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Do Aid for Trade Flows Affect Technology Licensing in Recipient Countries?

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Abstract: There is an abundant literature on the economic (including trade) effects of Aid for Trade (AfT) flows. However, little attention has been devoted to the effect of AfT flows on demand for technology licensing. The present article aims to fill this void in the literature by investigating the effect of AfT flows on technology licensing in developing countries. The analysis has used an unbalanced panel dataset of 77 countries over the period from 2002 to 2019 and mainly the two-step generalized method of moments estimator. It has been established that AfT flows foster technology licensing in countries that experience lower trade costs. In addition, the analysis has revealed that adverse environmental and external (economic and financial) shocks significantly hamper innovation, including the demand for technology licensing, and that AfT flows promote technology licensing in countries that experience lower magnitudes of such shocks. Finally, AfT flows foster technology licensing in countries that diversify export products.

Keywords: Aid for Trade; technology licensing; trade costs

JEL Classification: F10; F35; L24

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1. Introduction

The international trade literature has emphasized the critical role of technology in trade promotion. The Ricardian model has provided that technological differences explain trade and specialization patterns between countries (Dornbusch et al. 1977). In the same vein, the 'product life cycle' model of Krugman's (1979) has shown that the diffusion of technologies from the North (developed countries) to the South (developing countries) influences countries' trade patterns and comparative advantage. Countries with a low level of technology tend to export low-value-added goods (e.g., Hufbauer 1970; Weldemicael 2014). Technological upgrading plays a greater role than trade cost reduction in promoting export product sophistication, notably in low-income countries (e.g., Weldemicael 2014).

For developing countries, the acquisition of technology from international technology diffusion can take place through multiple channels, including trade in goods and services, in particular imports of capital goods and technological inputs, foreign direct investment inflows or the pursuit of project-specific joint ventures, migration, direct trade in knowledge through technology purchases or licensing,[1] imitation, and reverse engineering (e.g., Bahar and Rapoport 2018; Cai et al. 2022; Fons-Rosen et al. 2018; Harrison and Rodriguez-Clare 2009; Javorcik 2004; Hoekman and Javorcik 2006; Lind and Ramondo 2018; and Pack and Saggi 1997). According to Pack and Saggi (1997), while foreign direct investment inflows may foster innovation, other modes of technology transfer, such as joint ventures and technology licensing, may generate greater advantages for less developed countries. Technological spillovers from foreign firms to local firms are likely to be larger than the ones arising from FDI inflows because the increased interaction involved in such arrangements will result in a greater transfer of knowledge to domestic firms.

A technology licensing-in (also referred to in the present analysis as 'technology licensing') is a contract that provides a licensee with the right to exploit a technology in exchange for the payment of upfront fees and/or royalties (e.g., Choi 2002; Moreira et al. 2020). It involves deals that are similar to arm's-length transactions, whereby one firm sells a technology and another buys the technology (Moreira et al. 2019; Conti et al. 2013). Moreira et al. (2020) have shown that in response to competitive pressure from rivals, firms resort to technology licensing, which is one of the most commonly observed contractual mechanisms used to acquire technologies. In contrast with alternative external knowledge-seeking actions such as alliances, technology licensing has some specific properties that facilitate firms' efforts to upgrade their R&D capabilities promptly and directly (e.g., Moreira et al. 2018, 2020).

At the Ministerial Conference of the World Trade Organization (WTO) held in Hong Kong in 2005, Trade Ministers set up the Aid for Trade (AfT) Initiative, which aims to help developing countries and least developed countries (LDCs) among them overcome trade-related obstacles that impede their integration into the global trading system. Many studies have shown that by helping reduce trade costs (e.g., Calì and Te Velde 2011; Tadesse et al. 2019; Tadesse et al. 2021; Vijil and Wagner 2012), AfT flows promote recipient countries' exports.[2]

The present article addresses the question as to whether AfT flows promote technology licensing.

Existing relevant studies have demonstrated theoretically and empirically that technology licensing can spur innovation. For example, Moreira et al. (2020) have used firm-level data to empirically determine that in the context of competitive pressure originating from rivals (i.e., when a firm's technological position is threatened by rivals), licensing-in increases a firm's capacity to innovate in areas where competitors have exerted pressure, notably in the presence of cumulative Research and Development investments. Other studies have shown that the innovation level is greater under licensing than under no licensing (e.g., Chang et al. 2013; Gallini and Winter 1985; Mukherjee and Mukherjee 2013). More recently, Colombo (2020) has explored theoretically the effect of licensing on innovation incentives when firms are heterogeneous. The author has established that licensing promotes cost-reducing innovation when the products are sufficiently different. However, in the presence of similar products, innovation under licensing is smaller than innovation under no licensing.

We posit that AfT flows can exert an effect on technology licensing through their trade cost reduction effect. To test this hypothesis, the analysis has used an unbalanced panel dataset of 77 countries over the annual period from 2002 to 2009 and the two-step system generalized method of moments (GMM) estimator. Empirical results have revealed that AfT flows encourage technology licensing in countries that experience lower trade costs. Furthermore, these resource inflows enhance technology licensing in countries that face low magnitudes of external and environmental shocks. In the same vein, AfT flows promote technology licensing in countries that diversify their export product baskets.

The remainder of this paper is structured around five sections. Section 2 presents a theoretical discussion on the effect of AfT flows on technology licensing, drawing from relevant literature reviews. Section 3 presents the empirical analysis, including the baseline model specification, an analysis of the data concerning the main variables of interest, and the econometric approach used to estimate the model. Section 4 interprets empirical outcomes. Section 5 goes deeper into the analysis, and Section 6 concludes.

2. Literature Review and Theoretical Discussion

The present analysis postulates that AfT flows would affect technology licensing primarily through their effects on trade costs. According to the Organization of Economic Cooperation and Development (OECD) (see OECD/WTO 2011), total AfT includes three main components[3] of total official development aid. These are the AfT for the build-up of economic infrastructure, the AfT allocated for the development of productive capacities, and the AfT related to trade policy and regulation. On the other hand, trade costs include all the costs incurred in delivering a good from the point of production to the final user. These are transport and time costs, tariff and non-tariff policy barriers, information costs, contract enforcement costs, regulatory and compliance costs, and distribution costs (Anderson and van Wincoop 2004, p. 692).

The effect of AfT flows (or AfT interventions) on recipient countries' exports has been the subject of important literature.[4] The latter has established that higher AfT flows—including AfT flows for the build-up of economic infrastructure, AfT flows for strengthening productive capacities, and AfT flows for trade policy and regulation—are associated with lower trade costs in recipient countries (e.g., Busse et al. 2012; Calì and Te Velde 2011; Gnangnon 2018; Helble et al. 2012; Hoekman and Nicita 2010; OECD/WTO 2015; Tadesse et al. 2017; Tadesse et al. 2019; Tadesse et al. 2021; Vijil and Wagner 2012). Thanks to their lower trade costs reduction effect, AfT flows enhance firms' goods and services exports (see the literature review of Benziane et al. 2022), promote export product diversification (e.g., Gnangnon 2019a, 2019b; Kim 2019), and facilitate service export diversification (e.g., Gnangnon 2021b). AfT interventions are also instrumental in facilitating the import of goods by recipient countries (Hühne et al. 2014) and in promoting the diversification of imported goods (Gnangnon 2021a; Ly-My et al. 2021).

On the other side, lowering trade barriers (and promoting trade openness) facilitates the diffusion of technology (e.g., Buera and Oberfield 2019; Harrison and Rodriguez-Clare 2009; Perla et al. 2021; Sampson 2016; Santacreu 2015) and encourages innovation[5] (e.g., Autor et al. 2016; Bustos 2011; Coelli et al. 2022; Gorodnichenko et al. 2010; Grossman and Helpman 1991; Rivera-Batiz and Romer 1991). According to studies such as Comin and Hobijn (2010) and Comin and Mestieri (2018), the adoption of the best knowledge arises only from the diffusion of technology from the economies on the technology frontier.

In light of the well-established finding that AfT flows help reduce trade costs and that reducing trade barriers (including trade costs) encourages innovation, we can hypothesize that AfT flows would likely promote innovation in countries that experience lower trade costs. The development that follows aims to clarify this hypothesis. After highlighting the advantages of technology licensing over other forms of technology acquisition in developing countries (Section 2.1), we briefly review the literature on the effect of trade costs on innovation (Section 2.2), and we lay out the research hypothesis.

2.1. Advantages of Technology Licensing

Technology licensing (notably technology licensing-in) and other knowledge-seeking actions are an important means for firms to have access to knowledge and technologies developed outside their organizational boundaries (e.g., Anand and Khanna 2000; Moreira et al. 2020). Technology licensing has certain specific characteristics that make it attractive compared to other knowledge-seeking actions. First, licensing entails lower setup costs and fewer interactions with the counterparty than other knowledge-sourcing agreements (e.g., Klueter et al. 2017). Second, technology licensing has the advantage of not requiring significant coordination and of limiting uncertainty over whether and how a firm can incorporate and use an acquired technology (e.g., Contractor 1990; Mowery et al. 1996). This is because, in contrast with research alliances that involve the collaboration of several firms through a combination of their resources and capabilities to develop a new technology, licensing contracts entail the licensor agreeing to unilaterally transfer know-how and intellectual property related to a technology to the licensee (e.g., Contractor 1990; Jensen and Thursby 2001). Third, in contrast with alliances, licensing involves the transfer of existing technologies, as it allows firms to choose the type and characteristics of the technology that they wish to acquire ex ante and incorporate it into their ongoing R&D tasks and efforts (e.g., Moreira et al. 2018, 2020). Fourth, technology licensing enables firms to expand their existing technological knowledge, including by leveraging the knowledge developed by the licensor (in particular if the latter operates at the technological frontier and if the licensee is not familiar with the technology acquired) to expand their technological base (e.g., Katila and Ahuja 2002; Leone and Reichstein 2012). Thus, the acquisition of specific ready-made external R&D solutions that can improve internal R&D (e.g., Leone and Reichstein 2012) allows licensees to focus their R&D activities on limited activities, which helps reduce the uncertainty associated with the development of future innovations (e.g., Markman et al. 2005). Fifth, licensing involves a transfer of legal rights from the licensor to the licensee (e.g., Moreira et al. 2020), thereby allowing the licensee to build on and exploit specific technologies through an alignment of its internal R&D with a changing technological landscape (e.g., Eisenhardt and Martin 2000; Ziedonis 2004).

