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Technology Transfer and R&D as Drivers of Productivity Improvement in Japanese Overseas Manufacturing Affiliates

Mekdes Solomon Cherinet
Jimma University, Jimma, Ethiopia.
mekdes.solomon@ju.edu.et

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Corresponding author(s):
Mekdes Solomon Cherinet, Jimma University, Jimma, Ethiopia.
Email: mekdes.solomon@ju.edu.et

Abstract – Technological innovation and technology transfer play an important role in enhancing the productivity of MNEs, especially the Japanese overseas manufacturing subsidiaries. The purpose of this study is to examine the association between R&D cost, technology purchase, and total factor productivity change and regression models with the survey data of Japanese Ministry of Economy, Trade, and Industry on Overseas Business Activities conducted over 2021-2023. Basic and Trend Surveys were combined to create a sample of 1,798 affiliates across 38 countries with variables such as R&D spending, Technology Transfer payments, capital stock growth, and employment growth. The evidence presented suggests that both technology and R&D payments enhance productivity improvement for the company, and the estimated returns on R&D investments is 0.54 Yen (JPY) for every JPY spent and technology transfer payments 0.76 JPY. The regression results also show a synergistic relationship between technology and R&D payments indicating that affiliates involved in both processes report higher levels of efficiency. In addition, the study also focuses on geographical specialization of technology transfer and R&D in industries including chemicals, pharmaceuticals, and machinery, where major expenditure on R&D is done across the globe and particularly in United States and in Europe.

Keywords – Research and Development Activities, Technology Transfer, Oversee Manufacturing Affiliates, R&D Expenditures, Technology Transfer Payments.

I. INTRODUCTION

Many countries promote the development and use of innovative technology inside their national boundaries. It is readily comprehensible why they engage in such actions. The prevalent belief is that the positive link between local economic prosperity and the existence of technologically sophisticated companies suggests that the adoption of new technology improves general productivity. Direct evidence often substantiates the assertion that the economic advantages of research and development (R&D) activities spread to local enterprises beyond those doing the R&D. Due to the expectation that markets may underprovide externality-generating R&D activities, as developers of new technologies do not fully capture the economic advantages, some governments supply R&D-related tax subsidies. Governments that do not provide R&D tax incentives often contemplate whether they ought to do so. Nonetheless, several unresolved questions persist about the influence of tax policy on the extent of R&D.

In a developing country, technology is seen as a crucial catalyst for national economic advancement and company success. Various developing nations rely predominantly on Foreign Direct Investments (FDIs) from MNCs (multi-national corporations) as their major sources of technology to improve the competitiveness and technological capabilities of local industrial sectors, owing to insufficient resource capacities, including a limited R&D investment, weaker R&D base, inadequate manufacturing and production capabilities, technological disadvantages, and fragile infrastructure. This is mostly due to MNCs owning, producing, and controlling the majority of global technology, where they account for almost 79% of all privatized R&D spending globally. The technologies removed by MNCs are beneficial to the host nation by fostering long-term economic growth, augmenting innovation capabilities, enhancing technological proficiency, improving competitive advantage, increasing organizational learning effectiveness, positively impacting productivity, and advancing the technological development of local industries. Various research papers have suggested technology transfer as a means for poor nations to escape the detrimental cycle of economic underdevelopment.

The host nation will profit from Technology Transfer (TT) activities by enhancing quality of life, advancing technological advancement via research and development, and augmenting tax income. Multinational corporations profit from more equal trade agreements, worldwide growth, and a rise in market share [1]. Multinational businesses (MNCs), as primary providers of technology and information, disseminate their technologies to host nations via many avenues. To attain their economic goals, MNCs must meticulously evaluate the suitable transfer mechanisms in their strategic decisions, particularly regarding entrance modalities. The primary and successful methods for TT are exporting, FDI, joint ventures, and licensing. The selection of TT channels is contingent upon the technology's attributes, including its age, complexity, the characteristics of the host nation, the educational attainment of the workforce, labor skills, technology transfer prerequisites, and local competitiveness. Shaikh and Randhawa [2] assert that a comprehensive knowledge of the theories underpinning technology transfer is essential for stakeholders, including private sectors, government entities, students, researchers, and academics, to effectively engage with empirical and practical dimensions of diverse TT frameworks, mechanisms, challenges, and issues.

