
Structural change in the international patenting level: the TRIPs agreement's role

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Abstract: The time series methodology with structural change is implemented to analyse the presence of breaks in the patenting level – of both residents and non-residents – for a large set of countries and world regions from 1963 to 2011. The international agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), underwritten in 1994, seeks to reinforce the protection of intellectual property rights and so stimulate the patenting activity, mainly in developing countries. From the estimated breakpoints, we find that the TRIPs convention has effectively prompted innovation in both developed and developing countries. Several economies and some world regions report a positive level shift in patenting after the TRIPs agreement, suggesting that the international transfer of technology is increasing. Residents' series for North America and European Union members estimate breakpoints by 1994 and 1997, while non-residents' series of the European Union and South Asia select 1994 and 2003, respectively.

Keywords: patents; TRIPs; structural change; time series; property rights; innovation; developing countries; Latin America; world regions.

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1 Introduction

A main concern for society, governments and academics is to incentive the economic growth, which itself motivates generation of employments, income, and well-being. Economic growth – along with innovation – sharply depends on the production of new ideas (Kremer, 1998; Jonesm 2002, etc.), but to produce and transmit ideas is costly and requires a complete mechanism of protection and diffusion. Society has created several mechanisms such as patents, copyrights, laws, and institutions to protect and incentive the inventive capacity at level of firms and countries. One example is the actual policy of worldwide impact namely as the Trade-Related Aspects of Intellectual Property Rights (TRIPs) agreement.

Why should countries be concerned about the protection of their intellectual property rights (IPRs)? The answer has several possible ramifications. One of them is that often IPRs are associated with high rates of innovation, while the innovation level improves the economic growth processes. Countries seeking to augment their rates of growth must, therefore, strengthen their IPRs (O'Donoghue and Zweimüller, 2004; Di Vita, 2013, 2016; Hudson and Minea, 2013, among other). The TRIPs agreement is a world effort to strengthen IPRs and so impact on countries' rates of growth, mainly for developing countries, the economic performance of which has not been fortunate at all.

The literature highlights some controversy about the impact of the TRIPs agreement in spurring on the world's economic growth. One reason is that innovative nations could not have comparative advantages sharing their innovations (Correia de Souza and Chami, 2011) or the international technology transfer could be related to the level of protection of property rights (Fosfuri, 2000). Other works find that TRIPs positively affect the exports, mainly in developing countries (Yang and Maskus, 2009; Ivus, 2010; Maskus and Yang, 2013), while in Di Vita (2016) TRIPs promote both technological progress and stock market capitalisation. Uncertainty remains especially in the impact on developing countries. Lall and Albaladejo (2002) and Lall (2003) highlighted, for example, that differences in the structures of the countries are determinant factors in the different outcomes by strengthening their IPR regimes, so the economic impact of the TRIPs agreement in developing countries is not clear. Léger (2005) reports a small role of the IPR in developing countries. Liao and Wong (2009) analysed the effects of the TRIPs agreement and found that the world will achieve a higher level of joint welfare if the poor

countries (the South in their model) increase their IPR protection level. Kim et al. (2012) find that the role of the patents varies by level of economic development. According to Di Vita (2013), the TRIPs agreement encourages innovation in developing countries, and he estimated an increment in per capita income of all countries due to this agreement.

Aghion et al. (2015) find evidence that regulatory changes foster innovation in those countries with strong patent rights, but not in countries with weaker patent rights. Gamba (2017) highlights the scarce empirical evidence on the effect of IPR for developing countries. Her results indicate that developing countries profit less than developed ones from the protection.

This research tries to verify whether the TRIPs agreement exerted a positive impact on residents' and non-residents' patent application intensity in 35 countries and six world regions. With this purpose, the time series methodology with structural change constitutes a suitable tool. Since the achievement of good results requires a large time interval, the period starts in 1963 and finishes in 2011. A summary of the findings indicates positive and significant effects on the patenting level since the TRIPs agreement was signed in 1994 by a great majority of developed and developing countries. Other breakpoints identified in years before the TRIPs agreement are easily related to the PCT, which entered into force in 1978. This evidence contributes to the debate on the impacts of the TRIPs agreement, identifying the structural change as well as its magnitude and direction. As a novelty, the occurrence of the breakpoints is not imposed but left to the decision of the data. Up to now, the previous literature has not undertaken an assessment of the TRIPs agreement by taking advantage of the time series approach, which, unlike other techniques, endogenously determines the potential structural changes. Specifically, there are two contributions. First, we study if as a result of the TRIPs the technology transfer is positively changing. Nowadays, is debated if stronger IPR increase the international technology transfer and if effectively multinationals respond to changes on reforms (Branstetter et al., 2006). Second, this study adds the perspective of structural change to the volume of empirical evidence on the role of the TRIPs convention on innovation and world transfer technology. Some authors suggest that a single global level of IPR is in general sub-optimal (Hudson and Minea, 2013; Campi and Dueñas, 2016).