2.2. A Literature Review on the Effect of Trade Costs on Innovation

There is an extensive literature on the adverse effects of trade costs on firms' willingness to innovate.[6] According to Yeaple (2005), a reduction in trade costs increases the share of firms that export and use the most advanced technology. Similarly, Atkeson and Burstein (2010) have found that trade liberalization leads to increased innovation by exporters. Desmet and Parente (2010) have found that trade liberalization always increases innovation, regardless of whether such a liberalization takes the form of a marginal decrease in trade costs or a shift from autarky to frictionless trade. Gorodnichenko et al. (2010) have obtained for the developing European countries that the increase in import competition arising from import market liberalization has enhanced firms' innovation. Bustos (2011) found for the Brazilian case that firms in industries that enjoyed higher tariff reductions increased their spending[7] on technology faster, notably by 0.20 to 0.28 log points. In other words, reducing tariff costs leads more firms (including both old and new ones) to expand sales and to innovate more (including adopting new technology) than non-exporting firms. In their theoretical analysis, Long et al. (2011) have found that trade liberalization increases aggregate R&D when trade costs are low and decreases R&D when trade costs are high. Iacovone (2012) has used Mexican firm data and established that trade liberalization under the North American Free Trade Agreement (NAFTA) has enhanced productivity growth on average. This strong positive productivity growth effect of trade liberalization was attributed to an increase in input usage and investments, but more importantly to firms' innovative and managerial efforts, which were significantly stronger in sectors where the scope for innovative activities was larger. Bloom et al. (2013) have shown that low-cost import competition (which represents an adverse shock for domestic trading firms) can increase the innovation rate if factors of production are trapped inside a firm. As a matter of fact, factors of production that are trapped inside a firm will likely suffer from the unexpected low-cost import competition. As the opportunity costs of the inputs used by these firms to innovate (i.e., to design and produce new goods) subsequently fall, the firms will be incentivized to innovate more.[8] Stoyanov (2013) has demonstrated theoretically that trade cost reduction (and in particular tariff reduction) induces exporters to switch to more productive and more capital-intensive technologies because they can spread the technology adoption costs over larger quantities of output.[9] Impullitti and Licandro (2018) have shown that by increasing product market competition and reducing markups, the reduction of trade costs forces the least productive firms out of the market and leads to a reallocation of resources towards surviving firms (see Melitz 2003). As a result, both the average size of surviving firms and their aggregate productivity increased. In turn, the increase in surviving firms' size stimulates cost-reducing innovation, which leads to faster productivity growth. Shu and Steinwender (2019) have demonstrated, inter alia, that trade liberalization promotes innovation in emerging countries. The firm-level analysis has revealed that trade liberalization exerts a higher positive effect on more productive firms, while it exerts a more pronounced negative effect on initially less productive firms. Navas (2015) has, however, found, among others, that the movement from autarky to free trade encourages innovation and productivity growth in those sectors that are initially less competitive. Akcigit and Melitz (2021) have shown theoretically how greater exposure to international markets through higher exports provides incentives for innovation. Perla et al. (2021) have found, inter alia, that lowering trade barriers encourages faster technology adoption. Using data on tariff cuts during the 1990s and data on innovation among firms from 65 countries, Coelli et al. (2022) have empirically obtained a large positive effect of tariff cuts on innovation (measured by patent data).

A key message from all these studies is that higher trade costs inhibit innovation, including in developing countries.

On the basis of the discussion laid out above, we postulate the following hypothesis:

Hypothesis 1. *AfT flows could exert an effect on technology licensing through the channel of trade costs, in particular, by reducing trade costs in recipient countries.*

3. Empirical Analysis

This section presents the model specification (Section 3.1), provides some data analysis (Section 3.2), and discusses the econometric approach to estimating the model (Section 3.3).

3.1. Model Specification

The empirical literature[10] on the determinants of technology licensing-in has usually focused on the determinants of the flows of royalties and licensing fees that accrue to licensors (i.e., the royalties and licensing received by licensors), notably in the developed world. These studies have essentially used firm-level data (e.g., Branstetter et al. 2006; Kim 2004; Kim and Clarke 2013; Kim and Vonortas 2006; Zuniga and Guellec 2009). Other studies have not relied on firm-level data but rather explored the macroeconomic factors underpinning royalties and licensing fees received by developed countries. For example, Yang and Maskus (2001a) have examined the effect of Intellectual Property Rights (IPRs) on the royalties and licensing fees received by the United States in a given year from a given foreign country. Few studies such as Gentile (2017) and Kanwar (2012) have yet focused on technology licensing in developing countries, but Gentile (2017) has used firm-level data to investigate the effect of IPRs on technology licensing in developing countries, where technology licensing has been measured by a dummy variable that takes the value of 1 if a firm located in a developing country uses technology licensed from a foreign firm and 0, otherwise. In contrast, Kanwar (2012) has used a country-year analytical framework[11] (and not a country-firm/year analytical framework) to examine the effect of IPRs on technology licensing in developing countries. The author has measured technology licensing by the royalty and license fee payments made by a given developing country in a given year.

The present study does not intend to examine the effect of IPRs on technology licensing, but rather the effect of AfT flows on technology licensing. It is close in spirit to works by Kanwar (2012) and Park and Lippoldt (2008).

To investigate the effect of AfT flows on technology licensing in developing countries (measured by royalty and license fee payments), we build on previous works on the macroeconomic determinants of technology licensing in developing countries. In particular, we draw many insights from the work of Kanwar (2012) and postulate the following baseline model:

$$\begin{aligned} RLFP_{it} = \beta_0 + \beta_1 RLFP_{it-1} + \beta_2 Log(AfT)_{it} + \beta_3 Log(GDPC)_{it} + \beta_4 SHOCK_{it} + \beta_5 HUM_{it} + \beta_6 FD_{it} \\ + \beta_7 INST_{it} + \beta_8 Log(POP)_{it} + \beta_9 DUMOUT_{it} + \gamma_t + \mu_i + \epsilon_{it} \end{aligned} \quad (1)$$

The subscripts i and t are, respectively, a recipient-country of AfT flows and a time-period. On the basis of the available data, we constructed an unbalanced panel dataset of 77 countries over the period from 2002 to 2019. To dampen the effect of business cycles on variables under analysis (and hence, avoid estimating cyclical effects), we use non-overlapping sub-periods of 3-year average data, which are 2002–2004; 2005–2007; 2008–2010; 2011–2013; 2014–2016; and 2017–2019. μ_i are countries' unobserved time-invariant specific effects. γ_t stands for global shocks that affect simultaneously all countries' AfT inflows. ϵ_{it} is an error term. β_1 to β_9 are parameters to be estimated.

The dependent variable "RLFP" is the transformed indicator of the real values of the royalties and license fee payments made by a given AfT recipient country in a time period t. The initial indicator of royalties and license fee payments made by countries was expressed in current US dollars. We have deflated it with the GDP deflator (constant 2015 US dollars) and obtained an indicator denoted "RLFP1". However, the latter contains many zeros and displays a highly skewed distribution. Therefore, we have transformed it so as to obtain the indicator "RLFP": RLFP $= \log(1 + RLFP1)$.

The presence of the one-period lagged dependent variable aims to account for the possible persistence of the indicator "RLFP" over time as well as mitigate omitted variable problems in model (1).

The regressor of interest "AfT" is the real gross disbursements of AfT flows, expressed in constant prices in 2019, US Dollar. The present analysis uses total AfT flows (denoted "AfTTOT") as well as its three major components, which are AfT flows related to economic infrastructure (denoted "AfTINFRA"), AfT flows allocated for building productive capacities (denoted "AfTPROD"), and AfT flows related to trade policy and regulation (denoted "AfTPOL"). All four types of AfT variables are described in Appendix A.

The control variables "GDPC", "SHOCK", "HUM", "FD", "INST," and "POP" are respectively the indicators of real per capita income, the magnitude of environmental and external economic and financial shocks, human capital, financial development, institutional and governance quality, and population size. The natural logarithm has been applied to the variables "GDPC" and "POP" in order to reduce their skewed distributions. All these variables have been described in Appendix A. The variable "DUMOUT" is an indicator of outliers identified in the dataset. It takes the value of 1 for outliers and 0 otherwise (see the next section).

3.1.1. Effect of the Country's Size

The population size and the real per capita income have been introduced in model (1) in order to capture differences in countries' sizes among the countries under analysis. Desmet and Parente (2010) have shown that larger markets (measured by a higher population size or greater trade openness) increase competition, support a larger variety of goods (thereby resulting in a more crowded product space), and facilitate process innovation. Kanwar (2012) has argued that economies that are larger in terms of production of goods and services are, ceteris paribus, likely to have greater needs for technology. Such economies would, therefore, increase their demand for technology imports. We expect that, ceteris paribus, the demand for foreign technologies by large countries is likely to be higher than that of countries with a relatively smaller size.

3.1.2. Effects of Adverse Environmental and External Economic and Financial Shocks

This variable has been introduced in the analysis in order to take into account the effect of adverse external shocks on innovation and, hence, on technology licensing. Developing countries are more prone to environmental and external economic and financial shocks than developed countries and hence face a greater magnitude of shocks than the latter (e.g., Aguiar and Gopinath 2007; Barrot et al. 2018; Cariolle et al. 2016). Adverse exogenous shocks, such as economic and financial crises and natural disasters, exert a negative effect on businesses' activities, including those of small and medium firms, as well as on their innovative capacity.[12] For example, a number of studies have pointed out that the vulnerability of firms to natural disasters tends to skew disproportionally toward smaller businesses, with impacts being unevenly distributed across geography, firm size, and economic sector (e.g., Miklian and Hoelscher 2021; Pan 2011; Sydnor et al. 2017). As for economic and financial shocks, Cowling et al. (2018) have shown that the 2008/09 global financial crisis had a long-lasting scarring effect on small and medium enterprises (SMEs), although signs of some recovery in performance loomed. Lee et al. (2015) have found for a large set of SMEs (over 10,000 SMEs in the United Kingdom) that the global 2008/2009 financial crisis has led to a restriction of access to finance for both innovative firms and non-innovative firms. However, the deterioration in general credit conditions has been more pronounced for non-innovative firms, with the exception of absolute credit rationing, which remains more severe for innovative firms. Aarstad and Kvitastein (2021) have argued that an unexpected external economic shock can affect innovation performance through its negative effect on demand and, hence, on competition. In particular, they have studied the innovation performance of Norwegian enterprises before and after the sudden and unexpected price decline of crude oil by the midyear of 2014. They have found that this crisis negatively affected enterprises operating across many industries in regions that were dependent on the petroleum sector, while other regions were almost unaffected. The analysis has also revealed that for enterprises that were innovative before the decline of the oil price, there was a borderline significant inverted U-relationship between regional oil dependency before the decline and enterprises' product innovation performance after the decline. Conversely, for non-innovative enterprises before the decline, there was a robust, significant positive linear relationship. Archibugi et al. (2013) have observed that the severe adverse effect of the 2008/09 global crisis on firms' short-term willingness to invest in innovation was uneven across firms. Using the United Kingdom's firm-level dataset (the United Kingdom Community Innovation Survey), they have uncovered that few firms have been able to increase their investment in the adverse macroeconomic environment induced by the crisis. Specifically, in the wake of the crisis, innovative activities have been concentrated within a small group of fast-growing new firms and those firms that were already highly innovative before the crisis. Companies that were engaged in more explorative strategies towards new product and market developments were those that coped better with the crisis. Overall, we expect that adverse environmental and external economic and financial shocks will negatively influence innovation in developing countries and, in this regard, could lead to a lower demand for foreign technology, including through technology licensing.

