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Has the Least developed countries' TRIPS Waiver Delivered on its Promise of Creating a Viable Technological Base?

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Abstract

The Trade-Related Intellectual Property (TRIPS) Agreement of the World Trade Organization has granted major flexibilities to least developed countries (LDCs). One of these flexibilities is the exemption from the implementation of the majority of the provisions of this Agreement over a certain period (referred to as "TRIPS Waiver"), so as to help LDCs create a viable technological base. The present article has investigated whether the TRIPS Waiver was instrumental in expanding LDCs' technological base measured by their total factor productivity level. The analysis has used 14 LDCs (based on available data) and two different control groups, over the period from 1981 to 2020. It has revealed that the TRIPS Waiver helped LDCs expand their technological base, in particular for LDCs that had very weak technological bases. In addition, this positive technological base effect of the TRIPS Waiver was larger in LDCs that implemented weaker intellectual property laws, as well as those that endeavour to relatively diversify their export products, and improve the quality of export products in a context of a greater export product diversification.

Keywords: Least developed countries; TRIPS Waiver; World Trade Organization.

JEL Classification: F13; O34.

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1. Introduction

The international community, including international organizations, regional organizations the donor community, think tanks, and non-governmental organization accord a special attention to the group of least developed countries (LDCs) in the world. This group², officially established in 1971 by the United Nations, includes the poorest countries in the world that are concurrently the most vulnerable to environmental shocks, and external economic and financial shocks. Three main criteria are used to determine whether a country can be included in or graduated from the LDC category. These are the income, the human assets, and the economic and environmental vulnerability. According to the income criterion, countries must have an average per capita income below US\$ 1,018 for inclusion in the category, and above US\$ 1,222 for graduation from that category. The human assets criterion provides that to be eligible as an LDC, countries must have a low score on the human assets index, which combines health and education outcomes. The economic and environmental vulnerability criterion requires that countries must have score high on the economic and environmental vulnerability index, which measures factors like remoteness, dependence on agriculture and vulnerability to natural disasters.

Promoting a sustainable economic growth and development in LDCs is, therefore, at heart of the international policy agenda (e.g., UNCTAD, 2021; United Nations, 2021), and technological progress is critical in this regard (e.g., Edwards, 1993; Matsuyama, 1992; Solow, 1957). In particular, the promotion of LDCs' integration into the global trading system has been a shared objective of the international trade and development communities, notably the Members of the World Trade Organization (WTO). LDCs face huge resource and capacity constraints that hinder their participation in international trade³, the latter being a major source of technical progress (e.g., Bloom et al., 2016; Coe and Helpman, 1995; Jones, 1996). In view of these constraints and to help LDCs enhance their participation in international trade, WTO Members have granted many flexibilities to LDCs in WTO Agreements and Decisions (e.g., WTO, 2022b, 2023). At the heart of the present study are the flexibilities related to the TRIPS Agreement and their relationship with technological progress. The Trade-Related Intellectual Property Agreement⁴ (TRIPS) of the World Trade Organization (WTO) is a multilateral trade agreement concluded as an annex to the Agreement establishing the WTO. It provides two major flexibilities to LDCs. The first one is the general transition period for the implementation of the TRIPS Agreement, with a view to helping them create a viable technological base⁵. The second major LDC-specific flexibility is the transition period during which LDCs are allowed not to grant patent protection and undisclosed information for pharmaceutical products.

² The United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UNOHRLS) provides detailed information on the criteria utilized to include a country in the LDC category or for the graduation of an LDC from this category (<https://www.un.org/ohrls/content/least-developed-countries>). As of August 2023 (that is, at the time of writing the present paper), the group of LDCs contains 46 countries (see information online at: <https://www.un.org/ohrls/content/list-ldcs>)

³ This is exemplified by their very low share of the world trade (e.g., WTO, 2022b), while representing 12% of the world population (see information online at: <https://www.un.org/en/conferences/least-developed-countries>)

⁴ This Agreement is available online at: https://www.wto.org/english/docs_e/legal_e/27-trips_01_e.htm

⁵ Article 66:1 of the Agreement reads as follows: "In view of the special needs and requirements of least-developed country Members, their economic, financial and administrative constraints, and their need for flexibility to create a viable technological base, such Members shall not be required to apply the provisions of this Agreement, other than Articles 3, 4 and 5, for a period of 10 years from the date of application as defined under paragraph 1 of Article 65. The Council for TRIPS shall, upon duly motivated request by a least developed country Member, accord extensions of this period."

The present analysis investigates whether the LDC-specific TRIPS flexibilities, in particular the general transition period accorded to LDCs in the TRIPS Agreement, has genuinely helped these countries expand their technological base. Well, the Agreement has not stipulated that the general transition period granted to LDCs (henceforth referred to as the "TRIPS Waiver") will help them expand their technological base. Rather, the wordings of Article 66:1 of the Agreement provide that this TRIPS Waiver should help LDCs create a viable technological base. Therefore, the issue that arises when it comes to assessing quantitatively whether this provision of the TRIPS Agreement had its intended effect, is how to measure quantitatively "a viable technological base". The TRIPS Agreement has not clarified the exact meaning of the expression of "creating a viable technological base". In that context, we opt for examining whether the TRIPS Waiver led to an expansion of the technological base, with a view to capturing its medium to long term average effect across a set of LDCs for which data is available.

This question is particularly relevant that a recent study has shown that the LDC-specific TRIPS flexibilities (notably the general transition period) have helped LDCs reduce their intellectual property rights (IPR) protection levels, with this reduction being larger in countries that had lower IPR levels. The adoption of a weak IPR protection policies could have helped expand the technological capacity of LDCs. We follow previous studies (e.g., Madsen et al., 2010; Smith and Anti, 2022; Vandebussche et al., 2006) and measure the technological base (i.e., technological capacity) by the level of total factor productivity (TFP). The TFP is the residual fraction of the Gross Domestic Product (GDP) that is not explained by the accumulation of factors of production (including physical and human capital) used in production. Its level is, therefore, determined by the efficiency in using capital and labour inputs (e.g., Barro and Sala-i-Martin 2004).

To the best of our knowledge, the question at the heart of the present analysis has not been explored in the literature. The only one study directly related to ours is that of Su et al. (2022) who have examined the effect of IPR protection on the TFP level in three groups of countries that are LDCs, developing countries and developed countries. This categorization of countries into three groups by the authors is based on the gross national income (GNI) criteria. Countries with a GNI lower than (or equals to) US\$ 1,005 were considered as LDCs. Developing countries were those with a GNI comprised between US\$ 1,006 and US\$ 12,275, and countries qualified as developed countries were those with a GNI equal to (or exceeding) US\$ 12,276. Su et al. (2022) have found that a weak IPR protection leads to productivity improvement in LDCs, while for developing and developed countries, there exists an inverted U-shaped relationship between IPR protection and the TFP level.

It is very important to clarify here the major differences between our present study and the one by Su et al. (2022). First, the category of LDCs considered by Su et al. (2022) in their analysis is in reality the group of low-income countries, and not genuinely LDCs as defined by the United Nations. In fact, the sub-sample of LDCs⁶ in the analysis by Su et al. (2022) - which we qualify here as low-income countries - have been chosen only on the basis of the income criterion (which is closed to the United Nations' income criterion for LDCs) but not on the basis of other main criteria, namely the human assets, and the economic and environmental vulnerability criterion.

⁶ Unfortunately, in their study, Su et al. (2022) have not provided the list of countries contained in the sub-sample of LDCs, as well as those of developing countries, and developed countries.

Second, Su et al. (2022) have studied the effect of the IPR protection on the TFP level in low-income countries, but not the effect of LDC-specific TRIPS flexibilities on the technological base in LDCs, even though as stated above, the present analysis also uses the TFP level as a proxy for technological capacity. Third, the present analysis builds on the work by Gnanon (2023), and uses two control groups to investigate the effect of LDC-specific TRIPS flexibilities (in particular the general transition period) on the TFP level. The first control group, which is the main one in the analysis, is the group of developing countries identified by Klasen et al. (2021) as countries that have not been included in the category of LDCs, but would not have fulfilled the criteria for graduation from this category if they had been in this category. Klasen et al. (2021) identified 18 developing countries that fulfil this condition, and that could, therefore, serve as a control group in the present analysis, given that they do not enjoy the LDC-specific TRIPS flexibilities. In the present analysis and based on data availability, 11 countries among the 18 developing countries identified by Klasen et al. (2021) are used as the first control group. The second group, used for robustness check, includes the low-income countries that are not in the LDC category (and hence did not enjoy LDC-specific TRIPS flexibilities), but are eligible to the Poverty Reduction and Growth Facility (PRGF) of the International Monetary Fund (IMF) (see IMF, 2022: p57).

The theoretical argument underpinning the analysis is that by helping LDCs adopt weak IPR protection, the LDC-specific TRIPS flexibilities would allow for imitation, including product quality-based imitation and product variety based imitation, which could in turn, contribute to the expansion of LDCs' technological capacity. The plausibility of this argument rests fundamentally on the theoretical finding by previous studies (e.g., Agénor, 2017; Agénor and Alpaslan, 2018; Aghion and Howitt, 2006; Benhabib et al., 2014; König et al., 2016; Perez-Sebastian, 2007; Vandebussche et al., 2006) that imitation is an important engine for productivity in countries at the early stages of countries' development.

The analysis covers 14 LDCs, 11 countries in the first control group, and 9 countries in the second control group, and the period from 1981 to 2019. It has used the within fixed effects estimator and the Quantile via Moments estimator developed by Machado and Santos Silva (2019). Results indicate that the general transition period accorded to LDCs in the TRIPS Agreement has helped expand LDCs' technological capacity, including by increasing their TFP level. In particular, LDCs with lower levels of export product quality enjoy a higher positive productivity effect of the LDC TRIPS flexibilities. In addition, these flexibilities exerted a positive effect on the TFP level in LDCs that diversified their export product baskets. Finally, LDCs that endeavoured to improve significantly export product quality while diversifying their export products basket enjoyed a larger positive effect of the TRIPS flexibilities on the technological capacity.

The rest of the paper is organized as follows. Sections 2 and 3 present a literature review that allows discussing the effect of the general transition period accorded to LDCs in the TRIPS Agreement on TFP. The empirical methodology is provided in section 4, and Section 5 interprets empirical results. Section 6 goes further into the analysis, while section 7 concludes.

2. LDCs' flexibilities in the TRIPS Agreement and the external constraints for their utilization

The TRIPS Agreement entered into force at the inception of the WTO (on 1 January 1995) and sets a “floor” of positive, minimum standards or general principles for how national systems

protect intellectual property (Mitchell et al., 2023). While these principles cover the eligible subject matter, the consequent rights, and the manner of their enforcement, they still provide WTO Members with some flexibility (or policy space) on how to achieve these minimum standards, and go beyond these standards, while availing defined exceptions and limitations to these standards in certain circumstances (see *Article 1 of the TRIPS Agreement*). WTO Members give effect to the TRIPS Agreement by amending their domestic laws and regulations (see *Article 8 of the TRIPS Agreement*). Article 65:1 of the Agreement provides that "*no Member shall be obliged to apply the provisions of this Agreement before the expiry of a general period of one year following the date of entry into force of the WTO Agreement.*"

In view of their huge capacity and resource constraints⁷ to give effect to the Agreement, WTO LDC Members have been granted specific flexibilities in the TRIPS Agreement that other Members, including both developed and developing Members, cannot avail. The first major LDC-specific TRIPS flexibility is the general transition period accorded to them for the implementation of the TRIPS Agreement ("TRIPS Waiver"), with a view to helping them create a viable technological base⁸. Specifically, Article 66:1 of the TRIPS Agreement provides that "*In view of the special needs and requirements of least-developed country Members, their economic, financial and administrative constraints, and their need for flexibility to create a viable technological base, such Members shall not be required to apply the provisions of this Agreement, other than Articles⁹ 3, 4 and 5, for a period of 10 years from the date of application as defined under paragraph 1 of Article 65. The Council for TRIPS shall, upon duly motivated request by a least-developed country Member, accord extensions of this period.*" The 10-year period provided for in Article 66:1 of the TRIPS Agreement refers to the period running from 1996 (one year after the entry into force of the Agreement) to 2005.

Concurrently, the TRIPS Agreement has allowed non-LDC developing Members of the WTO to delay the implementation of the TRIPS Agreement (other than Articles 3, 4 and 5) for a non-renewable 5-year period (starting from 1995) (see Article 65:2 of the Agreement). On the other side, developed country Members of the WTO were granted only a one-year period of transition for the implementation of the TRIPS Agreement, consistent with Article 65:1 of the Agreement.

At the request by LDC Members, and as allowed for by Article 66:1 of the Agreement, the initial general transition period accorded to LDCs in the TRIPS Agreement, which was to expire in 2005 for the renewal of this flexibility, has been extended three times¹⁰, including in 2005, 2013

⁷ See Article XI:2 of the Marrakesh Agreement establishing the WTO states that LDCs (as recognized by the United Nations) will only be required to undertake commitments and concessions to the extent consistent with their individual development, financial and trade needs or their administrative and institutional capabilities (see information available online at: https://www.wto.org/english/docs_e/legal_e/04-wto_e.htm).

⁸ The Preamble of the TRIPS Agreement also recognizes the special needs of the least-developed country Members in respect of maximum flexibility in the domestic implementation of laws and regulations in order to enable them to create a sound and viable technological base.

⁹ Articles 3, 4 and 5 of the TRIPS Agreement concern respectively "National Treatment", "Most-Favoured-Nation Treatment", and "Multilateral Agreements on Acquisition or Maintenance of Protection".

¹⁰ The first renewal of the general transition period (i.e., under Article 66.1 of the TRIPS Agreement) was on 29 November 2005, and the transition period was extended until 1 July 2013 (see the TRIPS Council Decision in document IP/C/40). The second renewal of the general transition period took place on 11 June 2013, with the transition period being extended until 1 July 2021 (see the TRIPS Council Decision in document IP/C/64). The third and most recent renewal of the general transition period occurred on 11 June 2013, and the transition period was extended until 1 July 2034 (see the TRIPS Council Decision in document IP/C/88).

and 2021. In their three requests¹¹ for the renewal of the extension of the general transition period, LDCs emphasized that protecting IPRs would prevent them from developing a technological base. This argument aligns well with the findings by many studies that strengthening patents laws promotes economic growth only after a country has reached a high threshold of economic development (e.g., Briggs, 2013; Chen and Puttitanun, 2005; Chu et al., 2014; Hudson and Alexandru, 2013; Kim et al., 2012; Schneider, 2005; World Bank, 2002). The latest extension of the general transition period was granted in 2021, and allowed WTO LDC Members not to implement the TRIPS Agreement (other than Articles 3, 4 and 5) until 1 July 2034, or until a WTO LDC Member graduates from the LDC status, whichever occurs earlier (e.g., WTO, 2022b).

This general transition LDC-specific TRIPS flexibility is different from a second major flexibility granted to LDCs concerning pharmaceutical products. The second major LDC-specific flexibility in the TRIPS Agreement is a transition period accorded to LDCs allowing LDCs not to grant patent protection and undisclosed information for pharmaceutical products. It¹² was to last until 1 January 2016, and was further extended to 1 January 2033, or until an WTO LDC Member graduates from LDC status, whichever is earlier (WTO, 2022a). This second LDC-TRIPS flexibility would allow LDC economies to enhance their local pharmaceutical production capacities, including by attracting investment for the local production of generic pharmaceutical products, and facilitating the import of affordable generic medicines (e.g., Islam et al., 2022; Jurua, 2017). It is worth noting that unlike other developing countries, LDCs are not subject to the non-rollback obligation for the utilization of these two major flexibilities in the TRIPS Agreement. The violation of the non-rollback obligation refers to the situation where a country that is already complying with intellectual protection under the TRIPS Agreement in some form, reduces the level of compliance¹³.

