&D=0		-4.8	[-11.1, 3.6]
Licensing effect when R&D=1		0.9	[-22.7, 25.6]
R&D effect when licensing=0		47.2	[24.7, 64.5]
R&D effect when licensing=1		52.9	[33.9, 67.6]
Probability-scale interaction		5.7	[-19.8, 31.0]

Note. Predictions average over observed control variables. Confidence intervals use 5,000 simulations. pp = percentage points.

Figure 1 *Adjusted Probability of Product Innovation by Technology Licensing and R&D*



Note. Error bars show simulation-based 95% confidence intervals from the full weighted interaction model.

Diagnostics and Sensitivity Analyses

Variance inflation factors ranged from 1.17 to 2.05 for the substantive predictors, indicating low multicollinearity. Quadratic terms for logged age, logged employment and manager experience were not significant. The linear continuous-control specification was therefore retained.

The weak-eligibility weight produced an interaction OR of 1.94, $p = .382$. The unweighted interaction OR was 0.64, $p = .432$. The six-sector specification, workforce-education model, binary foreign-ownership control and quadratic model all produced nonsignificant interactions. The licensing coefficient also remained nonsignificant in every full model.

The domestic-owned subsample contained 614 establishments. In this group, licensing without R&D had OR = 0.45, $p = .080$, R&D had OR = 9.11, $p < .001$, and the interaction had OR = 2.80, $p = .228$. Removing foreign-owned firms therefore did not reveal a significant complementarity effect.

The stratified bootstrap completed all 1,000 replications. The bootstrap interval for licensing was OR [0.26, 1.30], and the interval for the interaction was OR [0.29, 9.57]. R&D remained strongly positive, with a bootstrap interval of OR [4.06, 44.88].

The maximum Cook's distance was .045. Removing the most influential establishment did not change the nonsignificant licensing or interaction conclusions. Removing all observations above the heuristic 4/N threshold increased coefficient instability but still did not make the interaction significant. Because the observations were valid survey responses, the full sample was retained.

Ten-fold cross-validation produced a weighted AUC of .701 and a Brier score of .135. The calibration slope was .749 and the intercept was -.331. These results indicate moderate discrimination and some overfitting. The model is suitable for examining average theoretical associations but not for predicting whether a particular firm will innovate.

Table 6 Robustness Results for Licensing, R&D and Their Interaction

Analysis	n	Licensing OR	R&D OR	Interaction OR	Interaction p
Primary median weight	682	0.64 [0.31, 1.33]	11.26 [4.15, 30.54]	1.63 [0.39, 6.78]	0.503
Weak-eligibility weight	682	0.55 [0.25, 1.21]	11.40 [4.12, 31.56]	1.94 [0.44, 8.59]	0.382
Unweighted model	682	1.01 [0.56, 1.82]	9.03 [4.53, 17.98]	0.64 [0.21, 1.95]	0.432
Six realised sectors	682	0.63 [0.30, 1.32]	11.89 [3.66, 38.59]	2.06 [0.44, 9.66]	0.359
Add workforce education	497	0.88 [0.40, 1.97]	26.05 [7.37, 92.03]	0.74 [0.13, 4.09]	0.729
Foreign ownership as binary control	682	0.65 [0.31, 1.34]	11.32 [4.18, 30.67]	1.53 [0.36, 6.47]	0.561
Domestic-owned firms only	614	0.45 [0.18, 1.10]	9.11 [3.18, 26.11]	2.80 [0.53, 14.87]	0.228
Quadratic continuous controls	682	0.64 [0.31, 1.34]	11.66 [4.18, 32.56]	1.58 [0.38, 6.62]	0.53
Stratified bootstrap	1000	0.60 [0.26, 1.30]	13.06 [4.06, 44.88]	1.66 [0.29, 9.57]	0.57

Note. Odds ratios are from full interaction models. Bootstrap n is the number of replications rather than establishments.

DISCUSSION

Interpretation of the Main Findings

The study tested a central absorptive-capacity proposition: firms should obtain greater innovation value from external technology when they also invest in internal R&D. The Ghana data provided strong evidence that

R&D is associated with product innovation, but they did not provide evidence that R&D strengthens the effect of foreign-company technology licensing.

The licensing result changed substantially when R&D was added. Before R&D entered the model, licensing had a positive but marginal association. After R&D was controlled, the licensing coefficient became negative and nonsignificant. This pattern suggests that part of the apparent licensing advantage reflects the fact that firms engaging in R&D are also more likely to obtain licensed technology. Licensing and R&D may be jointly selected by firms with stronger innovation strategies, but R&D carries most of the observed association with product innovation.

The R&D result is consistent with the original absorptive-capacity argument and with the direct role of R&D in creating knowledge. R&D firms had adjusted product-innovation probabilities above 60%, compared with approximately 11% to 16% among firms without R&D. These differences remained under every sensitivity specification. Internal experimentation, technical problem solving and knowledge integration appear to be important features of innovative Ghanaian firms.