3.1.3. Effect of Human Capital

The demand for foreign technology with a view to increasing innovation also depends on the country's human capital base (e.g., Romer 1990; Van Reenen 2022), as the latter is key for absorbing the technology imported (e.g., Bye and Fæhn 2022; Kanwar 2012). In their literature review of microstudies concerning the factors underpinning technology diffusion in low-income countries, Foster and Rosenzweig (2010) have pointed out that schooling is a key determinant of the adoption of new technologies. We expect that an accumulation of human capital, including an improvement in the education level, will be positively associated with the demand for foreign technology.

3.1.4. Effect of Financial Development

Foster and Rosenzweig (2010) have also found, among other factors, that credit constraints are a major obstacle to the adoption of new technologies in low-income countries. According to Dabla-Norris et al. (2012), financial development encourages innovation, in particular for good innovation projects, as bad projects are unlikely to be funded. In other words, the effects of financial development on innovation are likely to be greater for high-technology firms than for low-technology firms. Brown et al. (2012) have shown that financing constraints discourage innovative activity because financially-constrained firms (especially younger, smaller firms) may invest in R&D to a level well below the privately optimal one (i.e., the one prevailing in a world with no financial frictions). In a recent study, Aristizabal-Ramirez et al. (2017) demonstrated that the effect of financial development on the probability of a firm to innovate in developing countries is conditioned on the firm's size. In particular, only larger firms benefit from financial development. Against this background, it is difficult to predict the direction of the effect (at the firm level) of financial development on innovation and, hence, on the demand for foreign technology through technology licensing. Trinugroho et al. (2021) have observed that there exists a non-linear relationship between financial development and innovation, whereby the levels of credit and equity market developments are beneficial to a country's innovation only up to a certain threshold. We may, therefore, expect that at the aggregate (i.e., macroeconomic level), financial development can encourage the demand for foreign technology, including through technology licensing.

3.1.5. Effect of the Quality of Institutions and Governance

The literature has also considered the effect of institutions on innovation. North (1991, p. 97) has provided that institutions may be defined as the 'humanly devised constraints that structure political, economic, and social interaction'. D'Ingiullo and Evangelista (2020, p. 1724) have argued that the institutional framework (i.e., the specific institutional characteristics of the considered system of innovation) affects the ability to translate innovation inputs into innovation outputs by acting as a social filter (e.g., Crescenzi and Rodríguez-Pose 2009). D'Ingiullo and Evangelista (2020) have obtained empirically that improving institutional quality, through better government effectiveness, regulatory quality, and voice and accountability, enhances innovation. Donges et al. (2022) have shown that institutions that broaden access to economic gains induce a large increase in a region's innovativeness. In particular, the positive innovation effect of institutions is stronger for high-tech innovation. The authors have concluded that inclusive institutions are a first-order determinant of innovation. Additionally, countries that are prone to conflicts and political violence are likely to experience a significant decline in innovation performance. This is because episodes of conflicts and political violence can undermine the physical security of SMEs, increase local political and economic instability, destroy human capital as well as supply chain and logistics, reduce access to finance, result in other operational challenges (e.g., Naudé et al. 2013), and reduce firms' investment (e.g., Canares 2011; Deininger 2003). On the basis of these findings, we can expect that an improvement in institutional and governance quality, materialized, for example, through better government effectiveness, regulatory quality, voice, and accountability, and the absence of conflicts and political instability, would provide incentives for the demand for foreign technology with a view to increasing innovation.

3.2. Data Analysis

We provide in Figure 1 the developments of both total AfT flows (i.e., "AfTTOT") and the real values of royalties and license fee payments (i.e., the indicator "RLFP1") over the period from 2002 to 2019. The left-hand side graph in Figure 2 shows the cross-plot between total AfT flows (expressed in natural logarithm) and the indicator "RLFP" (i.e., the transformed indicator of the real values of royalties and license fee payments). The right-hand side graph in Figure 2 shows the cross-plot between the indicator of total trade costs[13] (which is the channel through which AfT flows affect technology licensing) and the indicator "RLFP".

We observe in Figure 1 that, on average, over the full sample, both total AfT flows and royalties and license fee payments increased steadily over time. Total AfT flows moved upward from US$ 125.13 million in 2002–2004 to US$ 361.07 million in 2017–2019, and the real values of royalties and license fee payments also increased (almost tripled) from US$ 366.83 million in 2002–2004 to US$ 908.987 million in 2017–2019.

We also note from Figure 2 that while total AfT flows are positively correlated with the real values of royalties and license fee payments (see the left-hand side graph in this Figure), overall trade costs are negatively correlated with the real values of the transformed indicator of royalties and license fee payments (see the right-hand side graph in this Figure). In addition, some outliers appear in the two graphs and concern notably instances where the real values of royalties and license fee payments (i.e., the values of the indicator "RLFP") are lower than 10. These outliers are taken into account through the introduction of the variable "DUMOUT" in model (1).

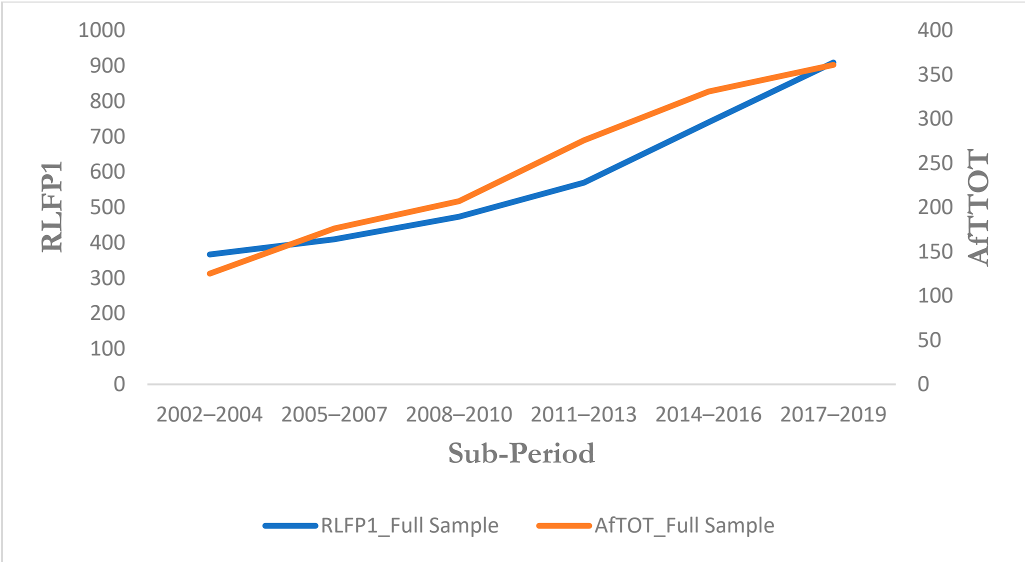

Figure 1. Total AfT and technology licensing_over the full sample. Source: Author. Note: The variable "RLFP" is the 'non-transformed' indicator of royalties and license fee payments and is expressed in millions of US$, constant 2015 prices. The variable "AfTTOT" (the gross disbursement of total Aid for Trade) is expressed in millions of US$ at constant 2019 prices.

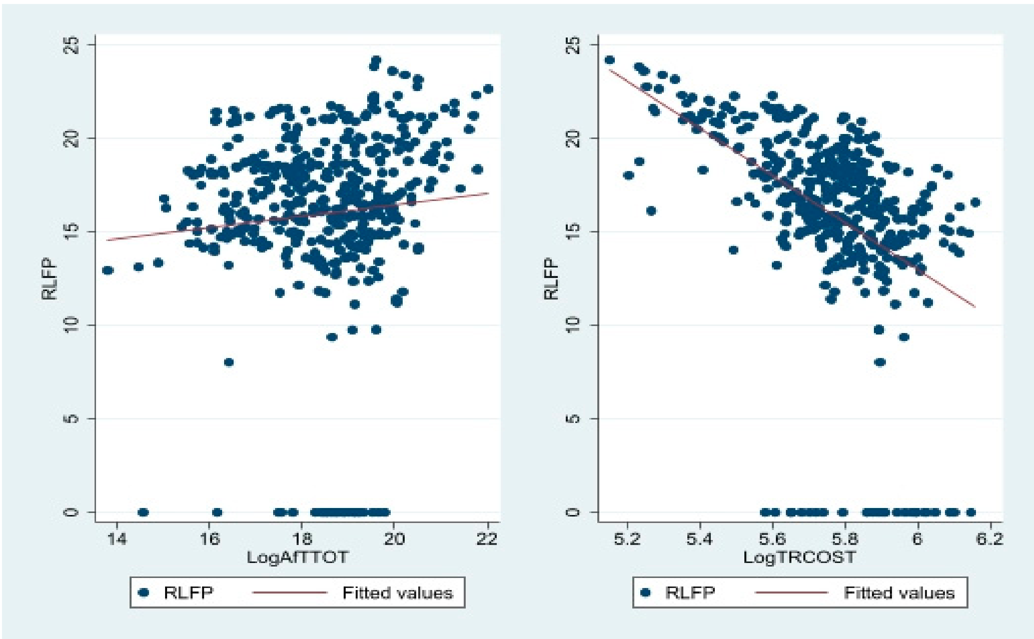

Figure 2. Correlation pattern between total AfT flows and technology licensing and between AfT flows and the overall trade costs_Over the full sample. Source: Author. Note: The variable "RLFP" is the 'transformed' indicator of the real values of royalties and license fee payments. The variable "AfTTOT" (the gross disbursement of total Aid for Trade) is expressed in constant 2019 prices.

3.3. Econometric Approach

We first estimate model (1) by means of the pooled ordinary least squares (POLS) estimator and the within fixed effects (FE) estimator, bearing in mind that these estimators do not address the Nickell bias[14] associated with the presence of the lagged dependent variable as a regressor in model (1) (Nickell 1981) as well as other potential endogeneity problems (including the reverse causality) that plague model (1). Note that standard errors obtained from the regressions based on the POLS and FE estimators are corrected for heteroscedasticity, autocorrelation, and the contemporaneous correlation among countries in the error term using the Driscoll and Kraay (1998) technique. The outcomes of these estimations are presented in columns [1] and [2] of Table 1. Note that despite the likely biased nature of these estimates, they have been presented with a view to comparing them with those obtained from the use of the two-step generalized method of moments (GMM) estimator, which is, as described below, our main estimator in the empirical analysis.

Table 1. Effect of AfT flows on Technology licensing. Estimators: POLS, FE, and Two-Step System GMM.