Despite the existence of the LDC-specific flexibilities in the TRIPS Agreement, the increasing participation of LDCs in bilateral and regional trade agreements, as well as in non-reciprocal trade agreements can constrain the full utilization of the LDC flexibilities in the TRIPS Agreement (e.g., Correa, 2007; Mitchell et al., 2013; Syam and Syed, 2023; UNECA, 2016; UNCTAD, 2007). This is because these bilateral, regional trade agreements, and non-reciprocal trade agreements tend to impose the so-called TRIPS Plus obligations on parties to these agreements, that is, provisions that are more stringent than the ones in the multilateral TRIPS Agreement (e.g., Campi and Dueñas, 2019; Maskus, 2015; Syam and Syed, 2023; Thrasher, 2021). Syam and Syed (2023) have examined the policy and developmental implication of the loss of benefits from the LDC-specific flexibilities embodied in the TRIPS Agreement for four graduating LDCs (Cambodia, Djibouti, Senegal and Zambia). The authors have observed that none of these four countries have made use of the general transition period available under Article 66.1 of TRIPS Agreement. In addition, only Cambodia among these four LDCs has utilized the transition period that waives obligations to extend patent protection and protection of undisclosed information for pharmaceutical products. In other words, all four LDCs provide patent protection in all fields of technology (as required for by Article 27.1 of TRIPS), with the exception of Cambodia that excludes pharmaceutical products from patent protection. Furthermore, Mitchell et al. (2023) have

¹¹ The three LDCs' requests for an extension of the transition period under TRIPS Article 66.1 for LDC Members, were submitted respectively on 13 October 2005 (see WTO document IP/C/W/457); 5 November 2012 (see WTO document IP/C/W/583); and 1 October 2020 (see WTO document IP/C/W/668).

¹² See also WTO official documents numbers WT/MIN(01)/DEC/2, IP/C/25, WT/L/478 and IP/C/73.

¹³ See information online at: https://www.wto.org/english/news_e/news13_e/trip_11jun13_e.htm

documented that in deviation from the TRIPS Agreement, Bangladesh has provided protection for patent rights for sixteen years, and Nepal has granted patents protection for seven years, but provided wider grounds for refusing to patent an invention. In line with Syam and Syed (2023), Mitchell et al. (2023) have also reported that the patent and industrial design law that prevails in Cambodia excludes the patentability of pharmaceutical products until 2016. Rwanda has availed itself of the LDC-specific pharmaceutical transition period by adopting a decision not to enforce patent rights that may have been granted within its territory with respect to pharmaceutical products to be imported under the system (IP/N/9/RWA/1) (see WTO, 2023: p 164). Soyeju and Wabwire (2018) have noted that among countries in the East African Community, Tanzania and Uganda (that are LDCs) have granted patents for pharmaceuticals, despite the availability of the LDC TRIPS specific flexibilities, and only Burundi and Rwanda have made use of these LDC-specific transition periods. However, Vawda (2022) has reported, from analysing the TRIPS Flexibilities Database¹⁴, that 40 of the 46 instances of the use of flexibilities by LDCs pertain to the LDC pharmaceutical transition period. Despite these findings on the ground concerning the utilization of LDC specific flexibilities in the TRIPS Agreement, Gnanon (2023) has established empirically that the LDC TRIPS Waiver has been associated with lower levels of IPR protection in LDCs, especially in those that had lower degrees of IPR protection.

3. Importance of imitation in LDCs and its possible effect on the technological base

This section first presents the rationale for the implementation of weak intellectual property laws in LDCs (sub-section 3.1). Second, it discusses the concepts of "imitation" versus "innovation" and provides a literature review on the importance of imitation in LDCs (sub-section 3.2). Third, it provides a literature review on how imitation can affect the TFP level, proxy for the technological base (sub-section 3.3). These three sections are relevant for discussing how the TRIPS Waiver can affect the TFP level in LDCs, and to subsequently lay out the hypotheses to be tested empirically in the analysis (sub-section 3.4).

3.1. The Rationale for adopting weak IPRs in LDCs

There are many studies in favour of implementing weak intellectual property laws in LDCs. According to McCalman (2001), strengthening IPRs in developing countries - including LDCs - may work against their national interests and transfer rents to multinational firms patent holders in most advanced countries in the world. Chen and Puttitanun (2005) have found that in developing countries, IPRs protection is non-monotonically relating to the level of development, namely that it first decreases, and then increases. In other words, poor countries (i.e., countries with low development levels) tend to adopt weak IPRs protection so as to encourage imitation of foreign technologies, and as they improve their development level, especially above a certain level, they increasingly strengthen their IPR protection so as to encourage innovation. According to Goldberg and Pavcnik (2007) and Madsen et al. (2010), strengthening IPRs in poor countries will impede innovation by limiting opportunities for technological learning through imitation. In these countries, innovation takes place essentially through imitation. Parello (2008) has found that

¹⁴ The database records some 155 instances of the use of various TRIPS flexibilities since 2001 in 82 countries, including LDCs, developing countries and high-income countries (see Vawda, 2022).

stronger IPRs affect negatively the imitation rate in developing countries. Bessen and Maskin (2009) have emphasized the need for caution in implementing stronger IPRs protection in developing countries. Their argument is that strengthening patent protection in the context of sequential innovation does not encourage innovation in developing countries. A weaker IPR protection seems to be favourable for technological progress in developing countries. Similar views have been held by Gangopadhyay and Mondal (2012) who have shown that stronger protection of IPRs may hinder innovation. According to Kim et al. (2012), gradual innovation in these countries (particularly in low-income countries) could help progressively establish a viable technological base that will expand as countries accumulate technological learning and improve technological capabilities in order to produce patentable inventions at later stages of development. The analysis by these authors has revealed that only minor forms of IPRs, namely utility models foster innovation in developing countries. Hudson and Alexandru (2013) have underlined the complexity of the relationship between IPRs and innovation and shown that strengthening IPRs in poor countries with weak IPRs will likely lead to lower incentives for innovation. Chu et al. (2014) have shown that the effect of patent strength on innovation increases as countries move toward the world technology frontier. At the early stage of development, countries tend to implement weak IPRs protection with a view to facilitating imitation, while at a later stage of development, they tend to adopt stronger IPRs protection so as to promote innovation. Sweet and Maggio (2015) have obtained evidence that stronger intellectual property laws enhance the expansion of the productive frontier and encourage the application of tacit and explicit innovative advances only in countries whose levels of development and economic complexity (a proxy for innovation) exceed a certain threshold. Specifically, as poorer countries have lower levels of sophistication and human capital, they are likely to experience a negative effect of IPR strengthening on innovation. Hwang et al. (2016) have uncovered a U-shape relationship between IPR protection and innovation (or imitation) and countries' levels of development. IPR protection tends to decrease for low-income countries, and goes up as the income rises. In their work, Auriol et al. (2023) have found that strengthening IPR protection in poorer countries discourages the learning (inside-the-frontier) activities as well as innovation (on-the-frontier) activities.

3.2. On the importance of imitation in LDCs

Aghion and Howitt (2009) have argued that developing countries can engage in two types of economic growth strategies, including imitation or transfer of technology available at the world technological frontier, and the development of their own technology. Imitation strategies allow firms to achieve and maintain competitive advantages (e.g., Wu et al., 2019), to grow (e.g., Fu and Tietz, 2019) and to improve performance, especially in uncertain environments featured by a rapid technological change and intense market competition (e.g., Haveman, 1993; Semadeni and Anderson, 2010). The analysis by Peng et al. (2021) has revealed that for firms to achieve a sustainable growth in a dynamic environment, they should adopt an imitation strategy that fits well with their unique attributes. Imitation fosters firms' growth in low-tech industries than in high-tech industries and in non-OECD countries than in OECD countries, although associated with an improvement in firms' performance in the short term but not in the long term.

The differences between the concepts of 'imitation' and 'innovation' have been the subject of a voluminous literature. According to Mansfield (1963: p28), innovation refers to the “first ever

use” of an idea, while imitation¹⁵ refers to the “subsequent usage” of the idea. Ulhoi (2012) has provided that imitation comprises both “replica” (imitation by legal means, through licenses obtained from the pioneer, or informal imitation, through copying of old and unprotected technologies) and “mimicry” (produced through reverse engineering¹⁶). Along the same lines, Yilmaz et al. (2023: p643) have claimed that "*Imitators copy all or some of the original's attributes, either creating pure “copycats” or using existing features of the original and adding distinctive attributes. Creative imitations combine attributes from the original product with new attributes that may represent a quality improvement or taste-based differentiation over the original.*" Liao (2020) has provided that imitation can be considered as the adoption of ideas already used by competitors, and involve for example the introduction by a firm of products or services that resemble ones already in the market, or the adoption of a production process, a managerial practice, or a marketing approach already used by competitors. In addition, 'not innovating' does not necessarily entail imitation, as imitation is not the only existing alternative to innovation: another alternative to innovation can be internationalization and diversification (Liao, 2020).

In general, the literature has established that 'laggards' tend to imitate, and 'leaders' tend to innovate¹⁷. Furthermore, at the early stage of development, the implementation of weak IPR protection facilitates imitation of foreign technologies¹⁸ and the development of the latter through reverse engineering and learning by doing, with a view to enhancing technological capacity (e.g., Agénor and Dinh, 2013). For example, Hobday (1995) has considered one firm in each Asian Tiger country, and shown that latecomer firms build up their innovation capacity by acquiring, assimilating, and adapting foreign technology.

Taking the specific case of LDCs, UNCTAD (2007) has provided that innovation takes the form of 'creative imitation' and 'commercialization of inventions', which derive from imitation of a pioneering firm through the introduction of 'minor' improvements in or adaptations to improve a product or a production process. LDCs are host of laggard firms, and many studies have supported the view that imitation - which is essentially intensive in low-skilled labour, bears cheaper costs than innovation and has been at the heart of the development strategies of Asian Tigers as well as many companies (e.g., Liao, 2020). Imitation is highly prevalent in LDCs (e.g., Correa, 2003; Chu et al. 2014; Goldberg and Pavcnik, 2007; Madsen et al., 2010; Sampath, 2007). For example, a survey conducted by Sampath (2007) on incentives for innovation's¹⁹ for Bangladeshi firms operating in three domestic processing sectors²⁰ has shown that the capacity of innovation is very weak within local firms across the three sectors.

¹⁵ The economic rationale for the high intensity of imitation has been discussed for example by Barro and Sala-i-Martin (2003) and Poyago-Theotoky (1998).

¹⁶ "Reverse engineering" refers to the process whereby local firms operating in the imitation sector invest resources to absorb and adapt the information needed to replicate new products invented abroad (e.g., Agénor and Dinh, 2013).

¹⁷ Liao (2020) has provided an extensive literature survey on the concepts of imitation and innovation, and their relationship with productivity.

¹⁸ See for example, Auriol et al. (2023); Chen and Puttitanun (2005); Chu et al. (2014) and Kim et al. (2012).

¹⁹ Sampath (2007) has defined "innovation" in a broader sense, that is, involving *incremental innovations that range from small changes in process technologies that lead to significant improvements in production methods, to new organizational techniques that lead to improved delivery efficiency for existing products or to the production of new technologically improved products. Innovation was measured by the number of new product and process developments applied by the firms in the past five years. Hence, innovation has been measured by the number of new product and process developments applied by the firms in the past five years* (Sampath, 2007).

²⁰ These sectors are the agro-processing, textiles and garments sectors (i.e., low-technology sectors), and the pharmaceutical sector (i.e., a patent-intensive high-technology sector).

3.3. State of the literature on the effect of imitation on productivity

Several reasons can justify why stronger intellectual property laws in low-income countries are unlikely to generate knowledge creation (which is a key antecedent for TFP) and may even have adverse effects on innovation (in particular imitation) in these countries (e.g., Su et al. 2022). These reasons include the weak resources (e.g., human capital, and financial resources) experienced by these countries that render irrelevant any role of stronger IPR protection in encouraging knowledge creation insofar as such IPR protection requires investments that come with a high cost that low-income countries cannot afford (Peng et al. 2017). Moreover, as low-income countries lack the requisite domestic innovation base to enhance innovation, stronger intellectual property laws are likely irrelevant in these countries to foster imitation (and eventually innovation) that could enhance TFP. Instead, the strengthening of IPR protection is likely to impede knowledge creation, inhibit domestic knowledge sharing, and ultimately hurt TFP (see also Chen and Puttitanum, 2005). Incidentally, stronger intellectual property laws in low-income countries will, as noted by McCalman (2001), result in a transfer of rents to multinational firms patent holders in industrialized countries, thereby further depriving these countries from financial resources needed to invest to improve their TFP.

Previous empirical studies on the relationship between imitation, innovation and productivity have essentially been carried out at the country level (e.g., Addison, 2003; Vandebussche et al., 2006; Madsen et al., 2010) or at the industry-level²¹ (e.g., Guo et al., 2015; Hobday, 1995; Lee and Lim, 2001). In these studies, the concept of "distance to the technology frontier" has been used to apprehend whether imitation or innovation was prevalent. Countries (or industries) far from the world technology frontier are considered as imitators, and those relatively close to the world technology frontier are considered as innovators. In practice, the concept of "distance to the technology frontier" has mostly been measured by the TFP²² (e.g., Madsen et al., 2010; Smith and Anti, 2022; Vandebussche et al., 2006) and labor productivity (e.g., Amable et al., 2010). The rationale for this is that productivity fairly reflects (and is often closely related to) the technology level so that the distance to the technology frontier can be captured by relative productivity. For example, Smith and Anti (2022) have argued that TFP can be considered as a broad proxy for technological capacity, which covers aspects such as research and development (R&D) along with policies, including science technology and innovation policies.

Regarding previous studies on the link between imitation, innovation and productivity at the country level, Vandebussche et al. (2006) have developed the arguments that imitation of technologies is the main engine of total productivity growth for countries that are far from the technology frontier, while innovation becomes the main engine of TFP growth as countries move closer to the technology frontier. On the basis of a panel dataset comprising mainly developed countries (i.e., 19 OECD countries) and state-level data for the United States over the period from 1960 to 2000, they have shown the key role played by human capital in TFP growth in economies closer to the technology frontier. Skilled human capital fosters TFP growth in economies that are closer to the technology frontier. Madsen et al. (2010) have used 23 OECD countries and 32 developing countries over the period from 1970 to 2004, to show that R&D intensity, its

²¹ See Liao (2020) for a literature survey on these studies.

²² Studies such as Coad (2011) have applied the concept of distance to the technology frontier to data at the firm-level.

interaction with distance to the technology frontier, educational attainment-based absorptive capacity, and technology gap positively affect TFP growth. These findings align with other theoretical works (e.g., Agénor, 2017; Agénor and Alpaslan, 2018; Agénor and Dinh, 2013; Aghion and Howitt, 2006; Benhabib et al., 2014; König et al., 2016; Perez-Sebastian, 2007) that have shown that thanks to large externalities associated with technology diffusion, imitation is the main engine of productivity at the beginning of countries' convergence process (i.e., at the early stages of development, where firms operate far from the world technology frontier), while innovation becomes the main driver of productivity improvement as the economy gets closer to the world technology frontier.

Deolalikar and Roller (1989) have found that the protection of patenting activity of Indian firms has provided significant gains in term of total factor productivity. While the analysis by Sweet and Eterovic (2019) has not focused on LDCs, but rather on a large sample of developed and developing countries, the authors have shown (at the country level) that what matters for enhancing productivity is not really strengthening patent rights protection (to promote innovation), but instead the ability to adapt, replicate and diffuse along the international productive chain. Su et al. (2022) have obtained empirical evidence (at the country level) that the strengthening of IPR protection in low-income countries (that the authors referred to as LDCs in their analysis) has been negatively associated with TFP in these countries, while an inverted U-shaped effect of IPR protection on TFP has been observed for developing and developed countries. Liao (2020) is the first to use a large sample of firms, to test empirically the effect of imitation and innovation on firms' productivity. He has obtained that laggard firms increase their productivity by imitating productive (leading) firms. However, as firms approach the productivity frontier, imitation reduces their productivity, while innovation fosters their productivity. This is because as they become more productive, firms have fewer possibilities of imitating as search costs increase. More recently, Hu and Yin (2022) have investigated empirically how stronger IPR protections affect Chinese manufactured firm's productivity in the context of trade liberalization. They have found that the strengthening of IPR protection in the context of trade liberalization fosters firms' TFP by encouraging the development of innovative activities, and the importation of higher quality capital goods.