This first section corresponds to the Introduction. A summary of the TRIPs agreement is presented in Section 2, while a review of the literature on patents and IPR is conducted in the Section 3. Next, in Section 4, the methodological time series strategy is explained, while Section 5 describes the data and the set of countries and world regions integrating the empirical evidence. The results are described in Section 6. Finally, Section 7 describes the conclusions.

2 The TRIPs agreement and the international transfer of technologies

The TRIPs agreement is the first effort to introduce intellectual property rules in a multilateral context. It was negotiated in the 1986–1994 Uruguay Round, entering into force in 1995. The agreement considers five general issues:

- 1 how the basic principles of the trading system and other international intellectual property agreements should be applied

- 2 how adequate protection should be given to IPRs
- 3 how countries should enforce those rights adequately in their own territories
- 4 how disputes on intellectual property between members of the World Trade Organization (WTO) should be settled
- 5 special transitional arrangements during the period when the new system is being introduced.¹

The theoretical work regarding IPR protection has been conducted to analyse its effects on the innovation levels of the countries differentiated by their economic growth degree – developed and developing nations – and their role in the technological transfer process – imitating and innovating countries. It is assumed that the South is the developing and imitating region and the north is the developed and innovating one.

In general, developed countries already apply strong IPR protection; therefore, the studies focus on analysing the effects of IPR enforcement in developing nations.² Consequently, stronger IPR protection in the South can be interpreted as an incentive to encourage the North's innovation. This is the case of the TRIPs agreement, as Liao and Wong (2009) suggested.

The implications of the theoretical analysis with respect to the effects on the innovation level of stronger IPR protection depend on the channel through which the technological transfer process takes place, as well as on the public policies that are applied in order to internalise the spillover effects that come from the North's innovating activity.

The relevance of the channel through which the technology is transferred was pointed out by Lai (1998). Applying a dynamic general equilibrium model of the international product cycle, he found that stronger IPRs in the South increase the rate of product innovation, production transfer and the Southern relative wage if foreign direct investment (FDI) is the channel of production transfer, but the effects are the opposite if production is transferred through imitation.

In addition, with a model of the product cycle, but one in which innovation, imitation and FDI are all endogenous and the southern firms can imitate the products of multinationals localised in the south and the products of northern firms, Glass and Saggi (2002) found that stronger IPR protection in the south does not alter the expected profit stream from becoming a multinational relative to remaining a northern firm and hence does not encourage FDI; therefore, the innovation and FDI decrease.

The role of the public policy is crucial in the findings of Connolly and Valderrama (2005) and Liao and Wong (2009). The first study analysed the effects of the TRIPs agreement, studying the competition in technology and production between a firm in the north and a firm in the south and how such competition may be affected by the north's subsidy for technology improvement and the south's IPR protection level. They found that the world will achieve a higher level of joint welfare if the South increases its IPR protection level but also the north provides an R&D subsidy. Meanwhile, the second study, using a dynamic quality ladder model of technological diffusion between innovating firms in one country and imitating firms in another country, found that IPR enforcement would lead to higher levels of welfare for both countries, if the south pays a one-time licensing fee to the north.

3 Patents and IPR, a review

The studies on innovation have been developed with some controversy on patents and its protection to boost innovation. Transfer of technology and high levels of protection of patents are costly because hurt the investment on R&D, the access to new technology becomes difficult (Romer, 1990) or raises the costs of innovating (Grossman and Helpman, 1991). According to Kremer (1998) a major challenge has been to establish the appropriate mechanism to determine the price of the patents, because depending of its valuation and protection will be the effects on technological progress. The centrepiece to encourage innovation is the followed patent policy on how to grant a property right to an inventor (Hopenhayn and Mitchell, 2001) and its effects on the economy. In Takalo and Kanninen (2000) patents always speed up the technological progress, but in Denicolò and Zanchettin (2002) more protection on patents may block or impede additional improvements on innovation. Fosfuri (2000) argues that patterns of international technology transfer are related to the level of protection of property rights in recipient countries. Under this idea, diffusion of technology brought by foreign investors occurs if licensing contract has been signed. In Alvi et al. (2007) there is a threshold in patent protection beyond which R&D slows down, while in Basmann et al. (2007) patent activity positively impacts the technical change of the US economy.