	POLS	**FE**	**Two-Step System GMM**
Variables	RLFP	RLFP	RLFP
	(1)	(2)	(3)
$RLFP_{t-1}$	0.268 ***	0.0598 ***	0.171 ***
	(0.0292)	(0.0205)	(0.0134)
Log(AfTTOT)	−0.173 ***	−0.0610 *	−0.234 ***
	(0.0278)	(0.0364)	(0.0610)
Log(GDPC)	0.774 ***	−0.307	0.922 ***
	(0.0268)	(0.483)	(0.156)
SHOCK	−0.00818	0.00327	−0.0195 ***
	(0.00798)	(0.0133)	(0.00512)
HUM	0.114	−0.146	0.355
	(0.187)	(0.247)	(0.223)
FD	0.00930 ***	0.0117 ***	0.00943 ***
	(0.000814)	(0.00160)	(0.00321)
INST	0.135	−0.255 ***	0.293 ***
	(0.105)	(0.0526)	(0.0915)
DUMOUT	−10.80 ***	−10.98 ***	−10.11 ***
	(1.254)	(0.865)	(0.349)
Log(POP)	0.799 ***	4.985 ***	0.765 ***
	(0.0556)	(0.817)	(0.0677)
Observations—Countries	333–77	333–77	333–77
R-squared	0.911		
Within R-squared		0.7688	
AR1 (*p*-Value)			0.0346
AR2 (*p*-Value)			0.7971
AR3 (*p*-Value)			0.2959
OID (*p*-Value)			0.3576

Note: * p-value < 0.1; ** p-value < 0.05; *** p-value < 0.01. Robust standard errors are in parenthesis. In the regressions based on the two-step system GMM estimator, all variables except for the variables "SHOCK" and "POP" have been treated as endogenous. The variables "SHOCK" and "POP" have been treated as exogenous. Time dummies have been included in the regressions. In the GMM-based regressions, two lags of endogenous variables have been used as instruments.

In fact, to mitigate the above-mentioned endogeneity concerns, we use the well-known and widely used two-step system GMM estimator of Blundell and Bond (1998). This estimator is now well employed in the macroeconomic empirical literature and applies to dynamic panel datasets of small time periods and a large number of individuals. It helps address the Nickell bias, the reverse causality issues, as well as the possible endogeneity problems arising from errors in the measurement of variables and omitted variables problems. It is asymptotically more efficient than the difference GMM estimator of Arellano and Bond (1991), as it uses additional moment conditions that reduce the imprecision and potential bias related to the difference GMM estimator (e.g., Bond 2002; Blundell and Bond 1998).

In the present analysis, we have considered all variables, with the exception of population size and the indicator of shocks, as endogenous due to the potential reverse causality from the dependent variable to each of these regressors. For example, concerning our variable of interest (i.e., AfT flows), we can reasonably argue that while we expect AfT flows to influence technology licensing, it is also possible that donors supply higher AfT flows to countries that are at the bottom of the technological ladder with a view to helping them move up this ladder and export higher value-added products. The same reasoning applies to the control variables considered endogenous.

To ensure the correctness of all specifications of model (1) estimated by means of the two-step system GMM estimator, we report the outcomes of the standard diagnostic tests, which are the Arellano–Bond test of the presence of first-order serial correlation in the first-differenced error term (AR (1)), the Arellano–Bond test of the absence of second-order autocorrelation in the first-differenced error term (denoted AR (2)), and the Sargan/Hansen test of over-identifying restrictions (OID). We also present the results of the test of the absence of third-order autocorrelation in the first-differenced error term (denoted AR (3)), as this test may signal whether the model specification concerned suffers from the omitted variable problem. A given model estimated by the two-step system GMM estimator is considered as well specified if the p-values of the AR(1) test are lower than 0.10 at the 10% level and the p-values of the AR(2) test and of the OID test are higher than 0.01 at the 10% level. Moreover, we expect that the p-value related to the AR(3) test should be higher than 0.01 at the 10% level.

To reduce the risk of instrument proliferation that could result in the loss of the power of the above-mentioned diagnostic tests (e.g., Roodman 2009), we limit to 2 the number of lags used to generate the instrumental variables in the GMM-based regressions.

The outcomes obtained using the two-step system GMM estimator are as follows:

Column [3] of Table 1 reports the outcomes of the estimation of the specification of model (1), where the variable of interest "AfT" is measured by total AfT flows.

Table 2 contains outcomes that allow testing Hypothesis 1, that is, whether (and if so, the extent to which) the effect of AfT flows on technology licensing works through the channel of trade costs. The first column of this Table contains outcomes that allow examining whether trade costs genuinely represent a channel through which AfT flows could affect technology licensing. These outcomes are obtained by estimating a specification of model (1), which is nothing else than the baseline model (1) to which we add the indicator measuring the overall trade costs. We expect that if trade costs represent genuinely a channel through which total AfT flows affect technology licensing, then further to the introduction of the indicator of the overall trade costs in the baseline model (1), the coefficient of the variable measuring total AfT flows should decrease while remaining significant at the conventional significance levels, or it should lose its statistical significance (i.e., it should become statistically not significant) at the conventional significance levels. Trade costs are measured using the indicators developed by Arvis et al. (2012, 2016) for goods, building on the definition of trade costs by Anderson and van Wincoop (2004). In fact, we use the overall trade costs, whose two major components are tariff costs and nontariff costs. The 'average' overall trade costs (denoted "TRCOST") represent, for a given country in a given year, the average of the bilateral overall trade costs on goods across all trading partners of this country. Likewise, the indicator of average tariff costs represents, for a given country in a given year, the average of the bilateral comprehensive tariff costs across all trading partners of this country. The indicator of average nontariff costs has been computed for a given country in a given year as the average of the bilateral comprehensive nontariff costs affecting goods (i.e., the comprehensive trade costs, excluding the tariff costs) across all trading partners of that country. It is important to emphasize that all three "average" trade cost indicators were first computed per year and then averaged over the non-overlapping sub-periods referred to above. Higher values of an indicator of trade costs show higher trade costs. Further details on the computation of these trade cost indicators are provided in Appendix A. The natural logarithm has been applied to all three trade cost indicators in order to reduce their skewed distributions.

Table 2. Effect of AfT flows on Technology licensing for varying trade costs. ***Estimator***: Two-Step System GMM.

Variables	RLFP	RLFP	RLFP	RLFP
	(1)	(2)	(3)	(4)
$RLFP_{t-1}$	0.181 ***	0.163 ***	0.148 ***	0.145 ***
	(0.0127)	(0.0107)	(0.00828)	(0.00622)
Log(AfTTOT)	−0.271 ***	3.079 ***	0.393 ***	3.969 ***
	(0.0416)	(0.575)	(0.151)	(0.679)
[Log(AfTTOT)]*[Log(TRCOST)]		−0.581 ***		
		(0.103)		
[Log(AfTTOT)]*[Log(TARIFF)]			−5.562 ***	
			(1.475)	
[Log(AfTTOT)]*[Log(NONTARIFF)]				−0.757 ***
				(0.120)
Log(TRCOST)	0.973 **	11.87 ***		
	(0.422)	(1.801)		
Log(TARIFF)			118.9 ***	
			(25.94)	
Log(NONTARIFF)				13.95 ***
				(2.160)
Log(GDPC)	0.548 ***	0.820 ***	0.624 ***	0.994 ***
	(0.121)	(0.0963)	(0.0674)	(0.0573)
SHOCK	−0.0245 ***	−0.0184 ***	0.00610	−0.00726 **
	(0.00520)	(0.00362)	(0.00440)	(0.00317)
HUM	0.510 ***	0.230 **	0.673 ***	0.447 ***
	(0.160)	(0.0967)	(0.120)	(0.0764)
FD	0.0163 ***	0.0145 ***	0.00636 ***	0.0101 ***
	(0.00271)	(0.00230)	(0.00151)	(0.00267)
INST	0.408 ***	0.342 ***	0.462 ***	0.138 **
	(0.0666)	(0.0552)	(0.0569)	(0.0644)
DUMOUT	−10.03 ***	−10.12 ***	−10.71 ***	−10.96 ***
	(0.242)	(0.209)	(0.204)	(0.138)
Log(POP)	0.747 ***	0.864 ***	1.059 ***	0.943 ***
	(0.0526)	(0.0392)	(0.0307)	(0.0246)
Observations—Countries	331–77	331–77	324–75	323–75
AR1 (*p*-Value)	0.0397	0.0460	0.0296	0.0374
AR2 (*p*-Value)	0.7107	0.8162	0.4568	0.5830
AR3 (*p*-Value)	0.2905	0.3584	0.4424	0.7236
OID (*p*-Value)	0.3988	0.3597	0.6654	0.4896

Note: * *p*-value < 0.1; ** *p*-value < 0.05; *** *p*-value < 0.01. Robust standard errors are in parenthesis. In the regressions based on the two-step system GMM estimator, all variables except for the variables "SHOCK" and "POP" have been treated as endogenous. The variables "SHOCK" and "POP" have been treated as exogenous. Time dummies have been included in the regressions. In these regressions, two lags of endogenous variables have been used as instruments.

Columns [2] to [4] of Table 2 present outcomes that help examine how the effect of total AfT flows on technology licensing changes for varying trade costs (the latter could be the overall trade costs or its components, namely tariff costs and non-tariff costs[15]). To obtain these outcomes, we estimate three specifications of the baseline model (1), with each specification of this model including the indicator of trade costs (either the overall trade costs or one of its two components, namely tariff costs and non-tariff costs) and the multiplicative variable between this indicator of trade costs and the variable measuring total AfT flows.

4. Interpretation of Results

The estimates presented in all columns of Tables 1 and 2 show that all coefficients of the lagged dependent variable are positive and significant at the 1% level. These results indicate the persistence of the indicator of real royalties and license fee payments over time, and hence the need for considering the specification of the baseline model (1) in a dynamic form. We also note from column [3] of Table 1 and from all columns of Table 2 that all model specifications whose results are reported in these columns are well specified. This is because all these model specifications pass successfully the diagnostic tests that help evaluate the validity of the two-step system GMM estimator as a suitable estimator for the empirical analysis (see the outcomes of the diagnostic tests reported at the bottom of all columns mentioned above). In other words, all models whose results are reported in column [3] of Table 1 and in all columns of Table 2 are correctly specified. On another note, we note from columns [1] to [3] that, in line with the recommendation by Bond et al. (2001), the coefficient obtained from the regression based on the two-step GMM estimator is higher than the one arising from the regression based on the FE estimator but lower than the one obtained from the regression based on the POLS estimator. On the basis of all these findings, we conclude that the two-step system GMM estimator is well suited for the empirical analysis.

As for the estimates themselves, we note from column [1] of Table 1 (results based on the POLS estimator) that total AfT flows are associated negatively and significantly (at the 1% level) with technology licensing (the coefficient of this effect is −0.173). At the same time, the estimates presented in column [2] of the same Table (results based on the FE estimator) also indicate a negative effect of total AfT flows on technology licensing, but significant only at the 10% level (the magnitude of the effect amounts to −0.06). We observe across columns [1] and [2] of the Table that financial development and population size affect positively and significantly the demand for technology licensing by AfT recipient countries. However, while the real per capita income influences technology licensing positively and significantly for results based on the POLS estimator, its effect is statistically nil for results based on the FE estimator (see results in column [2] of Table 1). On the other side, institutional and governance quality appear to exert a negative and significant effect on technology licensing only for results based on the FE approach, as the estimate of this variable stemming from the regression based on the POLS estimator is not significant at the 10% level. We once again recall that these outcomes are likely biased given the potential endogeneity concerns raised above.