3.4. Discussion on the effect of the TRIPS Waiver on LDCs' technological base

Besides the potential effect of the general transition period accorded to LDCs for the implementation of the majority of the TRIPS provisions, the specific transition period granted to LDCs in relation to pharmaceutical products can also affect TFP, including the effect of the general transition period on the TFP level. The improvement in the population health fosters human capital accumulation, and makes workers more productive (e.g., Dormont et al., 2011). Tompa (2002) has put forth that a better health could contribute to improving the aggregate productivity through three channels. A higher life expectancy would increase investment in education, as the returns on these investments increase. It would stimulate saving for retirement, which in turn would lead to a greater accumulation of physical capital. Lastly, as young children enjoy a higher survival rate and a better health, families would be incentivized to reduce fertility, which may improve the labour-force participation. Coe and Neumayer (2003) have found that poor health reduces aggregate productivity levels in developed and developing countries alike, with a larger effect on African countries, many of them being LDCs. Kumar and Chen (2013) have

uncovered for both developed and developing countries that health (and education) enhance TFP growth, and concluded that policies that promote both a better health and education are needed to facilitate technology diffusion. Mark et al. (2022) have shown that poor health in the workforce reduces productivity and represents important costs to employers and the economy. As far as the effect of intellectual property laws on health is concerned, Chaudhuri et al. (2006) and Dutta (2011) have found that the strengthening of IPR has resulted in a reduction in the variety of products available on the market and considerable consumer welfare losses, after the inception of the TRIPS Agreement. In a recent analysis, Islam et al. (2022) have focused on the specific case of Bangladesh (an LDC), and examined how the graduation of this country out of the LDC category would affect the price of insulin and consequently welfare and poverty in this country. The authors have observed that while the pharmaceutical related LDC flexibilities have helped build a generic medicines industry which serves both Bangladesh domestic market and other LDCs, the graduation of this country from the LDC category - and hence the loss of the benefits of these flexibilities - will result in a significant rise in insulin. As a result, Bangladeshi households that have one or more members living with diabetes will suffer a 15% decline in welfare. This would raise the poverty rate of these households unless policy adjustments are carried out.

It, therefore, follows from this that, the potential TFP positive health effect of the transition period granted to LDCs in relation to pharmaceutical products would enhance LDCs' imitation capacity by helping improve the population's health and education, and enhance the productivity of the work force. In this regard, it would reinforce the potential positive effect of the general transition period on TFP.

Building on the literature provided in sub-sections 3.1 to 3.4, we formulate the following hypotheses.

Hypothesis 1: The TRIPS Waiver will exert a positive effect on the productivity level in LDCs.

Hypothesis 2: This positive effect can be larger in countries that had lower IPR protection levels (and hence a greater imitation possibility) than in those with relatively higher IPR protection levels.

Imitations can take the form of quality improvements or the introduction of new varieties. In the present analysis, we measure imitation in LDCs by quality improvement (i.e., quality-improvement-type of imitation), expansion of product varieties (i.e., the variety-expanding-type of imitation.) and more importantly a combination of both, i.e., quality improvement in the context of expansion of product varieties. The combination of the product quality and variety expansion is particularly relevant as an imitation measure in LDCs because these countries produce low-quality goods even if they imitate foreign processes and products. In fact, the imitation sectors in low-income countries tend to develop “light” manufacturing activities (Agénor and Dinh, 2013). Imitation in LDCs can, therefore, take the form of improving the quality of products (although in terms of average low-quality goods) and/or increasing the variety of products, including toward light manufacturing products. As goods exports are a strong reflection of domestic production for physical related goods sectors or manufacturing sectors (Saltarelli, 2020), we proxy, for LDCs, the quality-improvement-type of imitation by export product quality improvement, and variety expansion type of imitation by export product diversification.

Hypothesis 3: By enhancing imitation, the TRIPS Waiver could spur productivity in LDCs, i.e., expand LDCs' technological base. We, therefore, expect that the TRIPS Waiver will affect TFP for varying levels of imitation.

4. Empirical methodology

This section first lays down the model specification used to examine the effect of the LDC TRIPS Waiver on the TFP level (sub-section 3.1). Second, it tests the relevance of carrying out the analysis using the difference-in-difference framework (sub-section 3.2). Third, it discusses the estimators used to estimate this model and its different variants (sub-section 3.3).

4.1. Model specification

It is not straightforward to choose control variables that will be included in the baseline model specification used to address empirically the issue at the heart of the analysis. This is because many studies on the factors underpinning total factor productivity at the country level have adopted ad-hoc approaches (see Bravo-Ortega and Marín, 2011) by building on the literature on economic growth led by Barro (1991). In the present analysis, we follow Bravo-Ortega and Marín (2011) and adopt a similar approach. In particular, we rely on previous studies on the effect of IPR on productivity at the country level (e.g., Bravo-Ortega and Marín, 2011; Coe et al., 2009; Su et al., 2022; Sweet and Eterovic, 2019) and consider a number of control variables deemed to influence the effect of the TRIPS Waiver on TFP in LDCs. These include the human capital accumulated, the inflation rate (to capture macroeconomic stability), the population growth rate, trade openness, the share of foreign direct investment (FDI) inflows in GDP, the share of government consumption in GDP, the terms of trade and an indicator of the quality of the political system as a proxy for the institutional quality.

The baseline model specification takes the following form:

$$TFP_{it} = \alpha_0 + \alpha_1[(LDC_i) * (TRIPS)_t] + \alpha_2LDC_i + \alpha_3TRIPS_t + \alpha_4HUM_{it} + \alpha_5POPGR_{it} + \alpha_6INFL_{it} + \alpha_7GCONS_{it} + \alpha_8FDI_{it} + \alpha_9OPEN_{it} + \alpha_{10}TERMS_{it} + \alpha_{11}POLITY_{it} + \gamma_t + \mu_i + \epsilon_{it} \quad (1)$$

The subscripts i and t stand respectively for a country, and a sub-period. The panel dataset, built on the basis of data availability, is unbalanced, and covers the period from 1981 to 2019. It contains 14 LDCs (the treatment group), and two control groups. The first control group (denoted "CG1") is our main control group in the analysis. It covers 11 developing countries identified by Klasen et al. (2021) as countries that had not been in the LDC category, but would not have met the criteria for graduating from the LDC category if they were included in that category (see details in Gnanon, 2023). The second control group (denoted "CG2") is used for robustness check, and contains 9 low-income countries (LICs). The latter are nothing else than countries that not in the category of LDCs but are eligible to the PRGF of the IMF (see IMF, 2022: p57). In other words, these are countries classified by the IMF as low-income countries, but are not included in the LDC category. As countries included in CG1 and CG2 do not benefit from TRIPS flexibilities that LDCs enjoy, they could genuinely serve as control groups in the present analysis. We will carry out later a statistical test to check whether CG1 and CG2 could genuinely serve as control groups. Overall, the empirical analysis is carried out using two different samples. The first sample, denoted

"FS1", is the main full sample in the analysis. It also covers the period from 1981 to 2019, and contains the 14 LDCs and the 11 countries of the control group CG1. The second full sample, denoted "FS2", is used for robustness check analysis. It covers the period from 1981 to 2019, and contains the 14 LDCs along with 9 countries of the control group CG2.

The dependent variable "TFP" is the total factor productivity, and is obtained as the residual fraction of the Gross Domestic Product (GDP) that is not attributable to the accumulation of factors of production, including physical and human capital. It is measured by the TFP level at current purchasing power parity (USA=1), and in this regard, shows relative TFP across countries. Data on TFP is drawn from the Penn World Tables 10.01 (see Feenstra et al., 2015). This indicator has been exclusively used in the empirical literature, including in works that have examined the effect of IPR protection on TFP (e.g., Sweet and Eterovic, 2019; Su et al., 2022). It has been calculated using a Cobb-Douglas production function, which maps factors into inputs.

Control variables "HUM", "POPGR", "GCONS", "FDI" and "OPEN" are respectively the level of human capital (education) accumulated, the population growth rate, the share (in percentage) of government consumption in GDP, the share of FDI inflows in GDP and the indicator of trade openness, measured by the share of the sum of goods and services in GDP. Likewise, the variables "TERMS" and "POLITY" are respectively the indicators of terms of trade, and the quality of the political system proxied by political institutions. Data on the variables "POPGR", "GCONS", "FDI", "TERMS" and "INST" were extracted from the World Development Indicators (WDI) of the World Bank, while the indicator of human capital "HUM" was collected from the Penn World Tables 10.01 (see Feenstra et al., 2015), and represents the number of years of schooling and returns to education.

The control variable "INFL" is the transformed indicator of inflation rate denoted "INFLATION". The latter is the annual inflation rate (in percentage) based on consumer price index (in percentage) where missing values were replaced with values of the GDP Deflator (in percentage). Given its skewed distribution and the fact that it contains both positive and negative values, its transformation uses the following formula: $INFL = \text{sign}(INFLATION) * \log(1 + |INFLATION|)$ where $|INFLATION|$ refers to the absolute value of the annual inflation rate, denoted "INFLATION". Data on the annual inflation rate and on the GDP deflator were extracted from the WDI of the World Bank.

The indicator "POLITY" is the measure of political institutions, which acts as a proxy for the quality of the political system. It is measured by the Polity IV index developed by Marshall et al. (2018) and used in many studies as a measure of the quality of the political system (e.g., Aidt and Eterovic, 2011; Eterovic and Sweet, 2014; Sweet and Eterovic, 2019).

Data on the dependent variable "TFP" cover the sub-periods 1986-1990; 1991-1995; 1996-2000; 2001-2005; 2006-2010; 2011-2015 and 2016-2019. Data on the indicator of human capital covers the years 1985; 1990; 1995; 2000; 2005; 2010 and 2015. Data on all other control variables cover the sub-periods 1981-1985; 1986-1990; 1991-1995; 1996-2000; 2001-2005; 2006-2010, and 2011-2015. Hence, we obtain a structure of the panel dataset that allows investigating the effect of each variable in the sub-period $t-1$ (e.g., the sub-period 1981-1985) on TFP in the sub-period t (for example in the sub-period 1986-1990). This structure of the panel dataset helps dampen the endogeneity problem of a number of regressors in the form of reverse causality from those regressors to the dependent variable. The regressors that could be endogenous include the human

capital, the inflation rate, the government consumption, FDI inflows, trade openness and the quality of political institutions.

The variable "LDC" is a dummy indicator that captures LDCs, i.e., the treatment group. It takes the value "1" for LDCs, and the value "0" for countries in the control group, either CG1 or CG2. The variable "TRIPS" captures the years of the implementation of the TRIPS Agreement, i.e., the years during which LDCs have enjoyed the LDC-specific TRIPS flexibilities, specifically the general transition period for the implementation of TRIPS provisions. It is a dummy indicator that takes the value "1" from the sub-periods 1996-2000 to 2011-2015, and the value 0 for the preceding sub-periods that are 1986-1990; 1991-1995. As the TRIPS Agreement is a multilateral Agreement (i.e., adopted by all WTO Members), the variable "TRIPS" is unlikely to be subject to the reverse causality problem from the dependent variable ("TFP"). Therefore, the dummy variable "TRIPS" is considered as exogenous in model (1).

The interaction variable "LDC*TRIPS" in model (1) represents the interaction between the dummy "TRIPS" and the dummy "LDC". We label this interaction variable "DiD" in the regression Tables: $DiD = (LDC_i) * (TRIPS)_t$. The coefficient of this variable (i.e., α_1) is our main coefficient of interest in the analysis, and represents the causal effect of the LDC-specific TRIPS flexibilities on the TFP level in LDCs. It measures the difference-in-difference effect between control countries (either in CG1 or CG2) pre-and-post-TRIPS Agreement, and treated countries (LDCs) pre-and-post-TRIPS Agreement. The above-mentioned exogeneity of the variable "TRIPS" implies that the interaction variable "DiD" is also exogenous.

The parameters α_0 to α_{11} are to be estimated. μ_i are countries' time invariant specific effects. γ_t are sub-period dummies that represent global shocks affecting TFP in all countries taken together. ε_{it} is an error-term. Appendix 1 provides the description of all variables used in the analysis. The standard descriptive statistics of these variables are provided in Appendices 2a, 2b, and 2c respectively for the treatment group (i.e., LDCs), the control group CG1, and the control group CG2. The lists of countries contained in each of these groups are provided in Appendix 3.

What are the expected theoretical effects of the control variables described above? Human capital accumulation plays a major role in technology adoption, and hence in countries' capacity to acquire and use relevant foreign technologies (e.g., Benhabib and Spiegel, 1994; Kumar and Chen, 2013; Liberto et al., 2011; Nelson and Phelps, 1966; Romer, 1990; Vandenbussche et al., 2006). Acemoglu and Zilibotti (2001) have explained the decline in TFP growth, notably in low-income countries, by the differences between the supply of and demand for skills. However, while a high level of education (i.e., higher skilled workers) is needed for innovation, a low level of education (unskilled workers) is rather fitted for imitation, which is highly prevalent in LDCs (e.g., Aghion et al., 2009; Madsen et al., 2010; Vandenbussche et al., 2006). This in line with the argument by Gerschenkron (1962) that the low effective innovation costs allow countries that are far from the technology frontier (e.g., LDCs) to catch-up quickly to the technology frontier, and hence to enjoy a higher TFP growth. Miller and Upadhyay (2000) have found that the effect of human capital on TFP growth depends on the economic development level, with human capital being negatively associated with TFP growth in low-income countries, and positively affecting TFP growth in middle-and high-income countries. Barro and Sala-i-Martin (1995) and Barro (1998) have suggested that in low-income countries, particularly LDCs where secondary and tertiary education enrolments do not reach high levels, TFP is likely to be primarily driven by primary

education. Overall, while we expect a positive effect of human capital on TFP, we do not rule out the possibility of a negative or a non-significant effect of human capital on TFP in LDCs.

A low inflation rate can be associated with a higher productivity as it contributes to improving efficiency, and shows signs of the dynamism of the economy (e.g., Groß and Danzinger, 2017). Many studies have reported the negative effect of a higher inflation rate on productivity in developing countries, especially less developed countries (e.g., Akinlo, 2005; Edwards, 1998; Groß and Danzinger, 2017). An increase in government spending may crowd-out private investment (e.g., Farla et al., 2016; Jongwanich and Kohpaiboon, 2008) and consequently undermine productivity. Likewise, the effect of government consumption on productivity is a priori unknown. Government inefficiencies and low quality of public spending can reduce productivity (e.g., Barro, 1991; Sala-i-Martin et al., 2004). Meanwhile, government consumption can foster productivity if the related investment takes place in areas where there is no private investment (e.g., Groß and Danzinger, 2017).

FDI inflows represent another critical vehicle for transferring the advanced technological knowledge and superior management practices from developed to developing countries. As a result, higher FDI flows to developing countries can be associated with positive externalities in the form of knowledge spillovers to the domestic economy, and therefore, contribute to improving productivity. However, in the absence of such spillover effects, FDI inflows can be associated with lower productivity (e.g., Aitken and Harrison, 1999). As, the bulk of FDI inflows is primarily located in the natural resource sector in LDCs (UNCTAD, 2019), FDI flows to these countries may not result in productivity improvement, given the potential negative effect of natural resource dependence on TFP (e.g., Farhadi et al., 2015; Papyrakis and Gerlagh, 2004). Borensztein et al. (1998) have uncovered a positive effect of FDI inflows on TFP.