Another main concern is to know if stronger IPRs have some positive effect on innovation. The traditional point of view is that stronger patents rights should increase innovation and economic growth. However, this argue has been debated because recent investigations have found that stronger patents rights reduce innovation, it has had small effects, or this relationship is not clear of all (Takalo and Kanninen, 2000; Denicolò and Zanchettin, 2002; Lerner, 2002; Kultti et al., 2006; Bessen and Meurer, 2006; Hunt, 2006; among others). It is a fact that stronger patents and the composition of patents rights vary across countries by level of economic development (Park, 2008; Kim et al., 2012). Some research has found that effectively there is a positive effect, but it is differentiated according to the level of development of the countries and the channels of technology transfer, as in Maskus (1998), Hoekman et al. (2005), Hudson and Minea (2013), and Mehlig Sweet and Eterovic Maggio (2015). Park (2008) builds an index of patents rights along 1960–2005 and finds that most of the countries are above of the mean, particularly after TRIPs came into force, but this augment varies by level of economic development. Dey (2016) analyses the US semiconductor industry patenting and finds that a stronger patent regime leads to higher patenting, but it creates weak incentives to increase R&D. In the case of Aghion et al. (2015) the reform of the European Union in 1992 enhanced innovation in manufacturing industries of countries with strong patent rights, but not so in industries of countries with weaker patent rights. One possible explanation on the different performance results of the protection on IPR is found in the variations on the norms and standards of IPR offices across countries (Andersen and Konzelmann, 2008). A review of studies on the benefits and costs of strong patent protection by Mazzoleni and Nelson (1998) concludes that stronger patent protection may hinder rather than stimulate technological and economic progress. However, Zobel et al. (2016) suggest that patents encourage the collaborative innovation, and therefore they are important mechanism for innovation, while Rahko (2016) finds that firms with a greater number of innovations present more possibilities to internationalise their R&D activities.

This brief review suggests that the role of the property rights and innovation is highly debated and highlights the necessity of more empirical evidence on this domain.

4 Methodological strategy

Following the time series approach with structural change, the stochastic properties of a sequence of data are assessed under the hypothesis that the time series is characterised by one or two structural changes. If one of them is associated with the TRIPs convention, then it is possible to infer that this agreement created a radical change in the international transfer of technologies through the patenting activity. The time series methodology is a correct and convenient tool to assess the effects of stronger IPRs protection on the creation of patents, basically because it allows the identification not only of the existence of structural change but also of the size and direction of this shift once it has been proved to be stationary.

The theoretical core of this approach rests on the argument that any time series, say $\{y_{it}\}$, is a collection of random variables that follows a stochastic process: it has a normal distribution and it is characterised because its mean, variance and autocovariance are constants, in such a way that the joint distribution of $y_{t1}, \dots, y_{tm}$ is the same as the joint distribution of $y_{t1+\tau}, \dots, y_{tm+\tau}$ for all $t_1, \dots, t_n$ and τ . The distribution of the stationary process remains unchanged when shifted in time by an arbitrary value τ . Thus, the parameters that characterise the distribution of the process do not depend on t , but on the lag τ (see Maddala and Kim, 1998). However, the normal distribution would also be affected by structural changes occurring at some moment during the time, so misleading conclusions could be extracted if important changes are not taken into account when testing for long-run stochastic properties of the phenomenon under study. Thus, the expectation of structural change is for any statistical data evolving in the time.