We now turn to the estimates reported in column [3] of Table 1, that is, the ones arising from the regressions based on the two-step system GMM estimator. We observe from column [3] of this Table that the coefficient of the variable "AfTTOT" is negative and significant at the 1% level and amounts to −0.234. We conclude that total AfT flows reduce the demand for foreign technology through technology licensing. A 1 percent increase in total AfT flows leads to a decrease in the payment of royalties and license fees by 0.234 percent. The magnitude of this negative effect of total AfT flows on technology licensing is higher (in absolute value) than the one obtained from results based on both the POLS and FE estimators. While this puzzling outcome certainly reflects the fact that the effect of total AfT flows on technology licensing likely depends on the prevailing trade costs in the AfT recipient country,[16] we also question whether the magnitude of shocks that hit countries matters significantly for the effect of total AfT flows on technology licensing. We will test this hypothesis later in the analysis. For the time being, we test Hypothesis 1, i.e., we examine whether the effect of AfT flows on technology licensing works through the channel of trade costs (see estimates reported in Table 2).

Estimates of control variables in column [4] show that countries' size, measured by both real per capita income and population size, is positively and significantly (at the 1% level) associated with technology licensing. At the 1% level, higher shocks discourage technology licensing. Likewise, at the 1% level, financial development and the improvement of institutional quality induce a higher demand for foreign technology through technology licensing. Finally, there is no significant effect of human capital on technology licensing at the conventional significance level.

We now consider estimates in Table 2. At the outset, we find that estimates of control variables in Table 2 are in line with those in column [3] of Table 1. We note from the first column of this Table that after introducing the variable measuring the overall trade costs in the baseline model (1), the coefficient of the variable "AfTTOT" (in Logs) becomes −0.271, moving from −0.234 in column [3] of Table 1 (which was obtained from the estimation of the baseline model (1) without the indicator of the overall trade costs). It appears that this coefficient has diminished after the introduction of the indicator of overall trade costs. We deduce that trade costs represent a channel through which total AfT flows affect technology licensing. Incidentally, the positive coefficient of the variable measuring the overall trade costs in column [1] of Table 2 surely reflects the existence of a strong interaction effect between total AfT flows and the overall trade costs on technology licensing. These outcomes lead us to consider estimates in columns [2] to [4] of Table 2. We obtain from these three columns of the Table that the estimates related to the variable "Log(AfTTOT)" are positive and significant at the 1% level, while the interaction terms associated with the multiplicative variables between the indicator of total AfT flows and the relevant indicator of trade costs are negative and significant at the 1% level. These outcomes suggest that, on average, over the full sample, total AfT flows encourage technology licensing as long as the values of a relevant trade cost indicator are below a certain level. These values amount to 200.2 [= exponential(3.079/0.581)], 1.073 [= exponential(0.393/5.562)], and 189.25 [= exponential(3.969/0.757)], respectively, for the overall trade costs, tariff costs, and non-tariff costs. We illustrate these effects by presenting in Figures 3–5, at the 95 percent confidence intervals, the marginal impact of total AfT flows on technology licensing for varying levels of the overall trade costs, tariff costs, and nontariff costs. We note from Figure 3 that the marginal impact of total AfT flows on technology licensing is always negative and significant and decreases as the overall trade costs increase. This suggests that total AfT flows always exert a negative and significant effect on technology licensing in countries that face higher overall trade costs, and the magnitude of this negative effect is larger the higher the overall trade costs. In other words, total AfT flows influence technology licensing positively and significantly in countries that face lower overall trade costs, with the magnitude of this positive effect increasing as trade costs diminish. Figures 4 and 5 display patterns that are similar to the ones in Figure 3. Specifically, for very low tariff costs[17] (i.e., lower than 1.09), total AfT flows exert no significant effect on technology licensing. In contrast, for higher tariff costs, there is a negative and significant effect of total AfT flows on technology licensing, with the magnitude of this negative effect becoming larger as tariff costs increase. Likewise, we observe in Figure 5 that for low nontariff costs[18] (i.e., lower than 156.25), there is a positive effect of total AfT flows on technology licensing. In contrast, in countries whose values of nontariff costs[19] range from 156.25 to 215, total AfT flows exert no significant effect on technology licensing. Finally, for nontariff costs[20] higher than 215, there is a negative and significant effect of total AfT flows on technology licensing, with the magnitude of this effect becoming larger as nontariff costs rise.

Summing-up, results in Table 2 and Figures 3–5 convey the message that total AfT flows encourage the demand for foreign technology, including through technology licensing in countries that experience lower trade costs, and the lower the trade costs, the greater is the positive effect of total AfT flows on technology licensing. These findings lend support for Hypothesis 1.

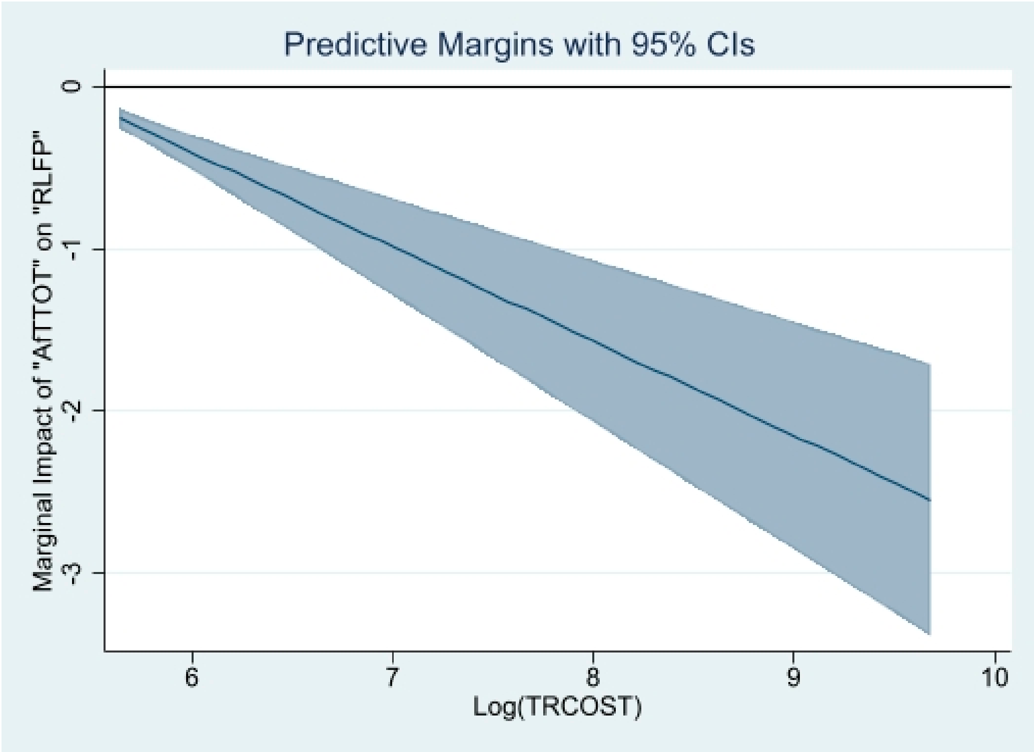

Figure 3. Marginal Impact of "AfTTOT" on "RLFP" for varying overall trade costs. Source: Author.

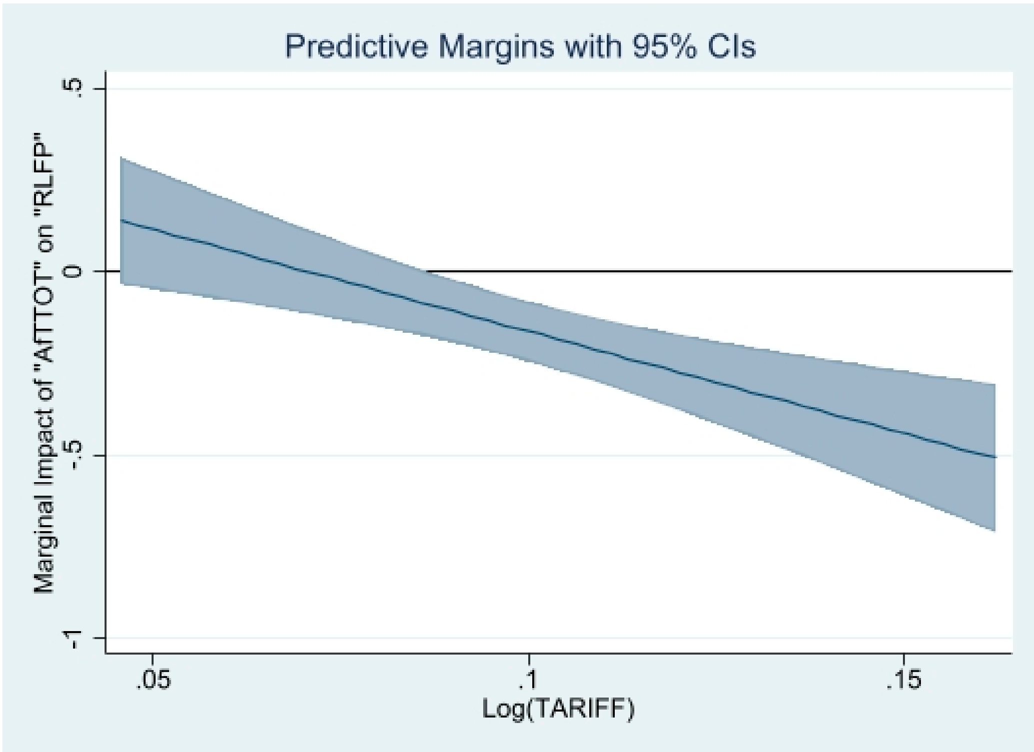

Figure 4. Marginal Impact of "AfTTOT" on "RLFP" for varying tariff costs. Source: Author.