The population growth rate can enhance productivity owe to the positive effect of the labour force on productivity (e.g., Klasen and Nestmann, 2006). The participation in international trade (i.e., greater trade openness) can be associated with a higher productivity if participating developing countries are capable of learning from others, including by adapting and developing technological capabilities, and adopting efficient production techniques thanks to technology diffusion from the technological leaders²³ (e.g., Bloom et al., 2016; Coe and Helpman, 1995; Coe et al., 1997; Keller, 1998). However, trade openness can negatively affect productivity if supply side bottlenecks (e.g., weak hard and soft infrastructure, and weak productive capacity) are not addressed (e.g., Groß and Danzinger, 2017; Stein et al., 1989).

The effect of terms of trade on TFP is ambiguous. On the one hand, terms of trade improvements can reduce TFP if the related revenues lead to a shift of resources towards physical exportable goods at the detriment of knowledge development. On the other hand, the improvement in terms of trade can be associated with a higher TFP if by making the entire economy better off, it leads to an expansion of both physical goods production and knowledge development activities (e.g., Teresiński, 2019). A positive effect of terms of trade on TFP has been uncovered by Bravo-Ortega and Marín (2011). Feenstra et al. (2013) have studied the effect of terms of trade improvements on TFP growth in the United States, and concluded that when upward biased, terms of trade result in a higher TFP growth than it should have been.

²³ A number of other studies have pointed to the positive effect of trade openness on productivity (e.g., Akinlo, 2005; Alcalá and Ciccone, 2004; Edwards, 1998; Frankel and Romer, 1999).

Finally, the quality of the political system proxied by political institutions is also expected to be strongly and positively associated with TFP (e.g., Sweet and Eterovic, 2019).

4.2. Testing the relevance of the difference-in-difference approach

To ensure that the difference-in-difference framework is appropriate to investigate the causal effect of the TRIPS Waiver on the technological base, measured by the TFP level, we need to test the assumption of parallel trends between the TFP level in the treatment group (i.e., LDCs) and the TFP level in countries of each control group (CG1, and CG2) in the pre-treatment period. To test this assumption, we use the ‘common pre-dynamics test’ developed by Mora and Reggio (2012, 2015, 2017). This statistical test involves examining the existence of a common pre-treatment dynamics in the treatment group (i.e., LDCs) and the control group. The null hypothesis of the test is the presence of common dynamics and equal dynamic effects in the treatment group and control group before the treatment, that is, here, before the entry into force of the TRIPS Agreement. In the present analysis, we implement the test proposed by Mora and Reggio (2012, 2015, 2017). The outcomes of this test are reported in columns [1] and [2] of Table 1, respectively for the full samples FS1 and FS2. They indicate that p-values relating to the Chi-squared statistics are higher than 0.10 at the 10% level of statistical significance. We deduce that we cannot reject the null hypothesis of common pre-treatment dynamics in the treatment group and each of the two control groups before the treatment. As a result, the empirical analysis can be carried out using the difference-in-difference framework.

4.3. Econometric approach

At the outset, we implement the cluster-robust Hausman test developed by Kaiser (2015) in order to choose the appropriate estimator, among the fixed effects estimator and the random effects estimator, to estimate model (1) or its different variants described below. The test helps uncover robust standard errors clustered at the country level, in contrast with the standard Hausman test (of fixed effects estimator versus random effects estimator) that has size distortions (see Kaiser, 2015). The results of the cluster-robust Hausman test are presented in columns [3] and [4] of Table 1, respectively for the full samples FS1 and FS2. We observe that the p-values related to the Chi-squared statistics are closed to 1. This, therefore, suggests that at the 10% level, we can opt either for the fixed effects model or random effects model.

In the present analysis, we use primarily the panel-corrected standard error (PCSE) estimator developed by Beck and Katz (1995, 1996), which is nothing else than an estimator based on the ordinary least squares (OLS) estimates with panel-corrected standard errors (PCSEs). It has the advantage of performing well in small panel data, and controlling for heteroscedasticity, autocorrelation of order 1 (AR(1)), and for contemporaneous correlation across panels (Beck and Katz, 1995, 1996). The autocorrelation of order 1 in the residuals is taken into account either with a common parameter across panels or with panel-specific parameters. In the present analysis, we control for the autocorrelation of order 1 in the residuals by estimating model (1) and its different variants described later using the common parameter with panel-specific parameters. For robustness check of the findings obtained using the PCSE estimator, we use the fixed effects estimator (denoted "FEDK") where standard errors of estimates are corrected by means of the Driscoll and Kraay (1998) technique that takes into account the heteroscedasticity, serial correlation and contemporaneous cross-sectional dependence in the residuals (see Hoechle, 2007).

It is important to note that all regressions were performed over the full samples FS1 and FS2. We start by estimating the baseline model (1) using the PCSE and FEDK estimators (the latter being for robustness check, as indicated above). The outcomes of these estimations are reported in Table 2, and help test [hypothesis 1](#).

We subsequently rely only on the PCSE estimator to estimate all other variants of model (1). The first variant of this model aims to test [hypothesis 2](#) that is, whether the effect of the TRIPS Waiver on TFP in LDCs is conditioned on the strength of IPR protection. The variant of model (1) estimated is model (1) in which we introduce the variable capturing the effective strength of the IPR protection (denoted "PRIE") along with its interaction with the variable "DiD". The outcomes of this estimation are presented in Table 3. The variable "PRIE" is computed using the index of patent rights (PRI) strength drawn from Park (2008) (see also Ginarte and Park, 1997) and widely utilized in the empirical literature (e.g., Auriol et al., 2023; Chu et al., 2014; Su et al., 2022; Sweet and Eterovic, 2019). The index "PRI" was computed as the unweighted sum of scores of the following five components whose values range between 0 and 1: the patent protection duration relative to the international standard; the subject matter that is patentable (or not unpatentable); the membership in international IPR agreements; the mechanisms available for patent enforcement; and how limited (or less restricted) the patenting exceptions are (for example, any requirement to practice the invention or license the patents to third parties). The score of the overall index of patent rights protection varies from 0 to 5, with higher values indicating stronger levels of patent rights protection. Data on the indicator "PRI" is available every five years, and covers the years 1985; 1990; 1995; 2000; 2005; 2010 and 2015 in the present analysis. Following a number of recent studies (e.g., Hu and Png, 2012; Liu et al., 2021; Maskus and Yang, 2018), we use the effectively enforced patent rights protection (denoted "PRIE") rather than "PRI" in the analysis. The indicator "PRIE", which reflects the scope of effective patent rights protection, is computed by multiplying the index "PRI" by the index of legal enforcement (of contracts) effectiveness, the latter having been extracted from the Fraser Institute database. Data on the indicator "PRIE" is available over the same years as for "PRI".

Estimates presented in Tables 4 and 5 allow testing [hypothesis 3](#), i.e., the extent to which the effect of the TRIPS Waiver on the TFP level is conditioned on the extent of imitation measured by the quality-improvement-type of imitation, by the variety expanding-type of imitation and the combination of both. Specifically, columns [1] and [2] of Table 4 contain results that allow examining the effect of the TRIPS Waiver on TFP for varying levels of export product quality. These outcomes are obtained by estimating a variant of model (1) that includes the indicator of export product quality (denoted "QUAL") and its interaction with the variable "DiD". The index of export product quality is obtained by transforming the IMF's indicator of export product quality (see the IMF's diversification Toolkit) so that its values range between 0 and 1. The transformation of the IMF's indicator of export product quality has been made for the sake of the analysis (see details in Appendix 1). An increase in the values of the indicator "QUAL" reflects an improvement in the quality of existing export products.

Columns [3] and [4] of Table 4 report results that allow exploring the effect of the TRIPS Waiver on TFP for varying degrees of the overall export product diversification. These outcomes are obtained by estimating another variant of model (1) that includes the indicator of the overall export product diversification (denoted "EDI") and its interaction with the variable "DiD". The index of the overall export product diversification is computed by transforming - for the sake of

analysis - the IMF's indicator of export product concentration (see the IMF's diversification Toolkit) so that its values range between 0 and 1 (see further details in Appendix 1). Higher values of the indicator "EDI" show a higher degree of the overall export product diversification. Two other variants of model (1) (similar to the one just described) are estimated where the variable "EDI" has been replaced with each of its components, namely export product diversification at the intensive margins (denoted "EDIINT") and export product diversification at the extensive margins ("EDIEXT"). The outcomes arising from the estimation of these two variants of model (1) are presented in Table 5. Export product diversification at the intensive margins reflects an increase in export volumes across active products or trading partners, while export product diversification reflects an increase in the number of new export products or trading partners. The indexes of the export product diversification at the intensive and at the extensive margins are computed by transforming the IMF's indicators of these two components of the overall export product concentration (see the IMF's diversification Toolkit) so that their values range between 0 and 1 (see further details in Appendix 1). Higher values of the indexes "EDIINT" and "EDIEXT" indicate higher degrees respectively of export product diversification at the intensive and extensive margins.

Given that greater export product diversification is conducive to the improvement of the export products quality (e.g., Can and Gozgor, 2018; Henn et al., 2020), we deepen the previous analysis by exploring the extent to which the effect of the TRIPS Waiver on TFP is conditioned on the level of imitation proxied by an improvement in export product quality in the context of greater overall export product diversification. To carry out this analysis, we estimate a specification of model (1) that includes the variable "QUALEDI" along with its interaction with the variable "DiD". The outcomes of these estimations are presented in Table 6. The variable "QUALEDI" is computed as the geometric mean of the indexes "QUAL" and "EDI" (see Appendix 1 for further details).

5. Interpretation of empirical results

Results in Table 2 indicate that the TRIPS Waiver exerted a positive and significant effect on the TFP level in LDCs. The coefficients of the variable "DiD" are positive and significant at the 1% level in all four columns of Table 2, i.e., regardless of whether we use the PCSE or FEDK estimator, or whether the regressions were performed over the full sample FS1 or FS2. These outcomes show that the TRIPS Waiver was instrumental in expanding the technological base in LDCs. Results reported in column [1] of the Table (which concerns FS1) indicate that the TFP level increased by 0.1 point in the treatment period (i.e., after the TRIPS Agreement entered into force and LDCs were granted flexibilities) compared to the period preceding the TRIPS Agreement. Likewise, results reported in column [3] (over the full sample FS2 that contains the second control group) show that the TFP level increased by 0.12 point in the treatment period compared to the preceding period. Thus, results over the full samples FS1 and FS2 are quite similar, regardless of the estimator used.

As for estimates associated with control variables, we focus on results reported in column [1] of the Table, i.e., the ones obtained when using the PCSE estimator over the full sample FS1. Note that results in other columns of the Table are, with few exceptions, similar to those of columns [2] to [4]. We observe that the accumulation of human capital is negatively and

significantly associated with TFP. This finding is consistent with the outcome obtained by Miller and Upadhyay (2000), but may also reflect the fact that for the set of countries considered in the analysis, TFP is mainly driven by primary education and perhaps less by secondary and tertiary education. To deepen the analysis, we may need to decompose the human capital indicator into primary, secondary and tertiary educations. However, this goes beyond the scope of the present paper. Results also suggest that the population growth, government consumption, trade openness, and terms of trade influenced positively TFP at the conventional significance levels. At the same time, and as expected, the inflation rate exerts a negative and significant effect on TFP at the 1% level, but we find no significant effect (at the 10% level) of FDI inflows and the quality of political institutions on TFP.

The outcomes of control variables in Tables 3 to 5 line-up with those in columns [1] and [3] of Table 3. Taking up specifically outcomes in Table 3, we observe in column [1] of the Table that the coefficient of the interaction variable "DiD*PRIE" is negative but not significant at least at the 10% level. In the meantime, the coefficient of "DiD" is positive and significant at the 1% level. Taken together, these two outcomes suggest that the TRIPS Waiver always exerted a positive effect on TFP in LDCs, but the magnitude of this positive effect was larger (lower) in LDCs that adopted weaker (stronger) IPR protection. We illustrate these outcomes in Figure 1, by plotting at the 95 per cent confidence intervals, the marginal impact the TRIPS Waiver on the TFP level for different degrees of IPR protection over the full sample FS1. It appears that this marginal impact was yet positive and always significant, but it slightly decreased as the strength of IPR protection became higher. In other words, while the TRIPS Waiver was instrumental in expanding the technological base in LDCs, LDCs that implemented effectively weaker intellectual protection laws experienced a slightly larger technological base expansion than those that adopted relatively stronger intellectual property laws.

Turning to outcomes reported in column [2] of Table 3 (i.e., based on the full sample FS2), we find that the coefficient of the variable "DiD" is positive and significant at the 1% level, while the interaction term of the variable "DiD*PRIE" is positive (in contrast with the outcome in column [1] of the same), although not significant at the 10% level. This signifies that while the TRIPS Waiver exerted a positive effect on TFP in LDCs, the magnitude of this positive effect was larger in LDCs that adopted stronger intellectual property laws than in those that implemented relatively weaker intellectual property laws. Figure 2 presents, at the 95 per cent confidence intervals, the marginal impact the TRIPS Waiver on TFP for different degrees of IPR protection over the full sample FS2. This marginal impact was yet always positive and significant, but increased as the level of PRIE rose. The similarity of the graphs contained in these two Figures lies on the fact that the marginal impact of the TRIPS Waiver on TFP was always positive and significant. However, the graph in Figure 1, which was constructed over the full sample FS1 indicates that this marginal impact was positive and higher in LDCs that adopted weaker IPR protection policies. The reverse pattern was obtained in Figure 2, which is built over the full sample FS2 that includes countries in the second control group used for robustness check analysis. The different patterns observed in Figures 1 and 2 can be attributed to the heterogeneity in the different set of countries in the two samples. Nonetheless, we still stick with the outcomes reported in column [1] of Table 3 and the related Figure 2, as our main outcomes in the analysis.

Results in Table 4 allow exploring the extent to which the effect of the TRIPS Waiver on TFP is conditioned on the extent of imitation, reflected in the quality of export products, and

alternatively by the degree of the overall export product diversification. These results show similar patterns in columns [1] and [2] on the one hand (concerning the coefficients of "DiD" and of the interaction variables "DiD*QUAL"), and in columns [3] and [4] on the other hand (concerning the coefficients of "DiD" and of "DiD*EDI"). These outcomes show that the patterns of the effect of the TRIPS Waiver on TFP in LDCs for varying levels of imitation are similar when using FS1 as full sample or when using alternatively FS2 for robustness check. In particular, in columns [1] and [2] of the Table, the coefficients of the variable "DiD" are positive and significant at the 1% level, while those of "DiD*QUAL" are negative and significant also at the 1% level. We deduce that on average, over LDCs, the TRIPS Waiver exerted a positive and significant effect on TFP as long as the export product quality level was lower than 1.274 ($= 0.114/0.0895$) for results based on FS1, and 1.416 ($= 0.177/0.125$) for results based on FS2. Both numbers 1.274 and 1.416 are higher than the maximum value (equal to 1) of the indicator "QUAL" in the full sample, and particularly in LDCs. We conclude that the TRIPS Waiver always led to the improvement in TFP (i.e., the expansion of the technological base) in LDCs as the latter improved their export product quality, but the magnitude of this positive effect fell as LDCs endeavoured to improve their export product quality through imitation. In addition, the greater the export product quality improvement, the larger was the positive effect of the TRIPS Waiver on the TFP level. These findings are, to some extent, confirmed in Figure 3. The latter displays at the 95 per cent confidence intervals, the marginal impact the TRIPS Waiver on TFP for different levels of export product quality, over the full sample FS1. Here, the marginal impact of the TRIPS Waiver on TFP is always positive and decreases as the export product quality improves, but it not always statistically significant. It is not significant for relatively high quality of existing export products. We conclude that the TRIPS Waiver always exerted a positive effect on TFP in LDCs with a low quality of export products, but no significant effect on LDCs with relatively high levels of export product quality. In addition, among LDCs with low export product quality levels, the lower the quality levels, the greater was the magnitude of the positive effect of the TRIPS Waiver on TFP. In other words, LDCs with low quality improvement-based imitation enjoyed a higher positive effect of the TRIPS Waiver on TFP (i.e., the technological base) than countries with a relatively higher export product quality level. Note that the pattern observed in Figure 3 is also observed when we used the full sample FS2 rather than FS1. For the sake of brevity, the Figure over FS2 has not been presented here and could be obtained upon request. We conclude that the TRIPS Waiver was instrumental in fostering the technological base in countries with low quality of export products, but exerted no significant effect on TFP in countries with relatively higher export product quality.