The interaction result does not mean that absorptive capacity is irrelevant. R&D is an imperfect proxy for a multidimensional capability. Lane et al. (2006) warned against treating absorptive capacity as a simple stock or single measure. Firms need routines for acquisition, assimilation, transformation and exploitation. A yes-or-no R&D item cannot reveal whether the research is related to the licensed technology, whether technical employees communicate with production teams, or whether managers provide resources for commercialization.

The measure of licensing is also broad. It does not distinguish patents from know-how, software from machinery, or exclusive licences from standard supplier agreements. Chung and Lee (2015) showed that patent and know-how licensing can have different relationships with absorptive-capacity formation. Some Ghanaian firms may use licences mainly to operate established production systems rather than to develop new products. Such use could improve quality or efficiency without changing the product-innovation measure.

Temporal differences may also weaken the moderation test. Product innovation covered the previous three years, R&D referred to the previous fiscal year and licensing reflected current use. A product may have been introduced before the reported R&D expenditure or licensing arrangement. Cross-sectional data cannot establish the sequence required by the theory.

The near-identical innovation rates of the two R&D groups are particularly important. Firms with R&D were highly innovative whether or not they used foreign-company technology. This could mean that internal R&D provides sufficient knowledge generation for many firms. It could also mean that external knowledge arrives through channels not measured by licensing, including suppliers, customers, consultants, digital platforms, universities and employee mobility.

The findings are compatible with threshold arguments. Sun et al. (2023) found that technology purchasing and R&D employment become complementary after important thresholds are crossed. The Ghana survey measures only whether R&D and licensing occur, not their scale. If complementarity requires substantial R&D staff, repeated interaction with the licensor or a large technology package, a binary interaction will mix firms below and above the relevant threshold.

The results also align with evidence that foreign technology can generate disruption as well as opportunity. Adbi et al. (2021) showed that licensing may reduce short-run productivity growth because implementation requires learning and reorganization. Product innovation may similarly be delayed when firms first focus on installation, training and process stability. A future panel study could observe whether licensed firms innovate after a longer adjustment period.

Theoretical Implications

First, the study reinforces the need to separate the direct innovation role of R&D from its proposed moderating role. R&D may increase innovation without necessarily increasing the marginal value of a particular external knowledge source. Models that treat a significant R&D coefficient as evidence of absorptive-capacity complementarity risk confusing direct capability with interaction.

Second, the results support a more precise view of external knowledge. Licensing is not a uniform strategic practice. The value of external technology depends on knowledge distance, codification, technical support, exclusivity and strategic relevance. Absorptive-capacity theory is more likely to predict outcomes when the nature of the external knowledge and the internal knowledge base are matched.

Third, the findings support Lane et al.'s (2006) argument that absorptive capacity should be studied as a process. The survey identifies inputs and outcomes but does not observe recognition, assimilation, transformation or exploitation. Future research should measure these stages directly and examine where licensing projects fail.

Fourth, the null interaction illustrates the difference between co-adoption and complementarity. Licensing and R&D can coexist without producing a super-additive innovation effect. Strategic-management research should use adoption models, productivity models and probability-scale interactions together, as recommended in the complementarity literature (Cassiman & Veugelers, 2006).

Managerial Implications

Ghanaian managers should not treat a technology licence as a complete innovation strategy. Before signing an agreement, the firm should identify the internal knowledge required to use the technology, the employees responsible for learning it, and the product opportunities the technology is expected to support. A licence should be accompanied by an implementation and learning plan.

R&D should be connected to commercial and operational problems. Firms do not necessarily need a large laboratory. They can create small cross-functional teams that test materials, adapt product designs, document customer feedback and work with suppliers or universities. What matters is a repeatable process for learning and experimentation.

Managers should examine the content of licensing contracts. Technical documentation, employee training, access to engineers, update rights and problem-resolution support may be as important as legal permission to use the technology. Contracts that transfer only codified information may leave the firm unable to solve local adaptation problems.

Firms should also measure learning outcomes. Useful indicators include the number of employees trained, local modifications completed, technical problems solved without the licensor, new product concepts tested and the time required to reach stable production. These measures show whether the firm is building capability rather than remaining permanently dependent on the external owner.

Where internal R&D is unaffordable, firms can build shared absorptive capacity through industry associations, technology centres, universities and supplier-development programmes. Collaborative laboratories and demonstration facilities can reduce the fixed cost of experimentation for smaller enterprises.

Policy Implications

Innovation policy in Ghana should combine technology access with capability development. Incentives that reduce licence fees or import costs may increase technology adoption, but they may not produce product innovation unless firms can adapt and exploit the knowledge. Public support should therefore include technical training, applied research partnerships and implementation assistance.