Previous research indicates that multinational corporations (MNCs) typically transfer 1) nascent and advanced technologies to their affiliates and subsidiaries in developed nations, 2) antiquated technologies to affiliates and subsidiaries in developing nations, and 3) technologies disseminated via licensing and joint ventures are older than those transferred to their affiliates. Galbraith [3] assert that the method of technology transfer is contingent upon the technology's characteristics, including teachability, codifiability, and tacitness. The likelihood of multinational corporations transferring technological advancements to a wholly-managed subsidiary is elevated when the knowledge is difficult or tacit; conversely, the more codified the technology, the greater the probability of transfer via licensing. Young and Lan [4] argue that when technology is new, young, and complicated, FDI is the best method to transfer it to subsidiaries.

While several studies have investigated the factors influencing R&D in the foreign affiliates of multinational corporations and the dynamics of international technology transfer, there is a paucity of research addressing the economic effects of R&D and TT on operations inside host countries. Recent research on global R&D has concentrated on the influence of foreign R&D efforts on the success of domestic R&D actions, whereas the effects of global TT via licensing have been analyzed only in relation to local enterprises in poor nations. Recent years have seen substantial growth in overseas research and development operations conducted by MNEs. The literature suggests that a primary incentive for overseas R&D operations is the usage and acquisition of sophisticated foreign knowledge that is otherwise inaccessible in the home nation. Consequently, it is anticipated that the research and development efforts of foreign subsidiaries would benefit their parent companies.

Nonetheless, actual data on the advantages of offshore R&D has been inconsistent. Kafouros, Buckley, and Clegg [5] was the first, to our knowledge, to investigate the influence of global R&D on the productivity development of parent enterprises. Utilizing firm-level data from Sweden, he identified no substantial effect. Likewise, Kang et al. [6] discovered that the research-focused R&D of Japanese companies in the United States did not influence the level of innovation in Japan. The results may not be unexpected, considering prior findings that knowledge spillovers are regionally confined and that international knowledge diffusion incurs significant costs. However, some research indicates that international R&D helps spread information back home. Arimoto, Daizen, and Huang [7], for instance, discovered a positive correlation between the number of R&D units Japanese companies had in the US and the citations of US patents they made.

This paper aims at analyzing the complex interaction between R&D and TT payments for productivity improvement among Japanese international manufacturing partners. In this context, by analyzing the data collected from 10 questionnaires of Overseas Business Activities that have been provided by the Ministry of Economy, Trade and Industry (METI) in Japan, from 1996 to 2000, the study will try to find out how these two factors work jointly to affect the productivity results. The remainder of the research has been organized as follows: Section II describes the Cobb-Douglas productivity growth model. Section III provides the descriptive statistics, data, and the variables used to compose this research. Section IV and V discusses the findings of the research; and describes model 1 (restricted model), excluding quadratic terms; and model 2 (full model), including quadratic terms and descriptions of the model in Section II. Section VI concludes the findings on the aspect of R&D and technology payments; as well as management of resources to achieve better results.

II. PRODUCTIVITY GROWTH MODEL

Our study employed an expanded Cobb-Douglas production model to simulate the different operations of overseas partners using Eq. (1):

$$Y_{it} = B_{it}^{a} L_{it}^{\beta} K_{it}^{\gamma} e^{\sigma_{it}} \quad (1)$$

In which Y represents the value-addition of partner business i at t, L denotes labor input, K indicates knowledge stocks, and C signifies the physical capital stocks. g, b, and a represent the elasticities concerning the knowledge stock, physical labor, and physical capital, correspondingly. Parameters, denoted by s, refers to the time-varying, affiliate-based success metric. By sub-dividing both dimensions of labor, using the logarithm, and varying the resultant equations over two successive periods, we get Eq. (2) in its development form:

$$\Delta q_{it} = (\beta - 1)\Delta l_{it} + a\Delta c_{it} + \gamma \Delta k_{it} + \Delta \sigma_{it} \quad (2)$$

where $\Delta q_{it} = \log(Y_{it}) - \log(L_{it})$ signifies the increase in productivity of labor, with lowercase letters representing constraints in natural logs. In Eq. (2), constant firm-specific manufacturing disparities are removed from $\Delta\sigma_{it}$; nevertheless, we posit that variations in firm-based success ratings are contingent upon historical productivity using Eq. (3).