Estimates in columns [3] and [4] of Table 4 indicate that the coefficients of "DiD" are positive and significant at the 1% level in column [3] and the 5% level in column [4], while the interaction term of the variable "DiD*EDI" was positive and significant in these two columns. We conclude that the TFP effect of the TRIPS Waiver was always positive and significant, and additionally increased as the degree of the overall export product diversification rose. In other words, LDCs that had higher levels of export product diversification (i.e., low export-variety imitation levels) experienced a larger positive effect of the TRIPS Waiver on TFP than countries with relatively lower degrees of the overall export product diversification. These findings are confirmed by Figure 4, which shows at the 95 per cent confidence intervals, the marginal impact the TRIPS Waiver on TFP for different degrees of the overall export product diversification, over the full sample FS1. This marginal impact was always positive and significant at the 1% level, and

additionally increased as the degree of the overall export product diversification rose²⁴. Overall, LDCs that had a relatively higher degree of the overall export product diversification experienced a larger positive effect of the TRIPS Waiver on TFP than LDCs with lower degrees of export product diversification. These conclusions are valid when we examined the effect of the TRIPS Waiver on the TFP level for varying levels of export product diversification at the intensive and extensive margins. In fact, we notice from columns [1] and [2] that the coefficients of the variables "DiD*EDIINT" are positive and significant at the 1% level, and the estimates related to the variable "DiD" are positive and significant at least at the 5% level. We deduce that on average over LDCs, the TRIPS Waiver always exerted a positive effect on the TFP level as the degree of export product diversification at the intensive margins increases, and the magnitude of this positive effect rose as countries improved their export product diversification at the intensive margins. This is clearly reflected in Figure 5, which shows at the 95 per cent confidence intervals, the marginal impact the TRIPS Waiver on TFP for different degrees of the overall export product diversification, over the full sample FS1²⁵.

Likewise, outcomes displayed in columns [3] and [4] indicate that the coefficients of the variables "DiD*EDIEXT" are positive and significant at the 1% level, and the estimated related to the variable "DiD" is positive and significant at the 5% level in column [3], but not significant at the conventional significance levels in column [4]. We conclude, once again, that the TRIPS Waiver always affected positively the TFP level in LDCs, with this positive TFP effect of the TRIPS Waiver being larger in LDCs with a higher level of export product diversification at the extensive margins. This finding is confirmed by the graph in Figure 6, which shows at the 95 per cent confidence intervals, the marginal impact the TRIPS Waiver on the TFP level for different degrees of the overall export product diversification, over the full sample FS1²⁶.

Regarding outcomes in Table 6, we find that the coefficients of the variable "DiD*QUALEDI" are positive and significant at least at the 5% level, and the coefficient "DiD" is not significant at the 10% level in column [1], and significant at the 5% level in column [2]. We conclude that LDCs that improved their export product quality in a context of the overall export product diversification experienced a larger positive effect of the TRIPS Waiver on the TFP level. Figure 7 presents, at the 95 per cent confidence intervals, the marginal impact the TRIPS Waiver on the TFP level for different values of "QUALEDI" over the full sample FS1 (the pattern is similar when using the full sample FS2). It appears that this marginal impact increased as the values of the indicator "QUALEDI" rose, but it is statistically significant for low values of the indicator "QUALEDI" (in particular values lower than 0.42, as per our own calculation when depicting the graph). The marginal impact is positive and significant for values of the indicator "QUALEDI" higher than 0.42. This suggests that as LDCs endeavoured to improve relatively significantly their

²⁴ The graph containing the marginal impact the TRIPS Waiver on the TFP level for varying levels of the overall export product diversification, over the full sample FS2, had similar a pattern to the one in Figure 4, and could be obtained upon request.

²⁵ The graph containing the marginal impact the TRIPS Waiver on the TFP level for varying levels of the overall export product diversification at the intensive margins, over the full sample FS2, had a similar pattern to in Figure 5, and could be obtained upon request.

²⁶ The graph containing the marginal impact the TRIPS Waiver on the TFP level for varying levels of the overall export product diversification at the extensive margins over the full sample FS2, had a similar pattern to the one in Figure 6, and could be obtained upon request.

export product quality in the context of the overall export product diversification, they enjoyed a higher TFP level.

Summing-up the findings from Tables 3 to 6, we conclude that the TRIPS Waiver exerted a larger positive effect on the TFP level in LDCs with a lower quality improvement-based imitation levels. However, it exerted no significant effect on TFP in LDCs with high quality improvement-based imitation levels. In the meantime, the TRIPS Waiver exerted a larger positive and significant effect on TFP in LDCs that experience a relatively higher degrees of export product diversification. Finally, LDCs that improve relatively significantly their export product quality in the context of the overall export product diversification, experienced a higher level of TFP.

6. Further analysis

The previous analysis helped uncovered 'average' effects (i.e., effects at the mean of the conditional distribution of TFP) of regressors, including our main variables of interest, on the TFP level. The present section deepens the previous analysis by using the quantile regression approach to investigate the effect of the TRIPS Waiver on different quantiles of the TFP distribution. We use the Method of Moments Quantile Regression (MMQR) with fixed effects approach (also referred to as "Quantile via Moments") developed by Machado and Santos Silva (2019). While it shares many features²⁷ with other quantile regression approaches (e.g., Canay, 2011; Koenker, 2004), the MMQR has some advantages over the standard quantile regression approaches. For example, in standard quantile regression approaches, countries' time-invariant fixed effects are considered as location (intercept) shifters, while in the MMQR approach, they vary across different quantiles of the conditional distribution of the dependent variable. Moreover, the MMQR approach relies on the method of moments, which helps tackle the endogeneity problems (in particular the reverse causality issue of regressors) in the model estimated. In the present analysis, the structure of the panel data might not help fully address the endogeneity problems (reverse causality problem) raised above.

In the present work, the MMQR approach is used to examine empirically the effect of the TRIPS Waiver on the level of TFP across the distribution of TFP, for 5 quantiles, including Q10th (i.e., the 10th quantile), Q25th, Q50th, Q75th and Q90th (i.e., the 90th quantile). Tables 7 and 8 contain the outcomes stemming from using the MMQR approach to estimate model (1) respectively over each of the two full samples FS1 and FS2.

Results in Table 7 show that the location parameter associated with the variable "DiD" is positive and significant at the 5% level (see column [1]), while the scale parameter related to the same variable is negative but not significant at the conventional significance levels. We infer that the TRIPS Waiver exerted a positive effect on TFP across all quantiles of the TFP distribution, but the magnitude of this positive effect fell as we move from lower quantiles to higher quantiles. Put differently, the TFP effect of the TRIPS Waiver was larger in lower quantiles (i.e., countries with lower TFP levels) than in upper quantiles (i.e., those with higher TFP levels). Specifically, this effect was statistically nil for countries located in the 75th and 90th quantiles, while for those situated in the 10th to 50th quantiles, its magnitude amounted respectively to 0.13, 0.113 and 0.087.

Concerning control variables, we find that the population growth and government consumption are significantly associated with the improvement in TFP in countries located in the

²⁷ These advantages include for example addressing the heteroscedasticity and outliers problems.

75th and 90th quantiles, but exerts no significant effect on TFP in other quantiles. The terms of trade improvement influences only significantly (and positively here) TFP in the 10th to 50th quantiles. Better political institutions are positively and significantly associated with an improvement in the TFP level across all quantiles of the TFP distribution, with the magnitude of this effect being higher in upper quantiles than in lower quantiles of the TFP distribution.

Results in Table 8 are broadly similar to those in Table 7, including for both the effect of the TRIPS Waiver and control variables on the TFP level. In particular, the TRIPS Waiver exerted a positive and significant effect (at the 5% level) in countries situated in the 10th to 50th quantiles, with the magnitude of this effect consistently decreasing as we move from the 10th quantile to the 50th quantile. Its effect is statistically significant only at the 10% level for countries situated in the 75th quantile, and not significant at the 10% level for countries in the 90th quantile. These findings show, once again, that the TRIPS Waiver was instrumental in expanding to a greater extent the technological base in countries with lower TFP levels than in those with relatively higher TFP levels, especially for countries in the 10th to 50th quantiles.

Overall, the findings in Tables 7 and 8 indicate that the TRIPS Waiver did not affect TFP in LDCs located in the upper quantiles (in particular 75th and 90th quantiles) of the TFP distribution. However, for the other quantiles (i.e., the 10th to 50th quantiles), its effect was positive and larger in countries with the lowest TFP levels (i.e., 10th quantile) than in those with relatively higher TFP levels (i.e., those in the 25th and 50th quantiles).

7. Conclusion

A major flexibility provided by WTO Members to LDCs in the TRIPS Agreement is the transition period for the implementation of the provisions contained in the Agreement, except for the provisions relating to the national treatment, most-favoured-nation treatment, and multilateral agreements on acquisition or maintenance of protection. The objective of this LDC-specific Waiver (that we referred to as "TRIPS Waiver") is to help LDCs create a viable technological base. The present analysis has examined whether the TRIPS Waiver was instrumental in expanding the technological base (proxied by the total factor productivity) in LDCs, as envisaged in the TRIPS Agreement. To that effect, it has used a panel dataset of 14 LDCs (based on available data) along with two different control groups, over the period from 1981 to 2020. The theoretical argument underpinning the empirical work was that by allowing LDCs to adopt weak intellectual property laws, the TRIPS Waiver could encourage imitation of foreign products and processes in LDCs, which could in turn facilitate the expansion of the technological base in these countries. The findings indicate that the TRIPS Waiver was genuinely instrumental in expanding the technological base in LDCs, especially in those with weak technological bases. In addition, LDCs with weak IPR protection levels experienced a larger positive effect of the TRIPS Waiver on the technological base than those with relatively stronger intellectual property laws. When measuring the extent of imitation by the quality of existing export products, we have obtained that the TRIPS Waiver exerted a larger expansion of the technological base in LDCs that had a lower quality of export products. However, for LDCs with a relatively higher quality of existing export products, there is no significant effect of the TRIPS Waiver on the technological base. When proxying imitation by export variety, we have found that the TRIPS Waiver led to a larger expansion of the technological base in LDCs that endeavoured to improve their level of overall export product diversification,

including export product diversification at the intensive and extensive margins. Finally, results based on imitation measured by export product quality improvement in the context of greater overall export product diversification, suggest that only LDCs that improved relatively substantially their export product quality in the context of greater export product diversification (even though on low value-added products) experienced a larger positive effect of the TRIPS Waiver on the technological base.

In a nutshell, the present analysis has shed light on the potential benefits of the TRIPS Waiver for LDCs, including in terms of expansion of the technological base. The latter is essential for achieving a sustainable economic growth and development. Yet, the participation of LDCs in bilateral and regional trade agreements may weaken the utilization of the LDC flexibilities in the TRIPS Agreement, but in the meantime, some leeway still exists for LDCs to make best use of these flexibilities in order to expand their technological base. A greater support from the international community in favour of LDCs would be very helpful in their journey to move toward the world technology frontier with a view to promoting a sustainable economic and social development.

One limitation of the present analysis is its country coverage. Based on the available data, the analysis has been carried out over a sample of 14 LDCs. While the findings provide clear evidence on the potential effect of the TRIPS Waiver on the technological base, it could be useful if in the future, and once the requisite data would be available, that study be replicated over the maximum possible LDCs for which data would be available.

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TABLES and APPENDICES

Table 1: *Outcomes of the statistical test proposed by Mora and Reggio (2012, 2015, 2017) and of the Cluster-Robust Hausman Test*

	Common pre-dynamics test over "FS1"	Common pre-dynamics test over "FS2"	Hausman test over "FS1"	Hausman test over "FS2"
	(1)	(2)	(3)	(4)
TFP	0.1307 (0.9367)	1.867 (0.3933)	1.91 (0.9970)	2.53 (0.9905)

Note: The statistical test proposed by Mora and Reggio (2012, 2015, 2017) is a 'common pre-dynamics test' to test the parallel trends assumption, i.e., to test the existence of common pre-treatment dynamics in the treatment group (i.e., LDCs) and the control group. The null hypothesis of the test is the presence of common dynamics and equal dynamic effects in the treatment group and control group before the treatment, that is, here, before the entry into force of the TRIPS Agreement. We report the Chi-squared statistics and its related p-value in brackets. The statistical Cluster-Robust Hausman Test was performed over each model specification where the dependent variable is "TFP". For this statistical test, we report the Chi-squared statistics and the related p-value in brackets.

Table 2: Effect of the LDC TRIPS Waiver on TFP in LDCs_Over FS1 and FS2
Estimators: PCSE and FEDK

Variables	Full sample "FS1"		Full sample "FS2"	
	PCSE	FEDK	PCSE	FEDK
	TFP	TFP	TFP	TFP
	(1)	(2)	(3)	(4)
DiD	0.0961*** (0.0126)	0.0874*** (0.0113)	0.120*** (0.0359)	0.123*** (0.0119)
TRIPS	-0.0616*** (0.0237)	-0.139*** (0.0324)	-0.0990*** (0.0272)	-0.167*** (0.0441)
LDC	-0.311*** (0.0308)		-0.265*** (0.0672)	
HUM	-0.0334*** (0.00943)	-0.0214 (0.0159)	-0.0118 (0.0166)	-0.0400 (0.0263)
POPGR	0.0115*** (0.00431)	0.0148** (0.00706)	0.00628** (0.00313)	0.0118* (0.00606)
INFL	-0.0121*** (0.00465)	-0.0178** (0.00847)	-0.0163*** (0.00466)	-0.0187* (0.00918)
GCONS	0.00231*** (0.000871)	0.00124 (0.00166)	0.00145 (0.000917)	0.00126 (0.00130)
FDI	-0.00164 (0.00137)	-0.000770 (0.00248)	0.00194 (0.00199)	0.00218 (0.00330)
OPEN	0.00111*** (0.000315)	7.25e-05 (0.000483)	-9.68e-05 (0.000526)	-0.00109** (0.000390)
TERMS	0.000352* (0.000190)	0.000330 (0.000198)	0.000267** (0.000110)	0.000607** (0.000251)
POLITY	0.00259 (0.00164)	0.00673*** (0.00108)	0.00855*** (0.00312)	0.00950*** (0.00134)
Constant	0.740*** (0.0512)	0.544*** (0.0414)	0.811*** (0.0662)	0.641*** (0.0521)
Observations - Countries	143 - 25	143 - 25	126 - 23	126 - 23
R ²	0.769		0.854	
Within R ²		0.3006		0.4029

Note: *p-value<0.1; **p-value<0.05; ***p-value<0.01. Robust standard errors are in parenthesis. The full sample "FS1" contains LDCs and countries in the control group CG1. CG1 includes countries that had not been in the LDC category, but would not have met the criteria for graduating from the category of LDCs if they were included in the category (see Klasen et al., 2021: p164). The full sample "FS2" contains LDCs and countries in the control group CG2. CG2 includes low-income countries (LICs) that are not LDCs but are eligible to the PRGF of the International Monetary Fund (IMF) (see IMF, 2022: p57). The dummy variable "TRIPS" takes the value 1 from the sub-periods 1996-2000 to 2011-2015, and the value of 0 for the preceding sub-periods. Time dummies have been included in the regression that used the PCSE estimator. The variable "DiD" is the interaction between the dummy "TRIPS" and the dummy "LDC", the latter taking the value 1 for LDCs, and 0, for countries in the control group (CG1 or CG2).