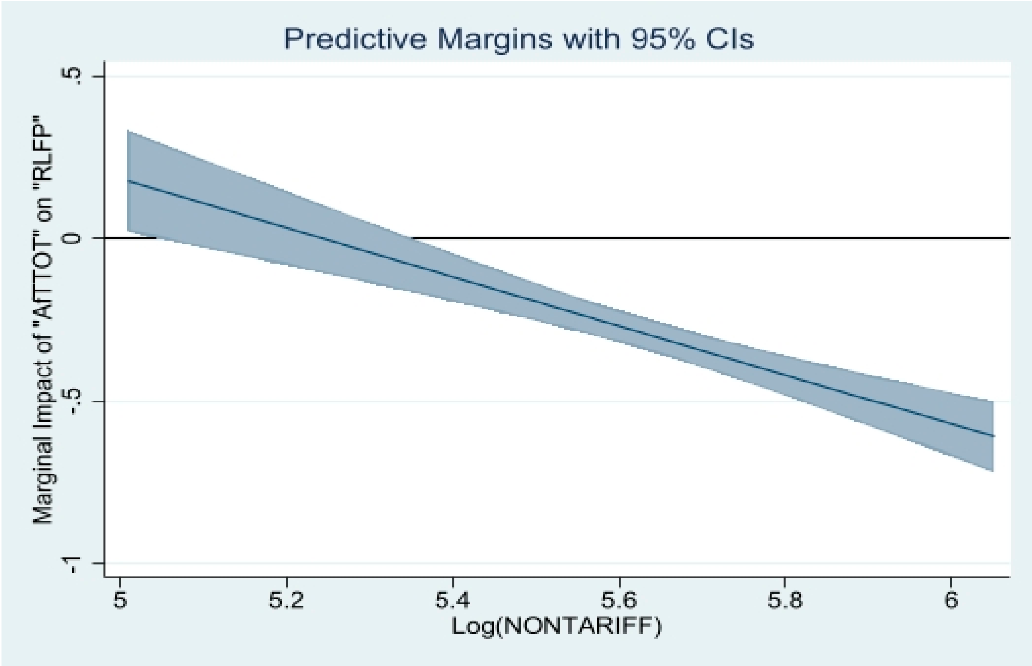

Figure 5. Marginal Impact of "AfTTOT" on "RLFP" for varying nontariff costs. Source: Author.

5. Additional Analysis

We deepen the analysis performed above in several ways. In particular, we investigate the extent to which adverse shocks and export product diversification matter for the effect of total AfT flows on technology licensing. Additionally, we examine the effect of the major components of total AfT flows on technology licensing when recipient countries face higher overall trade costs.

We provide in Figure 6 an insight into the correlation pattern between the indicator of shocks and the payments of royalties and license fees, on the one hand (see the left-hand side graph), and between the indicator of export product concentration and the payments of royalties and license fees (the right-hand side graph). The index of export product concentration, denoted "EPC," is computed using the Herfindahl–Hirschmann Index and its values range between 0 and 1. Higher values of this indicator indicate a greater export product concentration. We observe from Figure 6 that both shocks and export product concentration are negatively correlated with technology licensing.

First, the puzzling outcome of the negative effect of total AfT flows on technology licensing likely prompts us to consider the extent to which environmental and external financial and economic shocks matter for the effect of AfT flows on technology licensing. In other words, we assess how AfT interventions affect technology licensing in countries that face higher adverse shocks. In fact, greater shocks lead to higher trade costs (e.g., Gnangnon 2022; WTO 2021). Concurrently, we obtained from the previous analysis that AfT interventions exert a higher positive effect on technology licensing in countries that experience low trade costs. Therefore, we can expect that AfT interventions will promote technology licensing in countries that face lower magnitudes of shocks (Hypothesis 2). We test this hypothesis by estimating another variant of model (1), that is, model (1), in which we introduce the multiplicative variable between the indicator of shocks and the indicator of total AfT flows. The outcomes of the estimation of this model specification by means of the two-step system GMM estimator are reported in column [1] of Table 3.

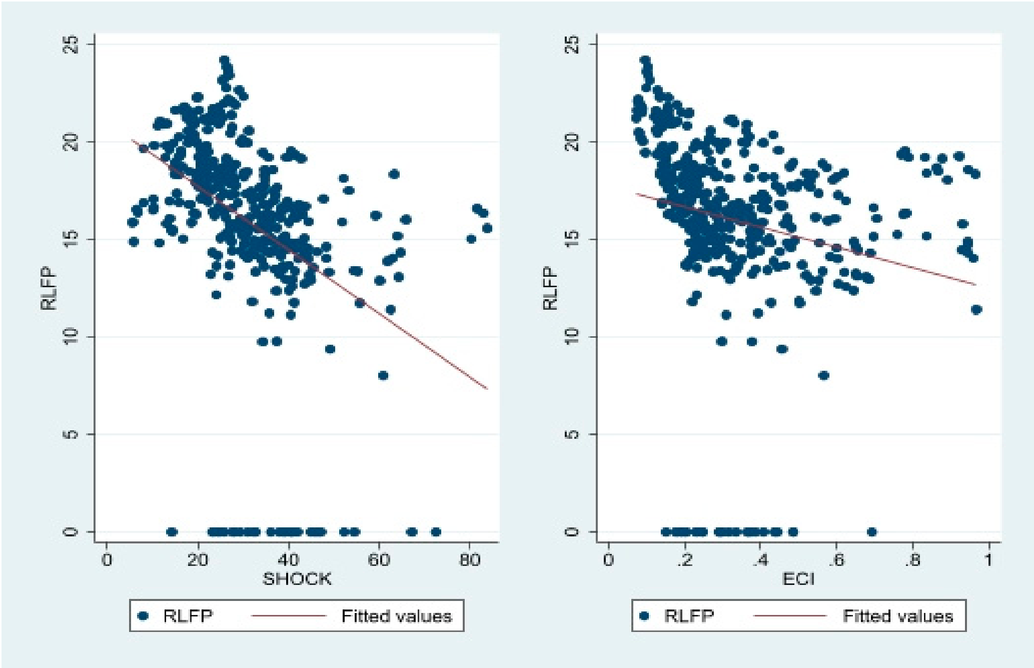

Figure 6. Correlation patterns between the magnitude of shocks, export product concentration, and technology licensing_Over the full sample. Source: Author. Note: The variable "RLFP" is the 'transformed' indicator of the real values of royalties and license fee payments. The variables "SHOCK" and "ECI" are, respectively, indicators of the magnitude of SHOCKs and export product concentration.

Second, we investigate whether the effect of AfT flows on technology licensing depends on countries' degree of export product diversification. In fact, countries that diversify their export products are likely to innovate more than those that do not diversify their export product baskets and rely mainly on the export of low-value-added (primary) products. On the one hand, the centrality of innovation for export performance has been underlined in studies such as Damijan and Kostevc (2015). The latter have provided evidence of the existence of a sequencing between trade (both export and import activities) and innovation, with stronger evidence for the sequencing proceeding from imports to exports through innovations. Mazzi and Foster-McGregor (2021) have also observed that technological capabilities are still positively associated with imports, but only with high-quality imports. These technological capabilities exert a strong positive effect on the export of products with a higher scope for quality differentiation but do not benefit export products with a low scope for quality differentiation. Other studies have established that innovation is key for the expansion of export product varieties, including in terms of export product diversification (e.g., Chen 2013; Cirera et al. 2015; Greenhalgh 1990; Parteka 2020; Zhao and Li 1997). At the same time, higher trade costs inhibit export upgrading (e.g., Bas and Strauss-Kahn 2015; Beverelli et al. 2015; Chen and Juvenal 2022; Mau 2016; Regolo 2013).

On the other hand, through their trade cost reduction effects, AfT flows help diversify export products. As noted above, AfT flows induce greater export product diversification in recipient countries (Gnangnon 2019a), in particular when countries diversify their import products (e.g., Gnangnon 2021a). Kim (2019) has determined that AfT flows reduce export product concentration in the short term but exert no significant effect on it in the long term. Gnangnon (2021b) has found that AfT flows are positively associated with economic complexity in countries that enjoy high productive capacities.

Table 3. Effect of AfT flows on Technology licensing. Estimator: Two-Step System GMM.

Variables	RLFP	RLFP
	(1)	**(2)**
$RLFP_{t-1}$	0.137 ***	0.116 ***
	(0.0113)	(0.00890)
Log(AfTTOT)	0.638 ***	−0.223 **
	(0.139)	(0.0915)
[Log(AfTTOT)]*[SHOCK]	−0.0384 ***	
	(0.00423)	
ECI		15.52 ***
		(2.209)
[Log(AfTTOT)]*[ECI]		−0.953 ***
		(0.122)
Log(GDPC)	1.368 ***	1.300 ***
	(0.117)	(0.0750)
SHOCK	0.718 ***	0.00280
	(0.0796)	(0.00347)
HUM	−0.320 **	−0.175
	(0.126)	(0.135)
FD	0.0126 ***	0.00426
	(0.00347)	(0.00270)
INST	0.220 ***	0.181 ***
	(0.0777)	(0.0690)
DUMOUT	−11.00 ***	−11.50 ***
	(0.304)	(0.223)
Log(POP)	1.159 ***	1.095 ***
	(0.0457)	(0.0424)
Observations—Countries	333–77	333–77
AR1 (*p*-Value)	0.0747	0.0531
AR2 (*p*-Value)	0.6538	0.5632
AR3 (*p*-Value)	0.5111	0.2940
OID (*p*-Value)	0.3467	0.7393

Note: * *p*-value < 0.1; ** *p*-value < 0.05; *** *p*-value < 0.01. Robust standard errors are in parenthesis. In the regressions based on the two-step system GMM estimator, all variables except for the variables "SHOCK" and "POP" have been treated as endogenous. The variables "SHOCK" and "POP" have been treated as exogenous. Time dummies have been included in the regressions. In these regressions, two lags of endogenous variables have been used as instruments.

In light of the foregoing, we can expect that total AfT flows will exert a positive effect on technology licensing in countries that diversify export products. We test this hypothesis by using the two-step system GMM estimator to estimate a specification of model (1) that includes both the indicator of export product concentration and the multiplicative variable between the indicator of export product concentration and the indicator of total AfT flows. The results arising from this estimation are presented in column [2] of Table 3.

We find from all columns of Table 3 that the coefficients of the one-period lag of the dependent variable are positive and significant at the 1% level. Additionally, the requirements for the validity of the two-step system GMM estimator are all met (see the outcomes of the relevant diagnostic tests at the bottom of the Table).

Turning to the estimates, we obtain from column [1] of Table 3 that while the coefficient of the variable capturing total AfT flows is positive and significant at the 1% level, the interaction term of the variable ("[Log(AfTTOT)]*[SHOCK]") is negative and significant at the 1% level. The combination of these two outcomes indicates that on average, over the full sample, total AfT flows exert a negative effect on technology licensing once the magnitude of shocks exceeds a certain level, which is 16.6 (=0.638/0.0384): countries that experience a magnitude of shocks lower than 16.6 experience a positive effect of total AfT flows on technology licensing, while total AfT flows reduce the demand for foreign technology through technology licensing in countries whose magnitude of shocks[21] exceeds 16.6. For these countries, the higher the magnitude of the adverse shocks, the greater the negative effect of total AfT flows on technology licensing. Figure 7 shows, at the 95 percent confidence intervals, the marginal impact of total AfT flows on technology licensing for varying magnitudes of shocks. It appears from this Figure that this marginal impact decreases while taking positive and negative values. It is not, however, always significant. In particular, total AfT flows exert a positive effect on technology licensing in countries that face shocks of magnitude lower than 11.8. For countries whose magnitudes of shocks range between 11.8 and 19.6, there is no significant effect of total AfT flows on technology licensing. Finally, countries whose magnitude of shocks exceeds 19.6 experience a negative effect of total AfT flows on technology licensing, with the magnitude of the effect of these adverse shocks on technology licensing being larger as the magnitude of shocks rises.