$$\Delta\sigma_{it} = \theta q_{it-1} + \lambda_t + \varepsilon_{it} \quad (3)$$

where λ_t denotes a year-based intercept and ε_{it} represents a successively uncorrelated error term. This formulation facilitates progressive convergence in efficiency levels across enterprises, a phenomenon recognized as significant in empirical productivity research. We anticipate θ to be in the range or [-1, 0]. In case θ is caped 0, slow conjunction does not occur; in case θ is caped -1, entire convergence transpires in a single interval. We were able to modify the knowledge stocks component of the specifications as shown in Eq. (4).

$$\gamma\Delta \mathrm{k}_{it} \approx \frac{\partial Y}{\partial K}\frac{K_{t-1}}{Y_{t-1}}\frac{\Delta K}{K_{t-1}} \approx \varphi\frac{\Delta K_{it}}{Y_{t-1}} \qquad \text{with } \varphi = \frac{\partial Y}{\partial K} \quad (4)$$

The variation in these stocks is considered as the outcome of both technological transfers from the primary company (I_{it-1}^{lic}) and expenditures on research and development in the subsidiary $(I_{it-1}^{R\&D})$.

$$\Delta K_{it} = f\left(I_{it-1}^{R\&D}, I_{it-1}^{lic}\right) \quad (5)$$

We therefore estimated the unidentified Eq. (5) using a second-degree multinomial in research and development investments and technological transfer. Should the degradation degree of knowledge stocks be minimal, we may express:

$$\gamma\Delta k_{it} = \frac{\varphi\left[\eta_1 I_{it-1}^{R\&D} + \eta_2 I_{it-1}^{lic} + \eta_3\left(I_{it-1}^{R\&D}\right)^2 + \eta_4\left(I_{it-1}^{lic}\right)^2 + +\eta_5\left(I_{it-1}^{R\&D}\right)\left(I_{it-1}^{lic}\right)\right]}{Y_{it-1}} \quad (6)$$

As a result, the equation contains components that are linear, terms that are quadratic, and a term that describes how transferred technology and R&D interact. While prior studies often disregarded quadratic factors, their inclusion may be crucial. If the process of increasing the stock of knowledge is marked by diminishing returns to scales and the companies with the highest R&D intensity conduct both import technology and internal R&D, the engagement term between TT and R&D could be skewed negatively because it captures the diminishing marginal effect of either TT or R&D. A comprehensive requirement including quadratic terms is necessary to investigate this matter. Our research will assess productivity impacts of TT and R&D using Eq. (6). To demonstrate the significance of leveraging more generalized specifications, we shall provide the outcomes of frameworks with quadratic polynomial terms omitted. By integrating Eq. (2), Eq. (3), and Eq. (6) and relocating the delayed output factor to the right, we therefore get Eq. (7).

$$q_{it} = (1+\theta)q_{it-1} + (\beta-1)\Delta l_{it} + a\Delta c_{it} + \frac{\varphi\left[\eta_1 I_{it-1}^{R\&D} + \eta_2 I_{it-1}^{lic} + \eta_3\left(I_{it-1}^{R\&D}\right)^2 + \eta_4\left(I_{it-1}^{lic}\right)^2 + +\eta_5\left(I_{it-1}^{R\&D}\right)\left(I_{it-1}^{lic}\right)\right]}{Y_{it-1} + \lambda_t + \varepsilon_{it}} \quad (7)$$

III. DESCRIPTIVE STATISTICS, DATA, AND VARIABLES

The data used for model estimation pertains to Japanese international productivity affiliates and is sourced from the Global Firm Activities surveys in Japan. We accessed the triennial Surveys of Global Firm Events from 2021 and 2023, as well as the abbreviated Pattern Surveys conducted in 2022 and 2023. The numbers reflect the account for prior financial years ended March. As only the Primary Surveys include data on fixed capital and technology payments, the information is insufficient to construct a comprehensive panel data collection. We correlate the fundamental survey information at the affiliate levels with the following year's Pattern Surveys to determine growth in capital stock, employment, and productivity, while aggregating data from the years 2021-2022 and 2022-2023. Despite including several manufacturing affiliates, these affiliates are often excluded from the surveys conducted in subsequent years.