Table 3: Effect of the LDC TRIPS Waiver on TFP in LDCs for varying strengths of IPR protection_Over FS1 and FS2
Estimator. PCSE

Variables	FS1	FS2
	TFP (1)	TFP (2)
DiD	0.101*** (0.0301)	0.141*** (0.0386)
DiD*PRIE	-0.00559 (0.0237)	0.0204 (0.0337)
TRIPS	-0.0671*** (0.0214)	-0.151*** (0.0285)
LDC	-0.331*** (0.0742)	-0.353*** (0.108)
PRIE	0.0426* (0.0241)	0.0307 (0.0221)
HUM	-0.0401** (0.0189)	-0.0365 (0.0371)
POPGR	-0.00238 (0.00346)	0.00205 (0.00190)
INFL	-0.0114** (0.00567)	-0.0233*** (0.00387)
GCONS	0.00246 (0.00212)	0.00172 (0.00143)
FDI	-0.00272** (0.00117)	0.00119 (0.00171)
OPEN	0.00155*** (0.000239)	-0.000978** (0.000410)
TERMS	0.000539*** (0.000157)	0.000377*** (0.000101)
POLITY	0.00268 (0.00171)	0.00539 (0.00398)
Constant	0.609*** (0.0587)	0.793*** (0.108)
Observations - Countries	110 - 21	96 - 18
R ²	0.808	0.860

Note: * p -value <0.1 ; ** p -value <0.05 ; *** p -value <0.01 . Robust standard errors are in parenthesis. The full sample "FS1" contains LDCs and countries in the control group CG1. CG1 includes countries that had not been in the LDC category, but would not have met the criteria for graduating from the category of LDCs if they were included in the category (see Klasen et al., 2021: p164). The full sample "FS2" contains LDCs and countries in the control group CG2. CG2 includes low-income countries (LICs) that are not LDCs but are eligible to the PRGF of the International Monetary Fund (IMF) (see IMF, 2022: p57). The dummy variable "TRIPS" takes the value 1 from the sub-periods 1996-2000 to 2011-2015, and the value of 0 for the preceding sub-periods. Time dummies have been included in the regression that used the PCSE estimator. The variable "DiD" is the interaction between the dummy "TRIPS" and the dummy "LDC", the latter taking the value 1 for LDCs, and 0, for countries in the control group (CG1 or CG2).

Table 4: Effect of the LDC TRIPS Waiver on TFP in LDCs for varying levels of export product quality/overall export product diversification_Over FS1 and FS2

Estimator. PCSE

Variables	FS1	FS2	FS1	FS2
	TFP	TFP	TFP	TFP
	(1)	(2)	(3)	(4)
DiD*QUAL	-0.0895*** (0.0218)	-0.125*** (0.0264)		
DiD*EDI			0.105*** (0.0336)	0.129*** (0.0397)
DiD	0.114*** (0.0320)	0.177*** (0.0465)	0.0591*** (0.0142)	0.0751** (0.0372)
TRIPS	-0.0513** (0.0223)	-0.100*** (0.0334)	-0.0627*** (0.0183)	-0.106*** (0.0213)
LDC	-0.288*** (0.0548)	-0.271*** (0.0659)	-0.316*** (0.0309)	-0.306*** (0.0549)
QUAL	0.0813*** (0.0195)	0.107*** (0.0255)		
EDI			-0.0647*** (0.0187)	-0.0988*** (0.0267)
HUM	-0.0366** (0.0164)	-0.0186 (0.0179)	-0.0329** (0.0133)	-0.0219 (0.0144)
POPGR	0.00300 (0.00324)	0.000224 (0.00324)	0.0101*** (0.00368)	0.00543** (0.00262)
INFL	-0.0113** (0.00510)	-0.0130*** (0.00444)	-0.0127** (0.00522)	-0.0161*** (0.00534)
GCONS	0.00120 (0.00115)	0.000168 (0.000899)	0.00164 (0.00105)	0.000122 (0.00143)
FDI	-0.000907 (0.00181)	0.00214 (0.00190)	-0.00224** (0.000970)	0.00129 (0.00171)
OPEN	0.000607 (0.000447)	1.51e-05 (0.000619)	0.00148*** (0.000415)	0.000509 (0.000578)
TERMS	0.000489*** (8.96e-05)	0.000502*** (0.000118)	0.000392*** (0.000149)	0.000363*** (0.000119)
POLITY	0.00654*** (0.00162)	0.00943*** (0.00289)	0.00214 (0.00145)	0.00805*** (0.00212)
Constant	0.755*** (0.0588)	0.786*** (0.0611)	0.757*** (0.0284)	0.866*** (0.0625)
Observations - Countries	135 - 25	125 - 23	143 - 25	126 - 23
R ²	0.788	0.842	0.768	0.866

Note: *p-value<0.1; **p-value<0.05; ***p-value<0.01. Robust standard errors are in parenthesis. The full sample "FS1" contains LDCs and countries in the control group CG1. CG1 includes countries that had not been in the LDC category, but would not have met the criteria for graduating from the category of LDCs if they were included in the category (see Klasen et al., 2021: p164). The full sample "FS2" contains LDCs and countries in the control group CG2. CG2 includes low-income countries (LICs) that are not LDCs but are eligible to the PRGF of the International Monetary Fund (IMF) (see IMF, 2022: p57). The dummy variable "TRIPS" takes the value 1 from the sub-periods 1996-2000 to 2011-2015, and the value of 0 for the preceding sub-periods. Time dummies have been included in the regression that used the PCSE estimator. The variable "DiD" is the interaction between the dummy "TRIPS" and the dummy "LDC", the latter taking the value 1 for LDCs, and 0, for countries in the control group (CG1 or CG2).

Table 5: Effect of the LDC TRIPS Waiver on TFP in LDCs for varying levels of export product diversification at the intensive margins/at the extensive margins_Over FS1 and FS2
Estimator. PCSE

Variables	FS1	FS2	FS1	FS2
	TFP	TFP	TFP	TFP
	(1)	(2)	(3)	(4)
DiD*EDIINT	0.0967*** (0.0235)	0.114*** (0.0366)		
DiD*EDIEXT			0.0742*** (0.0258)	0.0600** (0.0302)
DiD	0.0591*** (0.00992)	0.0968** (0.0422)	0.0543** (0.0253)	0.0582 (0.0355)
TRIPS	-0.0644*** (0.0178)	-0.124*** (0.0230)	-0.0527 (0.0330)	-0.0733*** (0.0241)
LDC	-0.317*** (0.0342)	-0.285*** (0.0570)	-0.314*** (0.0280)	-0.255*** (0.0687)
EDIINT	-0.0377** (0.0166)	-0.0737*** (0.0210)		
EDIEXT			-0.0849*** (0.0210)	-0.0787** (0.0339)
HUM	-0.0353*** (0.0126)	-0.0128 (0.0153)	-0.0304*** (0.00677)	-0.0151 (0.0163)
POPGR	0.0111*** (0.00357)	0.00555*** (0.00188)	0.00928** (0.00463)	0.00457 (0.00357)
INFL	-0.0132*** (0.00472)	-0.0167*** (0.00548)	-0.0114*** (0.00346)	-0.0160*** (0.00328)
GCONS	0.00245*** (0.000871)	0.00137 (0.00118)	0.00162 (0.000993)	0.000675 (0.00101)
FDI	-0.00197* (0.00108)	0.00143 (0.00174)	-0.00131 (0.00153)	0.00177 (0.00208)
OPEN	0.00125*** (0.000378)	4.47e-05 (0.000569)	0.00127*** (0.000308)	9.61e-05 (0.000523)
TERMS	0.000450*** (0.000139)	0.000419*** (7.06e-05)	0.000183 (0.000259)	0.000128 (0.000196)
POLITY	0.00264* (0.00138)	0.00824*** (0.00285)	0.00142 (0.00200)	0.00745** (0.00333)
Constant	0.756*** (0.0316)	0.842*** (0.0489)	0.815*** (0.0633)	0.854*** (0.0870)
Observations - Countries	143 - 25	126 - 23	143 - 25	126 - 23
R ²	0.760	0.862	0.791	0.848

Note: *p-value<0.1; **p-value<0.05; ***p-value<0.01. Robust standard errors are in parenthesis. The full sample "FS1" contains LDCs and countries in the control group CG1. CG1 includes countries that had not been in the LDC category, but would not have met the criteria for graduating from the category of LDCs if they were included in the category (see Klasen et al., 2021: p164). The full sample "FS2" contains LDCs and countries in the control group CG2. CG2 includes low-income countries (LICs) that are not LDCs but are eligible to the PRGF of the International Monetary Fund (IMF) (see IMF, 2022: p57). The dummy variable "TRIPS" takes the value 1 from the sub-periods 1996-2000 to 2011-2015, and the value of 0 for the preceding sub-periods. Time dummies have been included in the regression that used the PCSE estimator. The variable "DiD" is the interaction between the dummy "TRIPS" and the dummy "LDC", the latter taking the value 1 for LDCs, and 0, for countries in the control group (CG1 or CG2).

Table 6: Effect of the LDC TRIPS Waiver on TFP in LDCs for varying values of the index that combines export product quality and the overall export product diversification_Over FS1 & FS2 *Estimator*. PCSE

Variables	FS1 TFP (1)	FS2 TFP (2)
DiD*QUALEDI	0.0969*** (0.0227)	0.0765** (0.0362)
DiD	0.0217 (0.0342)	0.0952** (0.0404)
TRIPS	-0.0398* (0.0212)	-0.105*** (0.0228)
LDC	-0.295*** (0.0507)	-0.278*** (0.0526)
QUALEDI	-0.0959*** (0.0182)	-0.0856*** (0.0241)
HUM	-0.0383** (0.0173)	-0.0125 (0.0149)
POPGR	0.0121** (0.00516)	0.00861*** (0.00314)
INFL	-0.0129** (0.00504)	-0.0168*** (0.00483)
GCONS	0.00240** (0.000961)	0.00186** (0.000937)
FDI	-0.00217 (0.00164)	0.00162 (0.00181)
OPEN	0.000900** (0.000426)	-0.000203 (0.000562)
TERMS	0.000321*** (6.78e-05)	0.000266** (0.000120)
POLITY	0.00338* (0.00181)	0.00804*** (0.00306)
Constant	0.710*** (0.0450)	0.809*** (0.0535)
Observations - Countries	135 - 25	125 - 23
R ²	0.793	0.861

Note: *p-value<0.1; **p-value<0.05; ***p-value<0.01. Robust standard errors are in parenthesis. The full sample "FS1" contains LDCs and countries in the control group CG1. CG1 includes countries that had not been in the LDC category, but would not have met the criteria for graduating from the category of LDCs if they were included in the category (see Klasen et al., 2021: p164). The full sample "FS2" contains LDCs and countries in the control group CG2. CG2 includes low-income countries (LICs) that are not LDCs but are eligible to the PRGF of the International Monetary Fund (IMF) (see IMF, 2022: p57). The dummy variable "TRIPS" takes the value 1 from the sub-periods 1996-2000 to 2011-2015, and the value of 0 for the preceding sub-periods. Time dummies have been included in the regression that used the PCSE estimator. The variable "DiD" is the interaction between the dummy "TRIPS" and the dummy "LDC", the latter taking the value 1 for LDCs, and 0, for countries in the control group (CG1 or CG2).

Table 7: Effect of the LDC TRIPS Waiver on TFP in LDCs_Over the full sample "FS1"
Estimator. Method of Moments Quantile Regression (MMQR)

Variables	Location ^a	Scale ^b	Q10 th	Q25 th	Q50 th	Q75 th	Q90 th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DiD	0.0856** (0.0377)	-0.0291 (0.0243)	0.130*** (0.0416)	0.113*** (0.0354)	0.0868** (0.0376)	0.0583 (0.0513)	0.0326 (0.0711)
TRIPS	-0.0585 (0.0374)	0.0110 (0.0269)	-0.0751 (0.0529)	-0.0690 (0.0435)	-0.0589 (0.0373)	-0.0481 (0.0467)	-0.0384 (0.0648)
HUM	0.0303 (0.0295)	0.00862 (0.0145)	0.0173 (0.0271)	0.0221 (0.0256)	0.0299 (0.0292)	0.0384 (0.0380)	0.0460 (0.0493)
POPGR	0.00654 (0.00578)	0.00635*** (0.00243)	-0.00304 (0.00621)	0.000486 (0.00585)	0.00629 (0.00593)	0.0125* (0.00677)	0.0181** (0.00736)
INFL	-0.0151 (0.0117)	-0.00158 (0.00786)	-0.0128 (0.0140)	-0.0136 (0.0120)	-0.0151 (0.0117)	-0.0166 (0.0156)	-0.0180 (0.0209)
GCONS	0.00221 (0.00148)	0.00202* (0.00111)	-0.000833 (0.00169)	0.000288 (0.00140)	0.00213 (0.00152)	0.00410* (0.00220)	0.00588** (0.00297)
FDI	0.00106 (0.00347)	0.00264* (0.00139)	-0.00292 (0.00380)	-0.00145 (0.00366)	0.000960 (0.00353)	0.00354 (0.00386)	0.00586 (0.00425)
OPEN	-0.000446 (0.000558)	-0.000569* (0.000310)	0.000412 (0.000649)	9.57e-05 (0.000562)	-0.000424 (0.000566)	-0.000980 (0.000705)	-0.00148* (0.000880)
TERMS	0.000390** (0.000187)	4.60e-06 (9.94e-05)	0.000383** (0.000186)	0.000385** (0.000172)	0.000389** (0.000186)	0.000394 (0.000241)	0.000398 (0.000308)
POLITY	0.0103*** (0.00357)	0.00261* (0.00158)	0.00633** (0.00298)	0.00779*** (0.00302)	0.0102*** (0.00358)	0.0127*** (0.00461)	0.0150*** (0.00560)
Constant	0.576*** (0.0927)	0.0623* (0.0364)	0.482*** (0.0731)	0.517*** (0.0793)	0.573*** (0.0932)	0.634*** (0.117)	0.689*** (0.137)
Observations	143	143	143	143	143	143	143

Note: * p -value <0.1 ; ** p -value <0.05 ; *** p -value <0.01 . Robust standard errors are in parenthesis. (a) indicates the location parameters, and (b) refers to the scale parameters. The full sample "FS1" contains LDCs and countries in the control group CG1. CG1 includes countries that had not been in the LDC category, but would not have met the criteria for graduating from the category of LDCs if they were included in the category (see Klasen et al., 2021: p164).

Table 8: Effect of the LDC TRIPS Waiver on TFP in LDCs_Over the full sample "FS2"
Estimator. Method of Moments Quantile Regression (MMQR)

Variables	Location ^a	Scale ^b	Q10 th	Q25 th	Q50 th	Q75 th	Q90 th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DiD	0.134*** (0.0445)	-0.0261 (0.0269)	0.173*** (0.0448)	0.157*** (0.0401)	0.136*** (0.0440)	0.107* (0.0623)	0.0838 (0.0874)
TRIPS	-0.128*** (0.0443)	0.0126 (0.0266)	-0.147** (0.0588)	-0.139*** (0.0493)	-0.129*** (0.0443)	-0.115** (0.0530)	-0.104 (0.0718)
HUM	0.0141 (0.0406)	0.0272 (0.0214)	-0.0266 (0.0244)	-0.00943 (0.0277)	0.0124 (0.0395)	0.0422 (0.0603)	0.0665 (0.0840)
POPGR	0.00826 (0.00529)	0.00659*** (0.00198)	-0.00163 (0.00521)	0.00254 (0.00534)	0.00783 (0.00546)	0.0151** (0.00633)	0.0210*** (0.00649)
INFL	-0.0172* (0.0101)	0.00302 (0.00690)	-0.0217* (0.0125)	-0.0198* (0.0103)	-0.0174* (0.00997)	-0.0141 (0.0138)	-0.0114 (0.0190)
GCONS	0.00178 (0.00133)	0.00148 (0.00108)	-0.000443 (0.00184)	0.000494 (0.00146)	0.00168 (0.00136)	0.00330* (0.00198)	0.00463* (0.00280)
FDI	0.00218 (0.00324)	0.00193 (0.00154)	-0.000718 (0.00293)	0.000506 (0.00289)	0.00206 (0.00324)	0.00418 (0.00432)	0.00591 (0.00515)
OPEN	-0.00122* (0.000624)	-0.000364 (0.000375)	-0.000671 (0.000663)	-0.000901 (0.000575)	-0.00119* (0.000620)	-0.00159* (0.000874)	-0.00192* (0.00114)
TERMS	0.000578*** (0.000204)	-0.000100 (0.000108)	0.000729*** (0.000202)	0.000665*** (0.000187)	0.000585*** (0.000201)	0.000475* (0.000267)	0.000384 (0.000361)
POLITY	0.0131*** (0.00385)	0.00347** (0.00165)	0.00788** (0.00309)	0.0101*** (0.00324)	0.0129*** (0.00385)	0.0167*** (0.00523)	0.0198*** (0.00668)
Constant	0.620*** (0.0973)	0.0397 (0.0427)	0.560*** (0.0739)	0.586*** (0.0786)	0.617*** (0.0959)	0.661*** (0.132)	0.697*** (0.159)
Observations	126	126	126	126	126	126	126

Note: * p -value <0.1 ; ** p -value <0.05 ; *** p -value <0.01 . Robust standard errors are in parenthesis. (a) indicates the location parameters, and (b) refers to the scale parameters. The full sample "FS2" contains LDCs and countries in the control group CG2. CG2 includes low-income countries (LICs) that are not LDCs but are eligible to the PRGF of the International Monetary Fund (IMF) (see IMF, 2022: p57).