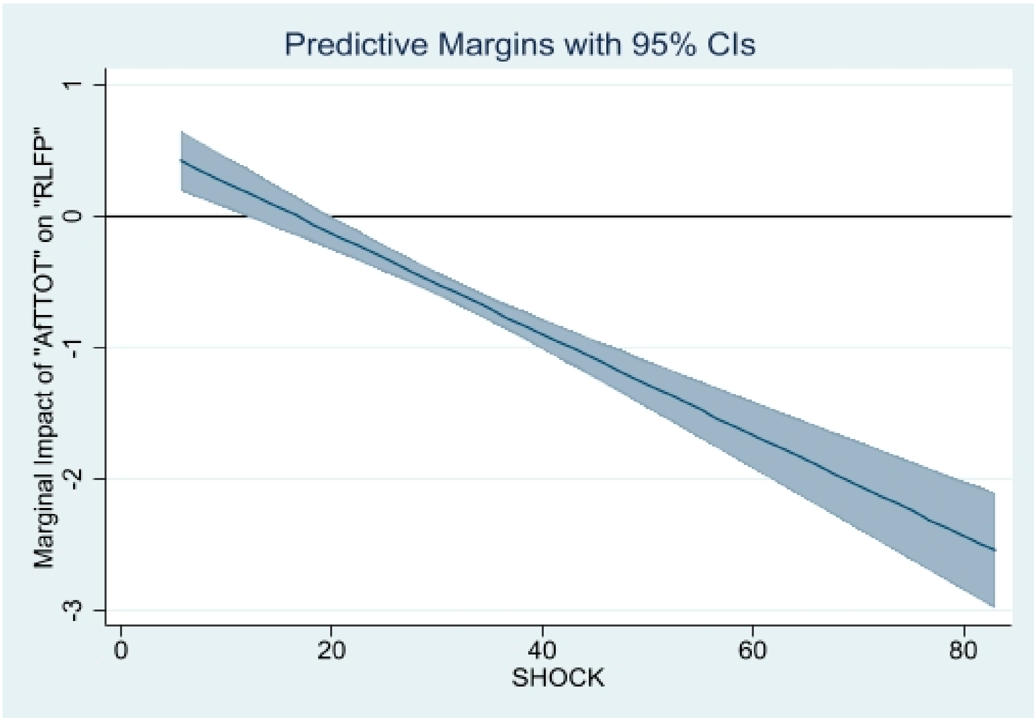

Figure 7. Marginal Impact of "AfTTOT" on "RLFP" for varying magnitudes of shocks. Source: Author.

In a nutshell, the key message conveyed by Figure 7 is that total AfT flows promote technology licensing in countries that face low magnitudes of shocks. Conversely, total AfT flows negatively affect technology licensing in countries that face a greater extent of shocks, and the greater the magnitude of this negative effect, the greater the size of adverse external shocks.

Outcomes in column [2] of Table 3 indicate that the coefficients of both the variable representing total AfT flows and of the variable ("[Log(AfTTOT)]*[ECI]") are negative and significant at the 1% level. Therefore, we first conclude that regardless of the level of export product concentration, total AfT flows always affect technology licensing negatively and significantly. Second, the greater the level of export product concentration, the greater the magnitude of the negative effect of total AfT flows on technology licensing. We plot in Figure 8, at the 95 percent confidence intervals, the marginal impact of total AfT flows on technology licensing for varying degrees of export product concentration. We note from this Figure that the marginal impact of total AfT flows on technology licensing is always negative and significant and, additionally, decreases as the degree of export product concentration rises. This is in line with what we observed above, on average, over the full sample. It is also consistent with the finding from column [1] of Table 3, given that developing countries with greater export product concentrations are likely to experience large magnitudes of adverse external shocks.

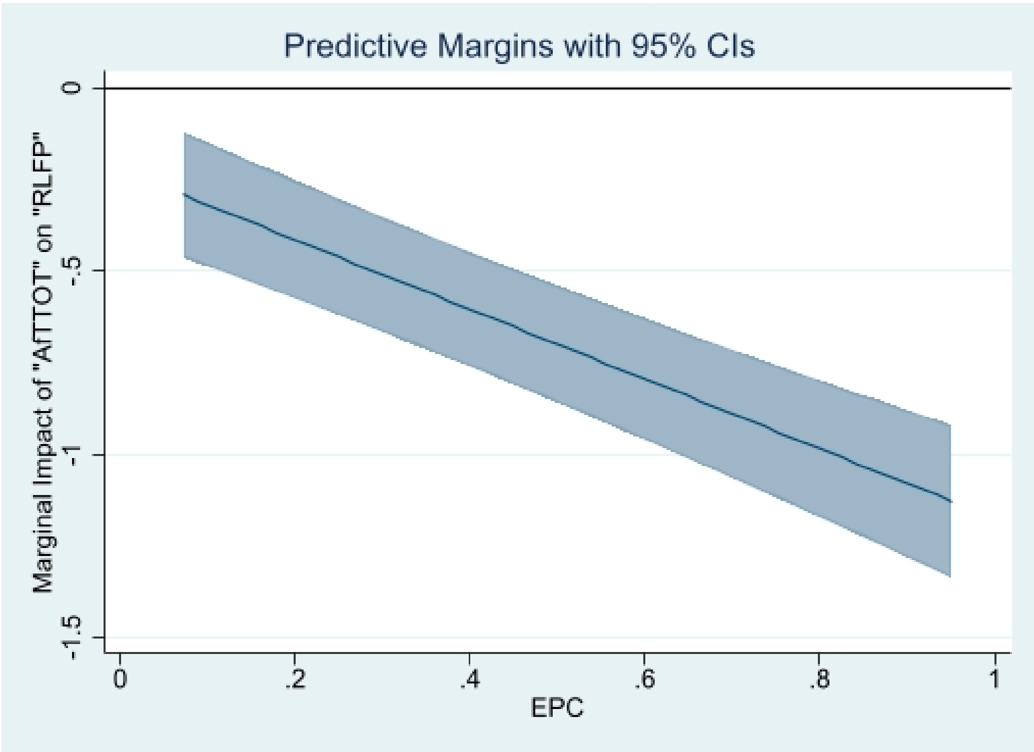

Figure 8. Marginal Impact of "AfTTOT" on "RLFP" for varying levels of export product concentration. Source: Author.

Summing up, total AfT flows induce a higher demand for foreign technology, including through technology licensing in countries that diversify their export product basket, with the magnitude of this positive effect increasing as the level of export product diversification rises.

6. Conclusions

The present article aims to contribute to the literature on the economic effects of AfT flows by investigating the effect of these resource inflows on the demand for foreign technology through technology licensing. It has established several outcomes, based on an unbalanced panel dataset of 77 countries over the period from 2002 to 2019, and using mainly the two-step generalized method of moments estimator. AfT flows foster technology licensing in countries that face lower trade costs. These capital inflows enhance the demand for foreign technology through technology licensing in countries that face lower magnitudes of environmental and external economic and financial shocks. In the same vein, AfT flows promote technology licensing in countries that diversify their export product baskets.

These findings highlight the critical role of AfT flows in promoting technology licensing, which in turn represents an important vehicle for technology transfer to developing countries. This is notably relevant in countries where AfT flows contribute to promoting export product diversification. Finally, the findings have pointed to the need for helping developing countries cope with external (economic and financial) shocks and environmental shocks if AfT flows were to enhance technology licensing in recipient countries.

One future avenue for deepening the present analysis could be to use the Structural Equation Modeling approach to investigate the effect of AfT flows on technology licensing through the channel of trade costs. Another future avenue for research could be to investigate whether AfT flows have resulted in an increase in the number of technology-licensing firms—that is; whether these resource inflows have led to greater technology licensing at extensive margins.

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Data Availability Statement: The data used in this analysis is available online in the public databases, could be obtained upon request.

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Conflicts of Interest: I hereby confirm that there is no actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations within three years of beginning the submitted work that could inappropriately influence, or be perceived to influence, the work.

Appendix A. Definition and Source of Variables

Variables	Definition	Source
RLFP	This is the 'transformed' indicator of the royalties and license fee payments made by a developing country (in a given year) for the use of the owner's intellectual property under agreed terms. The initial indicator of royalties and license fee payments made was expressed in current US dollars. We have deflated it with the GDP deflator (constant 2015 US dollars) and obtained an indicator denoted "RLFP1". However, it appears that the latter contains many zeros and has a highly skewed distribution. Therefore, we have transformed it as follows so as to obtain the indicator "RLFP": RLFP $= \log(1 + RLFP1)$.	The author's calculation is based on data extracted from the World Development Indicators (WDI).
AfTTOT, AfTINFRA, AfTPROD, AfTPOL	"AfTINFRA" is the real gross disbursement of Aid for Trade allocated to the buildup of economic infrastructure. "AfTPROD" is the real gross disbursement of Aid for Trade for building productive capacities. "AfTPOL" is the real gross disbursement of Aid allocated for trade policies and regulations. "AfTTOT" is the total real gross disbursements of total Aid for Trade. It is the sum of the three components of the official development aid described above. All four AfT variables are expressed as constant prices in the 2019 US Dollar.	The author's calculation are based on data extracted from the OECD statistical database on development, in particular the OECD/DAC-CRS (Organization for Economic Cooperation and Development/Donor Assistance Committee)-Credit Reporting System (CRS). Aid for Trade data covers the following three main categories (the CRS Codes are in brackets): Aid for Trade for Economic Infrastructure ("AfTINFRA"), which includes transport and storage (210), communications (220), and energy generation and supply (230); Aid for Trade for Building Productive Capacity ("AfTPROD"), which includes banking and financial services (240), business and other services (250), agriculture (311), forestry (312), fishing (313), industry (321), mineral resources and mining (322), and tourism (332); and Aid for Trade Policy and Regulations ("AfTPOL"), which includes trade policy and regulations and trade-related adjustment (331);
TRCOST	This is an indicator of the average comprehensive (overall) trade costs. The average overall trade costs (including both tariff and nontariff costs) have been calculated for a given country in a given year as the average of the bilateral overall trade costs on goods across all trading partners of this country. Data on bilateral overall trade costs has been computed by Arvis et al. (2012, 2016) following the approach proposed by Novy (2013). Arvis et al. (2012, 2016) have built on the definition of trade costs by Anderson and van Wincoop (2004) and considered bilateral comprehensive trade costs as all costs involved in trading goods (agricultural and manufactured goods) internationally with another partner (i.e., bilaterally) relative to those involved in trading goods domestically (i.e., intranationally). Hence, the bilateral comprehensive trade costs indicator captures trade costs in their wider sense, including not only tariffs and international transport costs but also other trade cost components discussed in Anderson and van Wincoop (2004), such as direct and indirect costs associated with differences in languages and currencies, as well as cumbersome import or export procedures. Higher values of the indicator of average overall trade costs indicate higher overall trade costs.	Author's computation using the ESCAP-World Bank Trade Cost Database. Accessible online at: https://www.unescap.org/resources/escap-world-bank-trade-cost-database (accessed on 1 December 2021). Detailed information on the methodology used to compute the bilateral comprehensive trade costs could be found in Arvis et al. (2012, 2016), as well as in the short explanatory note accessible online at: https://www.unescap.org/sites/default/d8files/Trade%20Cost%20Database%20-%20User%20note.pdf (accessed on 1 December 2021).