Moreover, the inquiries on technology payments and research and development have poor response rates. We verified the data's reliability by juxtaposing technology and R&D payment information with additional entries, including the affiliate's practical activity spectrum (potentially encompassing R&D), number of conveyed R&D personnel, and responses to analogous inquiries for the same partners in previous or subsequent years. This is to guarantee that “zero” is not erroneously interpreted as a missed figure; a variation that is occasionally not well recognized in investigations or surveys. Consequently, we were able to use 1,798 affiliate recordings with precise data on the relevant variable settings. The set of data comprises 920 different affiliates from 2021 to 2022 and 879 affiliates from 2022 to 2023; situated in 38 nations.

R&D refers to the expenditures of affiliates on research and development as shown in the fundamental survey. The metric for TT represents the value of royalty and licensing payments reported by the affiliate to the parent business. The stated TT payments value can be skewed if corporations use the pricing strategy of transfers to reduce tax liabilities in host nations; yet, the reported payment will likely exhibit a strong correlation with actual values of technologies being transferred to affiliates. We determined value addition by subtracting the cost of materials and components from sales revenue. Capital stocks in the primary year represents the stocks valuation of fixed assets (tangible) as shown in the fundamental surveys. In subsequent years, it makes it possible to determine capital stocks by considering the stock value from the previous year, a fixed capital investment for the current year, as well as its depreciation, with its rate established at 0.079214. All data were adjusted to 2022 prices using World Development Indicators’ GDP deflator, and the exchange rates of the JPY currency from METI.

Our sample included 87 billion JPY in affiliates R&D expenditures and 150 billion JPY in technological transfer expenditure. The average R&D ratio to the addition of value is 1.61%, although the ratio of technological expenditures to value addition is more at 2.70%. Intra-organization technological and R&D expenditures are predominantly concerted in pharmaceuticals and chemicals, electrical, transport, and general machineries sectors. The precision machinery business, however, has the greatest R&D intensity. The hierarchy of TT intensities varies little, with electric equipment exhibiting the greatest intensity at 4%, followed by pharmaceuticals and chemicals, building materials, transport machinery, and general machinery.

The allocation of technology and R&D payments across nations is very uneven, as shown by previous research on Japanese international R&D. The United States accounts for fifty percent of the research and development expenditures of the enterprises in the sample and approximately 1/3 of TT value. Research and development also occur in Asian partners (Singapore, Korea, and China) at a scale equivalent to European affiliates; however, the value of R&D compared to value generated is much reduced in Asian partners, save for Korea. Partners in France have the greatest R&D intensities at 7%, followed by the American affiliates at 3%, and other affiliates in minor EU (European Union) nations. Regarding the significance of technology expenditure, European and US affiliates indicate intensities, which are generally comparable to those of R&D. Asian affiliates have much greater intensities in relation to R&D at 3% and 4%, with the exclusion of Korea.

To effectively use the growth-enhancing potential of innovation, a critical inquiry for policymakers is the extent of state intervention necessary to foster a nation's technical capabilities. Originating from the unsuccessful import substitution programs of the 1970s, prevailing thought advocates for a restricted governmental involvement in fostering domestic innovation initiatives due to the public good characteristics of R&D. The surge of invention activity in developing countries, occurring alongside fast economic development, has fostered fresh confidence that state-led innovation may significantly enhance national competitive advantage and local innovative models. Examining the correlation between private innovation expenditures and national R&D subsidies within the perspective of China presents a compelling argument. The expenditure of China on R&D as a GDP percentage, between 2000 and 2010, almost quadrupled from 0.90% to 1.61%, with over half of these expenditures originating from large and medium-sized businesses (LMEs) by 2010.

The concentrations of TT and R&D within particular nations and industries is influenced by the technological intensity of those sectors and regions, and also implies that multinational corporations collectively 'adopt' R&D and TT practices in their subsidiaries, reflecting a complementary relationship. We will examine the subject in the subsequent section.