Appendix 1: Definition and source of variables

Variables	Definition	Source
TFP	This is the measure of total factor productivity (TFP) level at current purchasing power parity (USA=1). It shows relative TFP across countries.	Penn World Tables (PWT) 10.01 (see Feenstra et al., 2015).
QUAL	<p>This is the index of export product quality. It is obtained by transforming the IMF's indicator of export product quality so that its values range between 0 and 1. The indicator of export product quality reflects the quality of existing exported products, and a country's position on the quality ladder (implying world frontier value). It has been calculated using bilateral trade values and quantities at the SITC 4-digit level (see Henn et al., 2013, 2015). The calculation relies on an estimation methodology which derives quality from unit values, whereby export quality is measured by the average quality (unit value) demanded in an exporter's present destination markets for any product. The trade dataset contains information on trade prices, values and quantities as well as information on preferential trade agreements, and other gravity variables.</p> <p>The indicator of export product quality of the IMF (denoted "QUAL1") has been transformed as follows: $QUAL_{it} = \frac{QUAL1_{it} - \min(QUAL1_i)}{\max(QUAL1_i) - \min(QUAL1_i)}$, where the subscripts i and t stand respectively for a given country and a given year. Higher values of the index "QUAL" indicate greater export product quality.</p>	<p>Author's calculation based on data from the International Monetary Fund's Diversification Toolkit (see: https://www.imf.org/external/np/res/dfidimf/diversification.htm)</p> <p>Details on the methodology used to calculate this index can be found in Henn et al. (2013, 2015).</p>
EDI	<p>This is the index of the overall export product diversification. It is obtained from the transformation of the indicator of the overall export product concentration so that its values range between 0 and 1. This indicator was developed by the IMF, and computed using the Theil index and following the definitions and methods used in Cadot et al. (2011). The overall Theil index of export product concentration is the sum of the intensive and extensive components of export product concentration. Indeed, export product diversification can occur either over product narrowly defined or trading partners. It can be broken down into the extensive and intensive margins of concentration. Extensive export diversification reflects an increase in the number of new export products or trading partners, while intensive export diversification considers the shares of export volumes across active products or trading partners. The calculation of the indicator has relied on a classification of products into "Traditional", "New", or "Non-Traded" products categories.</p>	<p>Author's calculation based on data from the International Monetary Fund's Diversification Toolkit (see: https://www.imf.org/external/np/res/dfidimf/diversification.htm)</p> <p>Details on the methodology used to calculate this index can be found in Henn et al. (2013, 2015).</p>

	<p>If we denote "ECI" the IMF's indicator of overall export product concentration, then its transformation to obtain the indicator "EDI" is as follows:</p> $EDI_{it} = 1 - \left[\frac{ECI_{it} - \min(ECI_i)}{\max(ECI_i) - \min(ECI_i)} \right]$ <p>where the subscripts i and t stand respectively for a given country and a given year. The expression in brackets represents the index of overall export product concentration whose values range between 0 and 1. The index of overall export product diversification is obtained by taking 1 minus the expression in brackets above. The values of the index "EDI" also range between 0 and 1, with higher values indicating greater overall export product diversification, and lower values showing a tendency for a greater (overall) export product concentration.</p>	
EDIINT	<p>This is the index of the export product diversification at the intensive margins. Its values range between 0 and 1, and has been computed using the IMF's Theil indicator of export product concentration at the intensive margins, and following the same approach described above for computing the overall export product diversification.</p> <p>Concretely,</p> $EDIINT_{it} = 1 - \left[\frac{ECIINT_{it} - \min(ECIINT_i)}{\max(ECIINT_i) - \min(ECIINT_i)} \right]$ <p>where the subscripts i and t stand respectively for a given country and a given year. "ECIINT" the IMF's indicator of export product concentration at the intensive margins. The values of "EDIINT" range between 0 and 1, with higher values reflecting a higher degree of export product diversification at the intensive margins, and declining values of this index showing a greater export product concentration at the intensive margins.</p>	<p>Author's calculation based on data from the International Monetary Fund's Diversification Toolkit (see: https://www.imf.org/external/np/res/dfidimf/diversification.htm)</p> <p>Details on the methodology used to calculate this index can be found in Henn et al. (2013, 2015).</p>
EDIEXT	<p>This is the index of the export product diversification at the extensive margins. Its values range between 0 and 1, and has been computed using the IMF's Theil indicator of export product concentration at the extensive margins, and following the same approach described above for computing the overall export product diversification.</p> <p>Concretely,</p> $EDIEXT_{it} = 1 - \left[\frac{ECIEXT_{it} - \min(ECIEXT_i)}{\max(ECIEXT_i) - \min(ECIEXT_i)} \right]$ <p>where the subscripts i and t stand respectively for a given country and a given year. "ECIEXT" the IMF's indicator of export product concentration at the extensive margins. The values of "EDIEXT" range between 0 and 1, with higher values reflecting a higher degree of export product</p>	<p>Author's calculation based on data from the International Monetary Fund's Diversification Toolkit (see: https://www.imf.org/external/np/res/dfidimf/diversification.htm)</p> <p>Details on the methodology used to calculate this index can be found in Henn et al. (2013, 2015).</p>

	diversification at the extensive margins, and declining values of this index showing a greater export product concentration at the extensive margins.	
QUALEDI	<p>This is the combined index of export product quality and overall export product diversification. Higher values of this index reflect an improvement in the quality of exported products in a context of the overall export product diversification. It has been computed as the geometric mean of the index of export product quality calculated above ("QUAL") and the index of overall export product diversification.</p> $QUALEDI_{it} = \sqrt{QUAL_{it} * EDI_{it}}$ <p>where $QUAL_{it}$ and EDI_{it} are respectively the index of export product quality and the index of overall export product diversification, for a given country i, in a given year t. The values of this indicator range from 0 to 1, with higher values indicating a greater export product quality in the context of the overall export product diversification.</p>	Author's calculation using data on the indices "QUAL" and "EDI" computed above.
PRIE	<p>This is the effective patent protection (PRIE) computed as the index of Patent Protection (PRI) multiplied by the index of effectiveness of legal of contracts. The index of patent protection is based on of patentee rights, and comprises five components, each being scored out of one. These include the duration of patent protection relative to the international standard; the subject matter that is patentable (or not unpatentable); the participation in international Intellectual Property Rights agreements; the enforcement mechanisms available; and how limited (or less restricted) the patenting exceptions are (such as any requirement to practice the invention or license the patents to third-parties). The overall index of patent protection varies from 0 to 5, with higher numbers reflecting strong levels of patent rights.</p>	<p>The indicator "IPR" is developed by Park (2008) see data online at: http://fs2.american.edu/wgp/www/</p> <p>Data on the index of legal enforcement effectiveness is extracted from the Fraser Institute (https://www.fraserinstitute.org/economic-freedom/dataset) (see Gwartney et al., 2022)</p> <p>Note that values of "PRI" in the database of Park (2008) range between 0 and 5, while in the database of the Fraser Institute, the values of the index of legal enforcement of contracts range between 0 and 10. Following Liu et al. (2021), to compute the indicator of "PRIE", we use the index of legal enforcement deflated by 10 so that its values range now between 0 and 1.</p>

HUM	This is the indicator of human capital. It is measured by the average years of total schooling for the population aging between 15 and 64.	Barro and Lee Database, updated in 2021 (see Barro and Lee, 2013). Accessible online at: http://www.barrolee.com/
GCONS	This is the ratio (in percentage) of the general government final consumption expenditure to GDP.	World Development Indicators (WDI) of the World Bank
FDI	This is the indicator of the net inflows of FDI (in percentage of GDP)	WDI
TERMS	This is the indicator of terms of trade, measured by the net barter terms of the trade index (2000 = 100).	WDI
OPEN	This is the indicator of trade openness. It is measured by the share (in percentage) of sum of exports and imports of goods and services in GDP.	WDI
INFL	The variable "INFL" has been calculated using the following formula: $INFL = \text{sign}(INFLATION) * \log(1 + INFLATION)$ where $ INFLATION $ refers to the absolute value of the annual inflation rate, denoted "INFLATION". The annual inflation rate (%) is based on Consumer Price Index -CPI- (annual %) where missing values has been replaced with values of the GDP Deflator (annual %).	Authors' calculation based on data from the WDI.
POPGR	Population growth rate (in percentage)	WDI
POLITY	This variable is an index extracted from Polity IV Database (Marshall et al., 2018). It represents the degree of democracy based on competitiveness of political participation, the openness and competitiveness of executive recruitment and constraints on the chief executive. Its values range between -10 and +10, with lower values reflecting autocratic regimes, and greater values indicating democratic regimes. Specifically, the value +10 for this index represents a strong democratic regime, while the value -10 stands for strong autocratic regime.	Polity IV Database (Marshall et al., 2018)

Appendix 2a: Descriptive statistics on variables used in the analysis over the group of LDCs

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
TFP	78	0.356	0.124	0.159	0.942
PRIE	63	0.749	0.537	0	1.943
QUAL	77	0.517	0.356	0	1
EDI	78	0.515	0.355	0	1
EDIINT	78	0.493	0.341	0	1
EDIEXT	78	0.426	0.387	0	1
QUALEDI	77	0.406	0.330	0	1
HUM	78	3.655	1.678	0.855	7.988
POPGR	78	2.647	1.323	-5.049	8.562
INFLATION	78	7.633	7.399	-2.987	45.286
GCONS	78	15.319	6.075	7.020	39.687
FDI	78	2.548	4.343	-0.561	30.373
OPEN	78	57.856	26.506	24.207	158.222
TERMS	78	123.655	46.336	28.682	261.952
POLITY	78	-0.579	5.276	-7.000	8.000

Appendix 2b: Descriptive statistics on variables used in the analysis over the Control Group CG1

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
TFP	65	0.567	0.229	0.237	1.155
PRIE	47	0.948	0.450	0.280	1.779
QUAL	58	0.481	0.357	0	1
EDI	65	0.529	0.401	0	1
EDIINT	65	0.513	0.409	0	1
EDIEXT	65	0.400	0.381	0	1
QUALEDI	58	0.347	0.311	0	0.992
HUM	65	5.900	1.471	2.463	9.868
POPGR	65	2.339	0.928	0.516	4.498
INFLATION	65	97.495	607.202	-6.731	4828.690
GCONS	65	15.626	5.544	7.179	34.394
FDI	65	2.497	3.426	-1.462	19.722
OPEN	65	76.069	35.498	13.794	161.876
TERMS	65	115.708	37.644	76.060	253.839
POLITY	65	1.250	6.782	-9.000	10.000

Note: Control Group 1 comprises countries that had not been in the LDC category, but would not have met the criteria for graduating from the category of LDCs if they were included in the category (see Klasen et al., 2021: p164).

Appendix 2c: Descriptive statistics on variables used in the analysis over the Control Group CG2

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
TFP	48	0.496	0.178	0.237	1.136
PRIE	33	0.984	0.4609	0.2809	1.779
QUAL	48	0.499	0.348	0	1
EDI	48	0.481	0.393	0	1
EDIINT	48	0.461	0.393	0	1
EDIEXT	48	0.387	0.349	0	1
QUALEDI	48	0.351	0.296	0	0.985

HUM	48	6.662	2.302	2.463	11.167
POPGR	48	2.263	1.018	-0.246	4.184
INFLATION	48	128.585	705.881	-6.731	4828.690
GCONS	48	14.803	5.293	7.179	34.394
FDI	48	2.470	2.594	-0.165	9.017
OPEN	48	75.450	29.896	34.661	135.669
TERMS	48	112.383	37.065	71.535	253.839
POLITY	48	0.555	6.043	-9.000	9.000

Note: Control Group 2 contains LICs that are not LDCs, but that are eligible to the PRGF of the International Monetary Fund (IMF) (see IMF, 2022: p57).

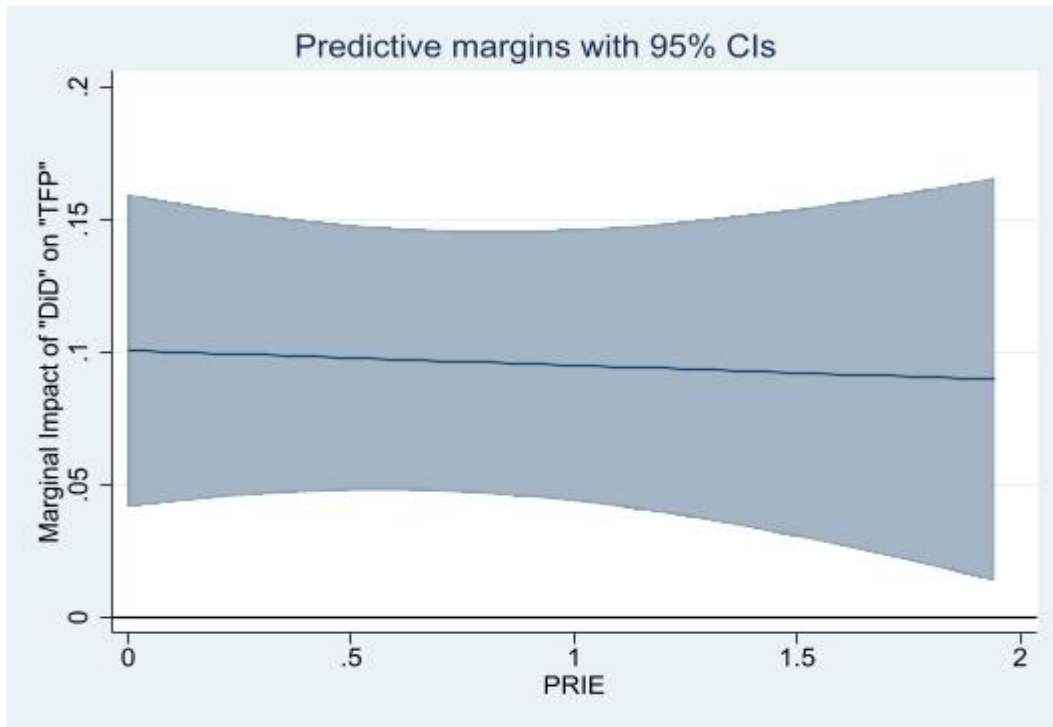
Appendix 3: List of LDCs (14 countries), countries in control group CG1 (11 countries), and countries in control group CG2 (9 countries)

LDCs	Control Group 1	Control Group 2
Benin	Cameroon	Cameroon
Burundi	Cote d'Ivoire	Cote d'Ivoire
Central African Republic	Eswatini	Honduras
Lao PDR	Honduras	Kenya
Lesotho	India	Kyrgyz Republic
Mauritania	Iraq	Moldova
Mozambique	Kenya	Nicaragua
Niger	Mongolia	Tajikistan
Rwanda	Namibia	Zimbabwe
Senegal	Nicaragua	
Sierra Leone	Zimbabwe	
Tanzania		
Togo		
Zambia		

Note: The Group "CG1" refers to the first Control Group, which comprises countries that had not been in the LDC category, but would not have met the criteria for graduating from the category of LDCs if they were included in the category (see Klasen et al., 2021: p164). The Group "CG2" refers to the second Control Group, i.e., that is the control group containing LICs that are not LDCs, but that are eligible to the PRGF of the International Monetary Fund (IMF) (see IMF, 2022: p57).