Variables	Definition	Source
TARIFF	This is an indicator of average tariff costs. It is the tariff component of the average overall trade cost. We have computed it for a given country in a given year as the average of the bilateral comprehensive tariff costs across all trading partners of this country. Data on the bilateral tariff costs indicator has been computed by Arvis et al. (2012, 2016). As the bilateral tariff costs indicator is (like the comprehensive trade costs) bi-directional in nature (i.e., it includes trade costs to and from a pair of countries), Arvis et al. (2012) have measured it as the geometric average of the tariffs imposed by the two partner countries on each other's imports (of agricultural and manufactured goods). Higher values of the indicator of average tariff costs show an increase in average tariff costs.	Author's computation using the ESCAP-World Bank Trade Cost Database. Detailed information on the methodology used to compute the bilateral tariff costs could be found in Arvis et al. (2012, 2016), as well as in the short explanatory note accessible online at: https://www.unescap.org/sites/default/d8files/Trade%20Cost%20Database%20-%20User%20note.pdf (accessed on 1 December 2021).
NONTARIFF	This is an indicator of average nontariff costs. It represents the second component (i.e., the nontariff component) of the comprehensive trade costs. This is an indicator of comprehensive trade costs, excluding tariff costs. We have computed it for a given country in a given year as the average of the bilateral comprehensive nontariff costs (i.e., the comprehensive trade costs, excluding the tariff costs) across all trading partners of this country. Data on the bilateral nontariff costs indicator has been computed by Arvis et al. (2012, 2016), following Anderson and van Wincoop (2004). Comprehensive trade costs, excluding tariffs, encompass all additional costs other than tariff costs involved in trading goods (agricultural and manufactured goods) bilaterally rather than domestically. Higher values of the indicator of average nontariff costs reflect a rise in nontariff costs. Detailed information on the methodology used to compute the bilateral nontariff costs could be found in Arvis et al. (2012, 2016), as well as in the short explanatory note accessible online at: https://www.unescap.org/sites/default/d8files/Trade%20Cost%20Database%20-%20User%20note.pdf (accessed on 1 December 2021).	Author's computation using the ESCAP-World Bank Trade Cost Database. Detailed information on the methodology used to compute the bilateral nontariff costs could be found in Arvis et al. (2012, 2016), as well as in the short explanatory note accessible online at: https://www.unescap.org/sites/default/d8files/Trade%20Cost%20Database%20-%20User%20note.pdf (accessed on 1 December 2021).
SHOCK	This is an indicator of the intensity of environmental and exogenous economic and financial shocks. This indicator has been computed as the weighted average of three components, namely the agricultural production instability, the export instability, and the victims of natural disasters. This indicator of the intensity of shocks is one of the two components of the economic vulnerability index set up at the United Nations by the Committee for Development Policy (CDP) and used by the latter as one of the criteria for identifying LDCs. It has been computed on a retrospective basis for 145 developing countries (including 48 LDC) by the "Fondation pour les Etudes et Recherches sur le Developpement International" (FERDI). The values of the indicator "SHOCK" range from 0 to 100. For further details on the computation of the EVI, see, for example (Feindouno and Goujon (2016).	Data on EVI are extracted from the database of the Fondation pour les Etudes et Recherches sur le Developpement International (FERDI)—see online at: https://ferdi.fr/donnees/un-indicateur-de-vulnerabilite-economique-EVI-retrospectif (accessed on 1 December 2021).

Variables	Definition	Source
EPC	This is the export product concentration Index. It is calculated using the Herfindahl-Hirschmann Index, and its values are normalized so that they range between 0 and 1. An index value closer to 1 indicates a country's exports are highly concentrated on a few products. On the contrary, values closer to 0 reflect that exports are more homogeneously distributed among a series of products.	United Nations Conference on Trade and Development (UNCTAD) Database. See online: http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=120 (accessed on 1 December 2021).
GDPC	Real per capita Gross Domestic Product (constant 2015 US$).	WDI
HUM	This is an indicator of human capital. It is measured by the number of years of schooling and returns to education.	Penn World Tables PWT 10.0 (see Feenstra et al. 2015).
POP	Total Population	WDI
FD	This is a proxy for financial development and is measured by the share (%) of domestic credit to the private sector by banks in GDP.	WDI
INST	This is the variable capturing the institutional quality. It has been computed by extracting the first principal component (based on factor analysis) of the following six indicators of governance: These indicators are, respectively: political stability and absence of violence/terrorism; regulatory quality; rule of law; government effectiveness; voice and accountability; and corruption. Higher values of the index "INST" are associated with better governance and institutional quality, while lower values reflect worse governance and institutional quality.	Data on the components of "INST" variables has been extracted from World Bank Governance Indicators developed by Kaufmann et al. (2010) and updated recently. See online at: https://info.worldbank.org/governance/wgi/ (accessed on 1 December 2021).

Appendix B. Descriptive Statistics on Variables Used in the Analysis

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
RLFP1	333	672,000,000	2,740,000,000	0	32,900,000,000
AfTTOT	333	282,000,000	430,000,000	1,927,895	3,670,000,000
AfTINFRA	333	168,000,000	291,000,000	95113.670	3,170,000,000
AfTIPROD	333	109,000,000	171,000,000	47382.330	1,840,000,000
AfTPOL	332	4,885,616	12,000,000	4979	165,000,000
TRCOST	331	321.425	57.576	172.718	473.515
TARIFF	324	1.096	0.020	1.047	1.176
NONTARIFF	323	279.786	54.427	149.745	433.378
SHOCK	333	29.781	11.875	5.653	82.998
ECI	333	0.326	0.194	0.073	0.968
GDPC	333	4142.975	3559.740	282.240	16,031.540
HUM	333	2.239	0.529	1.147	3.571
FD	333	39.677	32.053	3.685	159.366
INST	333	−0.942	1.275	−3.982	2.987

Appendix C. List of Countries Used in the Full Sample

Full Sample		
Algeria	Guatemala	Nicaragua
Angola	Guyana	Niger
Argentina	Honduras	Nigeria
Armenia	India	Pakistan
Bangladesh	Indonesia	Panama
Belize	Iraq	Paraguay
Benin	Jamaica	Peru
Bolivia	Jordan	Philippines
Botswana	Kazakhstan	Rwanda
Brazil	Kenya	Senegal
Burkina Faso	Kyrgyz Republic	Sierra Leone
Burundi	Lao PDR	South Africa
Cambodia	Lesotho	Sri Lanka
Cameroon	Madagascar	Sudan
Chile	Malawi	Syrian Arab Republic
China	Malaysia	Tajikistan
Colombia	Maldives	Tanzania
Congo, Dem. Rep.	Mali	Thailand
Costa Rica	Mauritania	Togo
Cote d'Ivoire	Mauritius	Tunisia
Dominican Republic	Mexico	Turkey
Ecuador	Mongolia	Uganda
Egypt, Arab Rep.	Morocco	Uruguay
El Salvador	Mozambique	Zambia
Eswatini	Myanmar	Zimbabwe
Fiji	Namibia	

Notes

1 Licensing may occur within firms, among joint ventures, or between unrelated firms (e.g., Hoekman and Javorcik 2006).

2 See Benziane et al. (2022) for a literature review on the matter.

3 See Appendix A for a detailed description of the coverage of each of these categories of development aid.

[4] See the literature survey provided by Benziane et al. (2022).

[5] See a recent literature survey by Akcigit and Melitz (2021).

[6] Nevertheless, studies such as those of Eaton and Kortum (2001) have shown that trade barriers exert no significant effect on innovation. In fact, in their baseline model, the effect of a larger market size is counteracted by the increased competition with technologies embedded in imports, so that there is ultimately no effect of lower barriers to trade on innovation.

[7] Spending on technology was measured by the author in various ways, for example, as spending on technology per worker and spending on technology over sales.

[8] Bloom et al. (2013) gave the example of a shoe company that faces an unexpected low-cost import competition. The workers of this firm might be trapped because they have human capital specific to this firm, which will be lost if they move to other firms. Moreover, it could be costly to uproot and sell the physical capital. Thus, further to the fall in the price of one of the goods produced by the firm (due to the import competition, which is an adverse trade shock for the firm), the opportunity cost falls for the inputs that are trapped within the firm. As a result, the firm will innovate more, not because the value of a newly designed good has increased but because the opportunity cost of the inputs used to design and produce new goods has fallen.

[9] The author has further found that the reduction in production costs by firms that install more advanced capital-intensive technologies leads to a reallocation of production shares toward exporters, with the consequence of amplifying the initial reallocation effects put forth by Melitz (2003), thereby further increasing aggregate industry productivity.

[10] Many of these studies have performed a firm-level analysis. Other theoretical works, such as Yang and Maskus (2001b), have considered the relationship between IPRs and technology licensing. They have shown that stronger IPRs increase the licensor's share of rents and reduce the costs of licensing contracts. Gallini (1984) has shown that an incumbent firm may license its production technology to reduce the incentives of a potential entrant (i.e., the firm's rival) to develop its own, possibly better, technology.

[11] A similar exercise has been performed by Park and Lippoldt (2008), who, in examining the economic implications of IPRs in developing countries, have considered the effect of IPR protection on technology licensing in the services sector, i.e., the royalties pertain to the importation of technological services, measured by the license fees and royalties paid for the use of foreign intangible assets (like intellectual property and know-how).

[12] See, for example, the literature review by Miklian and Hoelscher (2021).

[13] This indicator is described later in the analysis as well as in Appendix A.

[14] This endogeneity problem stems from the correlation between the lagged dependent variable and countries' unobserved time-invariant-specific effects in the error term.

[15] The indicators of tariff costs and non-tariff costs are described in Appendix A.

[16] It is worth recalling here that we hypothesized that the effect of AfT flows on technology licensing works through the channel of trade costs.

[17] We notice that over the last sub-period of the dataset (i.e., 2017–2019), 37.66 percent of countries had tariff costs lower than 1.09.

[18] In the full sample, over the last sub-period (i.e., 2017–2019), only China had nontariff costs lower than 156.25. For this country, the value of nontariff costs in 2017–2019 amounted to 149.74.

[19] In the full sample, over the last sub-period (i.e., 2017–2019), eight countries experienced nontariff costs ranging between 156.25 and 215. These countries (with their values of nontariff costs in brackets) are as follows (in ascending order): Panama (166.43); India (170.24); Turkey (171.18); Malaysia (173.95); Thailand (181.92); South Africa (185.05); Egypt, the Arab Republic (199.27), and Brazil (202.75).

[20] We notice that over the last sub-period of the dataset (i.e., 2017–2019), 83.12 percent of countries had nontariff costs higher than 215.

[21] The values of the indicator "SHOCK" in Appendix B range between 5.65 and 83 (see Appendix B).

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