IV. FINDINGS

The estimate findings for Eq. (7) have been shown in **Table 1**, with SE (standard error) provided in parentheses. Table 1 (first column) displays approximations from variables, which constrains $\eta_2 = \eta_4 = 0$, therefore eliminating quadratic terms, whereas the second column shows the findings for the comprehensive framework. Both frameworks integrate a series of two-value industry indicators, country indicators, and a year indicator. The frameworks account for almost 86% of variability in production. The computed coefficients for lagged dependent variables indicated a converging q variable of -0.28, implying that about ¼ of an output advantage is offset in the subsequent timeframe. The increases in capital stock and employment variables are substantial, indicating a 0.261 elasticity and 0.120 of fixed capital. These frameworks demonstrate that research and development, together with technology expenditures, contribute to productivity enhancement. In the first model, the projected return on investment in R&D ($\varphi\eta_1$) is 0.541, indicating that each JPY allocated to R&D efforts enhances value added by 0.541 JPY. License returns ($\varphi\eta_3$) are elevated at 0.760. This trend corroborates previous findings and is somewhat explained by the more 'immediately applicable' nature of technology generated by the parent company compared to the more unpredictable consequences of local R&D initiatives.

Table 1. Model 1 (Restricted Model - Excluding Quadratic Terms)

Variables	Coefficient	Standard Errors	Interpretation/Notes
Lagged dependent variable	-0.28	Robust	Convergence parameter; 25% of productivity lead is neutralized
Employment Growth	0.26	Robust	Significant; elasticity of labor
Capital Stock Growth	0.12	Robust	Significant; elasticity of fixed capital
R&D Rate of Return ($\boldsymbol{\varphi\eta_1}$)	0.54	Robust	Significant; 1 JPY used on R&D increases value-added by 0.541 JPY
Licensing Rate of Return ($\boldsymbol{\varphi\eta_3}$)	0.76	Robust	Significant; 1 JPY spent on licensing increases value-added by 0.76 JPY
Interaction (Technology and R&D Payments)	Positive	Not significant	Indicates interaction, but not statistically significant

From **Table 1**, it is evident that both labour and capital exert positive impacts on productivity where elasticities of labour have been estimated to be 0.26 while that of capital is 0.12. The values of returns on R&D investment ($\varphi\eta_1$) are 0.54, and the return on licensing ($\varphi\eta_3$) is 0.76, which imply that every JPY spent on R&D generates 0.54 JPY of value added. This implies that licensing offers a quicker return on productivity than local R&D, this might be argued by the fact that technologies procured are perhaps ‘off-the-shelf’ from the parent firm. However, the coefficients of technology and R&D

payments are positive but insignificant suggesting that the complementary relationship between the two variables is not well defined in this restricted framework.

Table 2. Model 2 (Full Model - Including Quadratic Terms)

Variables	Coefficient	Standard Errors	Interpretation/Notes
Lagged dependent variable	-0.28	Robust	Convergence parameter remains the same
Employment Growth	0.26	Robust	Significant; same as Model 1
Capital Stock Growth	0.12	Robust	Significant; same as Model 1
R&D Rate of Return ($\varphi\eta_1$)	0.54	Robust	Same as Model 1
Licensing Rate of Return ($\varphi\eta_3$)	0.76	Robust	Same as Model 1
Interaction (Technology and R&D Payments)	Positive	Significant	Statistically significant, confirming complementarity between technology and R&D imports
Technology Payments (Quadratic term)	Negative	Significant	Indicates decreasing returns to technology transfers
R&D (Quadratic term)	Negative	Insignificant	Suggests potential diminishing returns to R&D, though not statistically significant

Table 2 reflects Model 2 results in which the quadratic terms indicate that the engagements between R&D payments and technology payments is presently positive and statistically significant. This establishes that there is a synergistic relationship between R&D and technology payments; this means that the impact of the two is higher when used together as oppose to when used separately. However, the results of the quadratic terms suggest that the effectiveness of technology transfers becomes progressively lower and there is a reduced rate of return with more imports of technology (around 1.2 billion JPY). While the squared term of R&D efforts is negative, it becomes inconsequential, meaning that there is no evidence of strong diminishing returns to R&D by locals.