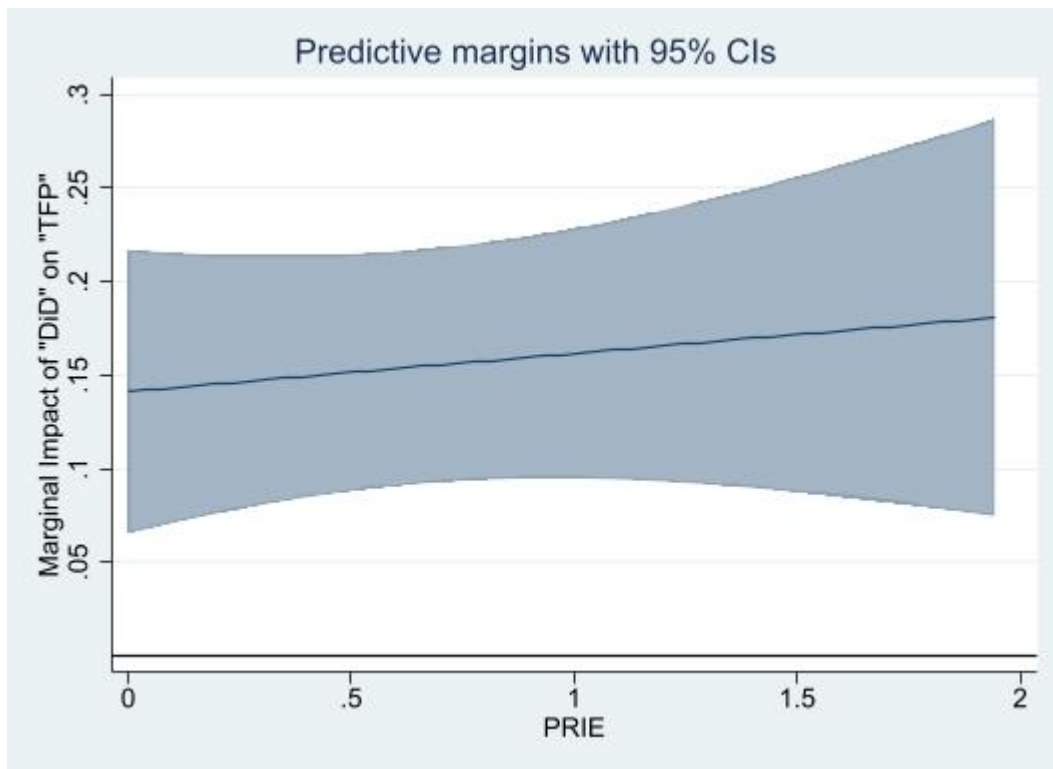
FIGURES

Figure 1: Marginal Impact of "DiD" on "TFP" for varying strengths of IPR protection_Over FS1



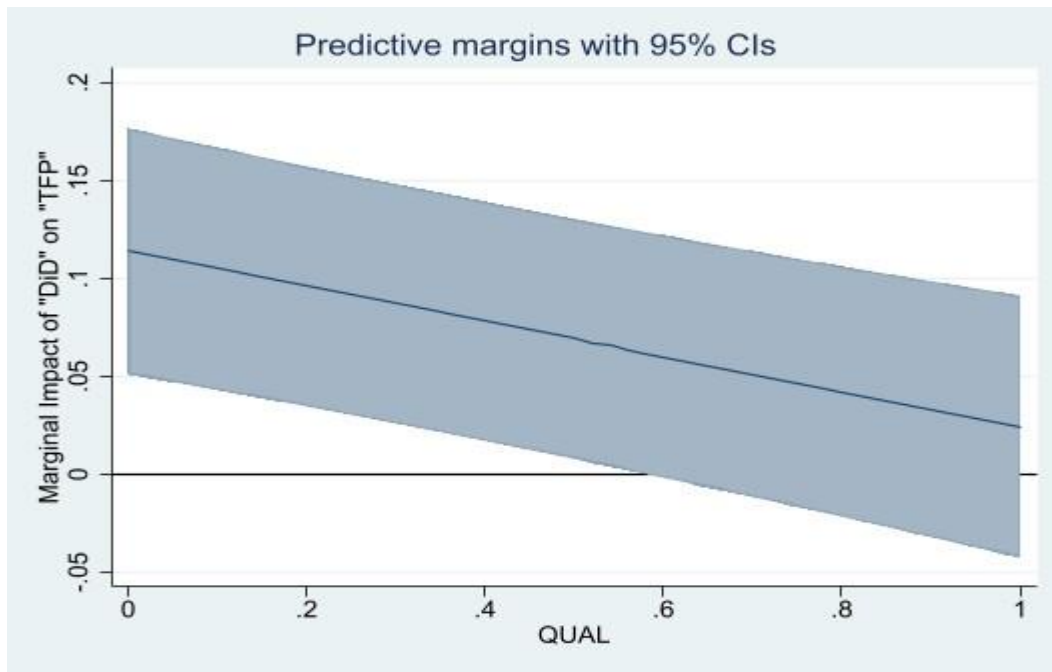
Source: Author

Figure 2: Marginal Impact of "DiD" on "TFP" for varying strengths of IPR protection_Over FS2



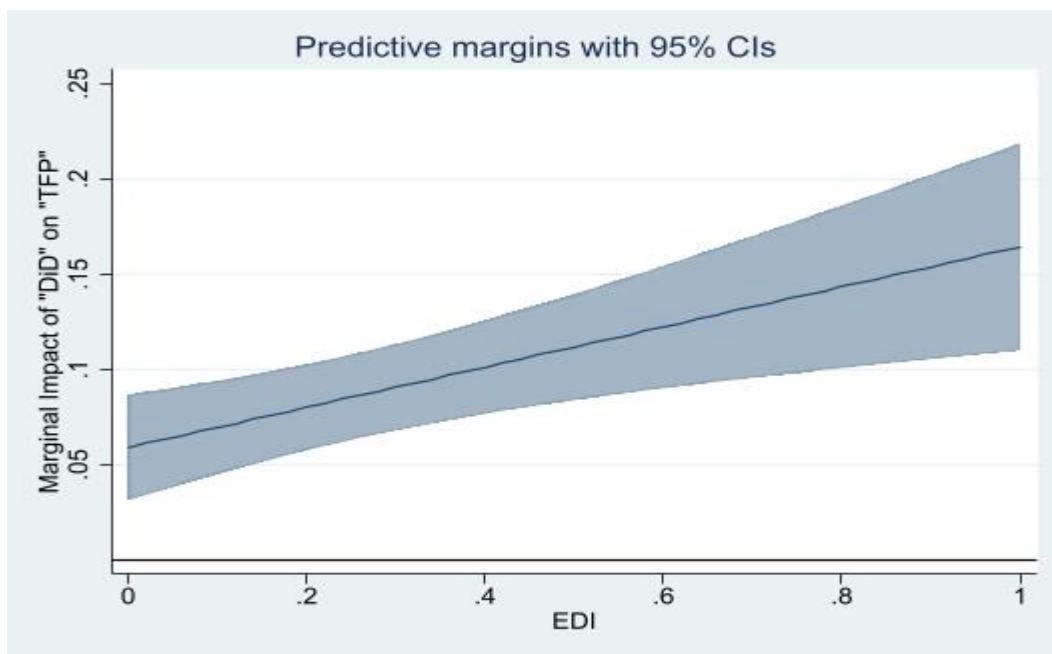
Source: Author

Figure 3: Marginal Impact of "DiD" on "TFP" for varying levels of export product quality_Over FS1



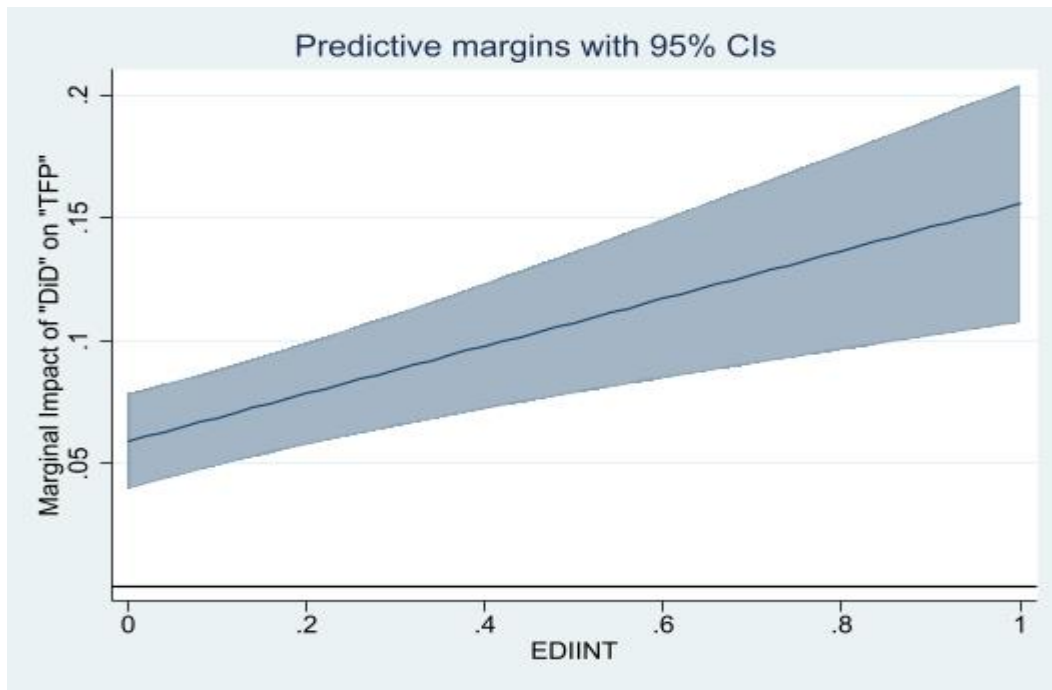
Source: Author

Figure 4: Marginal Impact of "DiD" on "TFP" for varying levels of export product diversification_Over FS1



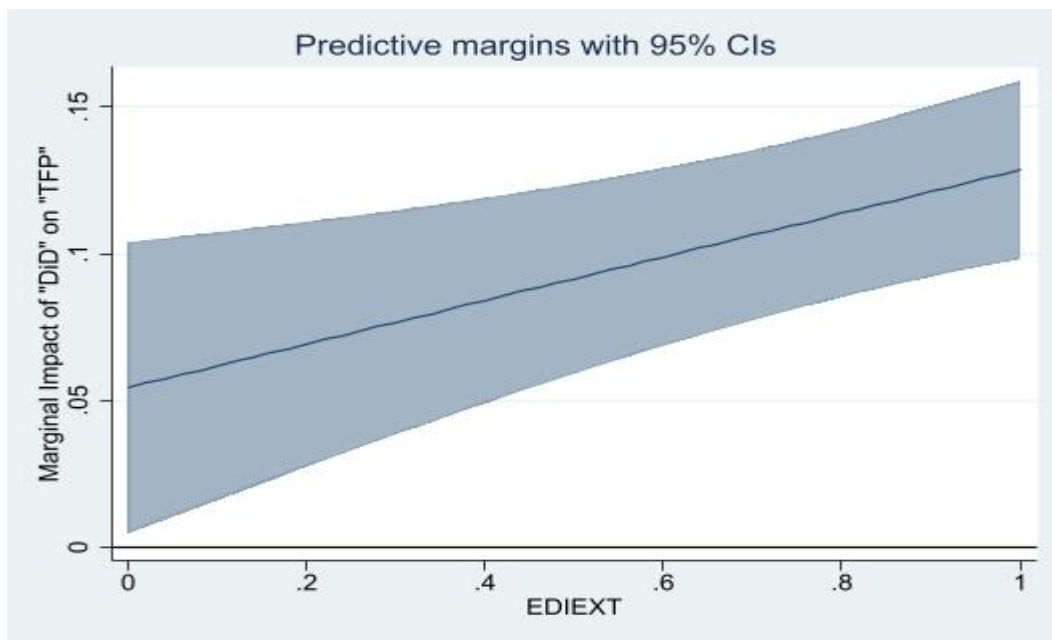
Source: Author

Figure 5: Marginal Impact of "DiD" on "TFP" for varying levels of export product diversification at the intensive margins_Over FS1



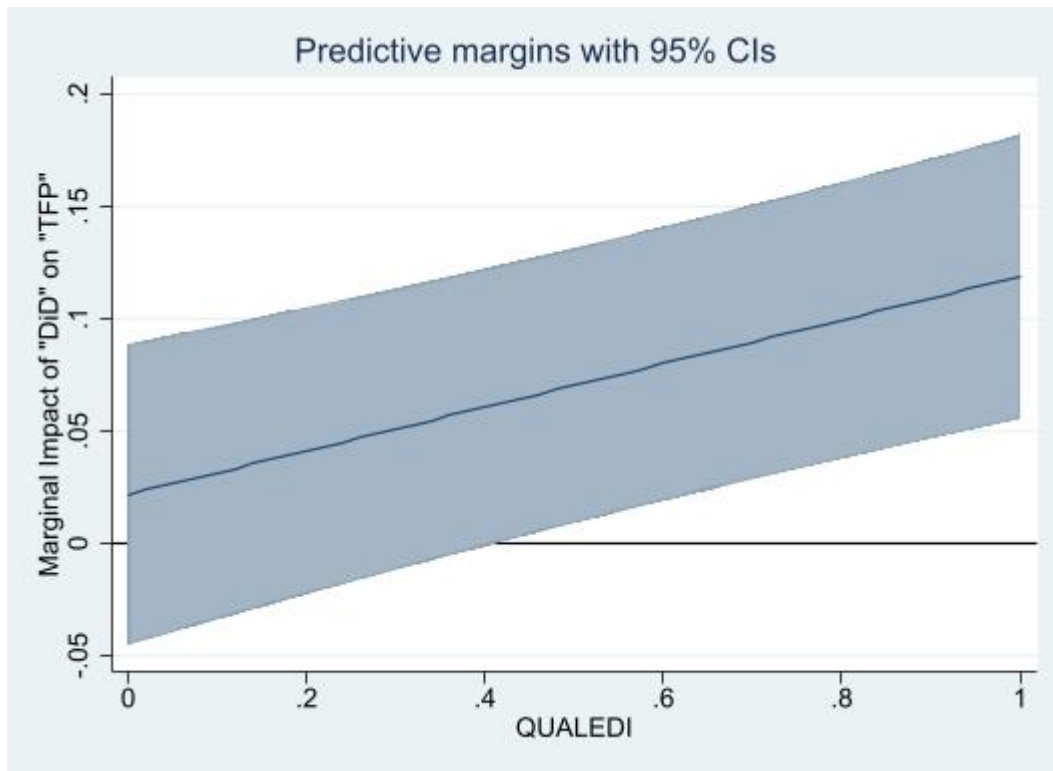
Source: Author

Figure 6: Marginal Impact of "DiD" on "TFP" for varying levels of export product diversification at the extensive margins_Over FS1



Source: Author

Figure 7: Marginal Impact of "DiD" on "TFP" for varying values of the index that combines export product quality and the overall export product diversification_Over FS1



Source: Author