R&D support should be accessible beyond a small number of large firms. Matching grants, tax incentives and competitive innovation vouchers can help firms undertake defined research and adaptation projects. Programmes should require clear technical objectives and evidence of learning rather than rewarding expenditure alone.

Universities and technical institutions can act as translation partners between foreign technology and local use. They can test materials, redesign components, develop local standards and help firms understand why a technology fails under Ghanaian conditions. Such services strengthen the national innovation system and reduce dependence on external technical support.

Technology-transfer programmes should collect more detailed information. Policymakers need to know whether firms license patents, software, brands, or know-how; whether agreements include training; and whether the technology is linked to new products, process efficiency, or regulatory compliance. Better classification would allow support to target arrangements with the greatest learning potential.

Foreign investors and licensors can also be encouraged to develop local suppliers and technical personnel. Supplier-development requirements, joint research projects and engineering internships may create broader spillovers than licensing alone. These policies should remain realistic and should not discourage beneficial investment through excessive administrative burden.

LIMITATIONS AND FUTURE RESEARCH

The study is cross-sectional and cannot establish causality. Innovative firms may be more likely to undertake R&D and seek foreign licences. Unobserved managerial capability may influence all three variables. Panel data or quasi-experimental designs are needed to identify causal effects.

The reference periods differ across variables. Product innovation covers three years, R&D covers the previous fiscal year, and licensing has no explicit historical start date. Future surveys should record when the licence was obtained, when R&D began and when the product was introduced.

The focal measures are binary. R&D expenditure, staff numbers and continuity are not available in a form suitable for the principal model. Licensing intensity, technology type and contractual support are also unknown. These limitations may conceal threshold or nonlinear complementarity.

R&D is only one indicator of absorptive capacity. Employee education, prior technology experience, internal communication, managerial cognition and external networks also matter. The workforce-education sensitivity did not change the conclusion, but the survey does not measure the complete learning system.

The product-innovation measure is self-reported. Respondents may differ in what they consider significantly improved. The variable also combines new goods and services and does not distinguish novelty or commercial success. Future studies can use product descriptions, sales from new products or patent and design data.

The interaction groups involving R&D were relatively small, especially the 33 firms combining licensing and R&D. The confidence interval for the interaction was wide. A larger multi-country or pooled-wave sample could estimate complementarity more precisely, provided the questionnaire variables and survey periods are harmonised.

The survey response rate was modest. The World Bank weights adjust known sampling and eligibility conditions, but unobserved nonresponse may remain. Results should be interpreted with appropriate caution and not generalised to informal businesses, microenterprises below the survey threshold or excluded sectors.

Future qualitative research could trace individual licensing projects from contract negotiation through technical learning and product launch. Such studies would show whether failures occur in knowledge transfer, employee

learning, adaptation, financing, production scale-up or market acceptance. A mixed-method approach would greatly improve understanding of absorptive capacity in Ghana.

CONCLUSION

This study examined whether R&D strengthens the product-innovation value of technology licensed from foreign-owned companies in Ghana. The evidence showed a strong and stable relationship between R&D engagement and product innovation. It did not show a significant direct licensing relationship after R&D was controlled, and it did not support the proposed licensing-by-R&D interaction.

The findings do not imply that foreign technology is unimportant. They show that licence possession alone is an incomplete measure of technology transfer and that R&D activity alone is an incomplete measure of absorptive capacity. Innovation depends on the relevance of the technology, the depth of transfer, the internal learning process and the firm's ability to commercialise adapted knowledge.

For managers and policy makers, the practical message is clear: technology access should be accompanied by deliberate capability building. Firms need people, routines and partnerships that turn external knowledge into locally useful products. Ghana's innovation strategy should therefore support not only acquisition of foreign technology, but also the organisational learning required to use it well.

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APPENDIX A

Variable Coding and Reproducibility Summary

Construct	WBES variable	Coding or transformation
Product innovation	h1	1 = new or significantly improved product/service in previous three years; 0 = no
Foreign-company technology licensing	e6	1 = uses technology licensed from a foreign-owned company; 0 = no
R&D engagement	h8	1 = spent on R&D in previous fiscal year, excluding market research; 0 = no
Firm age	a14y and b5	Interview year minus year operations began; $\ln(\text{age} + 1)$, centred
Employment size	l1	Natural logarithm of permanent full-time employees, centred

Foreign ownership	b2b	Percentage foreign owned, divided by 10 and centred
Manager experience	b7	Years top manager worked in sector, centred
Realised industry	d1a2_v4	Three groups in primary model; six groups in sensitivity model
Region	a2	Four World Bank survey regions
Primary weight	wmedian	Median-eligibility weight, normalised to mean one
Alternative weight	wweak	Weak-eligibility weight used in sensitivity analysis
Sampling stratum	strata	Used for within-stratum bootstrap resampling

Note. World Bank negative response codes were treated as missing. The primary complete-case sample contained 682 establishments.