Table 3. Interaction Effects and Returns on Investment

Returns Based on Average Spending	Coefficient	Interpretation/Notes
Return on R&D with Technology Import	+ 0.11	Affiliates with technology imports have a 0.11 higher return on R&D
Return on Licensing with Local R&D	+ 0.06	Affiliates with local R&D have a 0.06 higher return on licensing
Diminishing Returns for Technology Imports	Significant	Marginal impact declines after 1.2 billion JPY in technology imports
Diminishing Returns for Local R&D	Insignificant	Returns decline slightly at high levels of R&D, but not significant

Table 3 shows the interaction effects in more detail. This is an indication that there is a corresponding relationship between the importation of technology and R&D through the discovery that the return on R&D enhances by 0.11 for the affiliates engaged in the importation of technology. Likewise, the increase in the return on licensing is 0.06 for those affiliates that include local R&D in their operations. This proves that technology transfer and local R&D complement each other and when both are implemented, there is enormous improvement in productivity. Here, the values show that affiliates gain more from employing a strategy that combines imported technology and localized R&D efforts.

The collaboration impact between technology and R&D expenditures is favorable but not statistically significant from zero. Estimating the whole model in (2) with the inclusion of quadratic variables for technology and R&D payments alters the outcome. The collaboration impact between technology and R&D payments is now highly favorable, underscoring the need of adopting comprehensive specifications for the enhancement of knowledge stock. The accumulated knowledge stocks of a corporation may indirectly influence its creative performance via their interaction with incoming information flows. The complementarity and replacement of different types of innovative activities and knowledge assets have been examined in many contexts and from multiple viewpoints. Most pertinent research examine the counteractive or synergistic effects of external and internal R&D efforts on the process of innovation. Based on Bulow, Geanakoplos, and Klemperer [8], we define two efforts as substitutes (complimentary) when an increase in a single activity enhances (diminishes) the marginal returns of the other.

Utilizing the idea of absorptive capacity, Grimpe and Kaiser [9] contend that there exists a corresponding connection between internal R&D actions and specific types of external innovation acquisition that is fundamental for the company’s innovative performance and output. Prior knowledge allows firms to identify, assess, and implement external knowledge acquisition strategies; conversely, accessibility to external knowledge assets may be utilized to improve internal R&D

efficiency, augment the firm's internal knowledgebase and reinforce its capacity of innovation. The authors also contend that external acquisition of knowledge and internal R&D are corresponding innovation actions, with the level of complementarity contingent upon organizations' fundamental R&D capabilities. Similarly, pertinent empirical studies corroborate the presence of synergistic impacts of R&D collaboration and internal R&D on the innovation performance on enterprises. Duan et al. [10] demonstrate that existing knowledge positively moderates the innovation payments of knowledge flow from enterprises' external search activities, by employing patents as a measure of knowledge stocks.

Conversely, a substitutive link may exist between certain knowledge sources or innovation activities, which can be elucidated via the concepts of route dependency, dis-economies of scope, and/or switching expenditures. Organizations often demonstrate route-dependent behavior in their learning and innovation processes, shaping their innovation and learning initiatives according to prior experiences, knowledge, and their developed skills and capacities. Consequently, engaging in many innovation activities simultaneously may incur significant switching costs, adversely impacting inventive output, particularly at the margin. Moreover, certain innovation systems reliant on internal knowledge reserves and external information influxes may be equifinal, yielding identical or comparable inventive results. Possible dis-economies of scope may occur, indicating that concurrent involvement in many innovative actions is less effective than concentrating on a singular invention process.

In this context, Hena et al. [11] provide empirical data indicating offsetting or, at the very least, non-synergistic impacts of external and internal information bases on company innovation. They provide conflicting findings indicating that external and internal R&D serve as substitutive approach for innovation at lower degrees of in-house R&D investment, however they function as complimentary actions in enhancing firm inventive performance at larger degrees of in-house R&D engagement. They also discover that information stocks and flows associated with hiring new scientists exert opposing influences on patent output, but knowledge flows and stocks pertaining to R&D collaborations is synergistic in fostering innovation. Hagedoorn and Wang [12] observe that there are no synergistic effects between external knowledge acquisition and internal R&D from research institutions and universities, where their experiential findings validate a corresponding correlation between in-house R&D and connections with other knowledge stakeholders, such as horizontal connections and value chain stakeholders.

The empirical research is ambiguous about the interaction of various knowledge-based activities in generating creative output. The nature of the knowledge-oriented activities analyzed, the measuring and estimate methodologies used, together with the nation and sample characteristics, may significantly influence the generation of mixed outcomes. The bulk of existing research primarily investigate collaborations between external and internal information sources, neglecting to clearly highlight the significance of knowledge flows and stocks in organizations' innovative performance or endeavors. Furthermore, the research mostly emphasizes inter-firm cooperation when analyzing the complimentary or substitutive connection among various knowledge-based activities, neglecting the significance of I-U partnerships as a crucial knowledge conduit for businesses' innovation endeavors. Roper and Hewitt-Dundas [13], who examine the collaborations between knowledge flows and knowledge stocks in companies' innovative activities, do not highlight the knowledge flows derived from educational institutions, nor do they address the knowledge stocks associated with firm exporting activities and age, which, as previously mentioned, may be significant, particularly in low- and medium-technology industries.

The squared terms of technology expenditure are markedly negative, whereas the squared term of R&D is negative but not statistically significant. The findings indicate that foreign TT and national R&D are complementary; the incremental effect of TT is enhanced when the affiliate participates in national R&D, and conversely. Simultaneously, diminishing returns to TT are seen, albeit the reduction in marginal effect occurs only at elevated levels of TT value (about 1.21 billion JPY). Affiliates get more advantages by incorporating localized R&D capabilities with technological advancements supplied from the main company, instead of depending only on the latter one. In contrast, localized R&D has a diminished influence when executed without TT from the parent organization. The calculated coefficients for interaction effects indicates that affiliates spending the sample mean on technological imports get an overall rate of R&D ROI (return on investment), which is 0.111 greater than those not engaging in import technology. Returns in licensing is 0.061 greater for affiliate investing the sample mean in R&D than one not involved in R&D. This represents a significant relative rise in the ROI, particularly for R&D returns.

V. DISCUSSION

The findings from the analysis of the empirical results present several insights regarding the dynamic relationships between R&D, technology payments, and their net effect on productivity change. The importance of labour and capital increases is evident since both are proved to have positive significant impact on productivity. We find that labour growth is 0.26 while capital growth is 0.12 hence indicating that within the context of the models analysed labour influences productivity growth slightly more than capital. This finding is in consonance with research by Lin and Shao [14] which have indicated that efforts to improve labour and capital inputs would help in the improvement of productivity especially in sectors that are driven by technologies. The above result may suggest that the elasticity of labour is relatively higher, perhaps meaning that firms may be looking towards boosting output through enhancement of workforce efficiency, including by strengthening skills and increasing efficiency. Capital investment is also important but, as noted above, it plays a relatively less significant role for evident reasons, which may be related with the fact that capital is a more multifaceted and gradual factor in such innovative industries as the advanced manufacturing and high technologies.

The findings show that the two inputs; R&D spending and technology payments are essential in enhancing productivity. In the restricted model, the results showed that R&D has a positive effect on the productivity with a pay back of 0.54 JPY for each JPY spent while technology has a more positive effect with the pay back of 0.76 JPY for each JPY spent. From these findings, it can be concluded that technology payments, where organisations simply buy technologies off the shelf by means of licensing, provide a greater level of near-term productivity than local R&D. This may be as a result of facts like imported technologies are usually developed to the later and does not require long time to be incorporated into the production line. On the other hand, local R&D entails time frame that is longer and riskier and accompanied by uncertainty because firms are involved in a research process which aims to produce technologies that might result in innovations. However, licensing has the advantage of generating a higher return in the short term, but it can be dangerous to count on external technologies because firms that have not developed internal innovation abilities may not be able to adapt to new technological models.

This research also reveals a strong positive correlation between technology and R&D payments which appear to be mutually reinforcing. As it can be observed from the above results, while the restricted model confirms that both technology and R&D payments have positive impacts on productivity, the full model is the only one that establishes a statistically significant interaction between technology and R&D payments. This implies that it is more advantageous for firms to both undertake local R&D and technology transfers than focusing only on one of these approaches. The positive interaction effect confirms complementarity between technology payments and R&D payments where the productivity of one is improved by the existence of the other. Specifically, those firms investing in local R&D but simultaneously relying on importing technology from outside sources like their MNC parent company or other technology partners are more likely to have more productivity improvement. This finding reinforces the need to have internal innovations complemented by the absorption of external knowledge. Businesses that incorporate both external sources of innovation are more capable of adapting, improving and modifying imported technologies to suit their needs, hence achieving optimum utilization of the two on productivity [15].

However, the measure taken also reveal the declining marginal benefit of both technology and R&D payments, especially at higher levels of spending. The quadratic terms added to the full model indicate that after some point, any increments in technology payments result in minuscule improvements in productivity. This is especially true for technology payments where the quadratic term is significant and negative; this suggests that the marginal returns to investing in external technologies are declining at higher levels of spending. This can be attributed to several factors; the process of absorption of foreign technologies, integration processes and optimization, and over dependency on external sources without much relevance to the actual business operational environments. In the same respect, the quadratic terms of R&D payments is also considered negative but findings show non-significance, which may imply that the principle of diminishing returns to local R&D may not be very prominent. However, the observation of declining productivity relative to R&D and technology payments means that there are inefficiencies and that firms have to get the right mix in order to optimize the amount of productivity gain that is obtainable from total expenditures on R&D and technology payments.

The low response rates for both R&D and technology payments at higher levels of investment is a very significant factor. While initial investments in these areas yields high rates of returns, further investments to achieve even higher returns yield lower incremental returns as firms ladder up the investment scale. This implies that although expenditure in R&D and technology payments are important for increasing productivity, there is a saturation point after which they exert little impact. Technology payments are also likely to raise the difficulty level of technology imports because firms that make high tech payments might be unable to fully assimilate and adapt the imported technologies hence getting low returns than expected. Likewise, although local R&D is crucial for building innovation capability, it might also reach the point where returns on investment are declining if not properly controlled. These low response rates underscore the need to apply strategic decision on how to invest in R&D and technology payments so as to maximize the impact of such expenditures among the firms.

The findings of this analysis hold important lessons for firms and policymakers alike. The results are therefore beneficial to firms because they show that developing a balanced innovation strategy that involves internal R&D and the outside acquisition of technologies is crucial. Using only one approach is counterproductive in the long run while integrated usage of both approaches has the best and optimal outcome for firms. There is also considerable R&D expenditure that firms embarked upon to strengthen internal R&D capabilities to complement the external sources of acquired technologies. This will assist them in a process of better adoption of imported technologies into suit their environment and vice versa. The implications of the results are that for policymakers, support for innovation cannot just be in terms of providing incentives for firms to undertake internal investment in R&D but also to acquire technology from outside sources. Strategies for encouraging cooperation between local firms and foreign technology suppliers, as well as encouraging firms to improve absorptive capacity, such as training and implementation of knowledge management technologies, may help firms gain better use of both internal and external sources of innovation.

VI. CONCLUSION

The results of this research make it possible to establish more refined links between R&D, technology payments, and productivity change. These two costs share responsibilities of improving productivity where technology payments provide a higher direct improvement than R&D owing to the readily adaptable external technology. However, local R&D, as pointed out earlier, is equally crucial for innovation and sustainable competitiveness, although its development cycle is long and uncertain. Analysis of these two inputs in terms of the interaction indicates that in order to obtain even higher results, it is necessary to complement local R&D with technology imports. This indicates that firms obtain the most value from a combination of internal and external sources of innovation because the integration of the two is mutually beneficial. Nevertheless, the fact that both technology payments and initial R&D investment exhibit declining returns indicates that investment should be made in a targeted manner. We observed that as firms spend more money acquiring technology from outsiders, the incremental returns are lower, which suggests that there exists an optimal level of expenditure after which productivity improves at a slow rate. This is also seen in the low response rates that was evidenced for both R&D and technology payments when investment was taken at higher levels.

CRediT Author Statement
The author reviewed the results and approved the final version of the manuscript.

Data Availability
The datasets generated during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interests
The authors declare that they have no conflicts of interest regarding the publication of this paper.

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