This idea has been developed in different stages of the literature since Dickey and Fuller (1979) proposed a unit root test for autoregressive time series. Lately, Perron (1989), Perron and Vogelsang (1992) and Zivot and Andrews (1992) developed several tests to consider one structural change endogenously determined by the model, while Lumsdaine and Papell (1997) and Carrion-i-Silvestre et al. (2004) extended this methodology to include the possibility that time series are dominated by up to two structural changes. All these are based on the modified unit root tests of Dickey and Fuller (1979) and are known as augmented Dickey-Fuller (ADF) unit root tests. They can be specified under the following general expression:

$$y_{i,t} = \mu_i + \beta_i t + \sum_{j=1}^2 \theta_{i,j} DU_{i,j,t} + \sum_{j=1}^2 \gamma_{i,j} DT_{i,j,t} + \sum_{j=1}^2 d_{i,j} D(TB)_{i,j,t} + \alpha_i y_{i,t-1} + \sum_{j=1}^k c_j \Delta y_{i,t-j} + \varepsilon_{i,t} \quad (1)$$

where $y_{i,t}$ is the variable of interest, i.e., the patenting level in country i ; μ and β are parameters of the intercept and linear trend to be estimated, respectively; DU and DT are dummy variables to measure changes in the intercept and linear trend, respectively;

$D(TB)$ denotes the time of the break, i.e., the moment at which the change in the parameters of the trend function occurs, and seeks to capture a possible different growth path after the change; and the k additional parameters included in the equation represent the number of extra regressors added with the aim of eliminating the possible serial autocorrelation. The interest parameter is the t -value of α_i , the named *ADF* coefficient, because if significant it would indicate that the series is stationary with a structural change – the alternative hypothesis in those models. As we can see, the structural breaks would occur as changes in the mean (DU1 and DU2), the trend (DT1 and DT2) or a combination of the two. All these possibilities are explored by equation (1), in which the null hypothesis is defined as follows:

$$y_t = \mu + y_{t-1} + \varepsilon_t \quad (2)$$

For each country, equation (2) suggests that $\{y_t\}$ is integrated without structural change. Therefore, in the alternative hypothesis, $\{y_t\}$ could be defined as a stationary process in trend with one or two points of break occurring at an unknown time. Following the strategy of Perron (1989) and Zivot and Andrews (1992), among others, when there is only one structural break, equation (1) is reduced to either of the following expressions:

$$y_t = \mu + \beta t + \theta_1 DU_t + \alpha y_{t-1} + \sum_{j=1}^k c_j \Delta y_{t-j} + \varepsilon_t \quad (3)$$

$$y_t = \mu + \beta t + \theta_1 DU_t + \gamma_1 D(TB)_t + \alpha y_{t-1} + \sum_{j=1}^k c_j \Delta y_{t-j} + \varepsilon_t \quad (4)$$

where $DU_t = 1$ for $t > TB$, and 0 otherwise; $D(TB) = t - TB$ for $t > TB$, and 0 otherwise. Perron (1989) and Zivot and Andrews (1992) named regression equations (3) and (4) models A and C, respectively, and they were only concerned with the structural change occurring in the intercept (model A) or in the variable's level (model C). Another possibility explored by Perron and Vogelsang (1992) allows for a one-time change in the intercept but without a trend function (labelled as model An):

$$y_t = \mu + \theta_1 DU_t + \gamma_1 D(TB)_t + \alpha y_{t-1} + \sum_{j=1}^k c_j \Delta y_{t-j} + \varepsilon_t \quad (5)$$

Following the same idea for one structural break, Lumsdaine and Papell (1997) extended the methodology to the case of series with up to two structural changes. They named the models with two changes as models AA [equation (6)] and CC [equation (7)]:

$$y_t = \mu + \beta t + \theta_1 DU1_t + \theta_2 DU2_t + \alpha y_{t-1} + \sum_{j=1}^k c_j \Delta y_{t-j} + \varepsilon_t \quad (6)$$

$$y_t = \mu + \beta t + \theta_1 DU1_t + \gamma_1 D(TB)1_t + \theta_2 DU2_t + \gamma_2 D(TB)2_t + \alpha y_{t-1} + \sum_{j=1}^k c_j \Delta y_{t-j} + \varepsilon_t \quad (7)$$

Finally, excluding the linear trend from equation (6), we obtain the model named AAn by Carrion-i-Silvestre et al. (2004):

$$y_t = \mu + \theta_1 DU1_t + \theta_2 DU2_t + \alpha y_{t-1} + \sum_{j=1}^k c_j \Delta y_{t-j} + \varepsilon_t \quad (8)$$

The critical values to determine the parameters' significance and the stationarity of the series are not standard and they were calculated through procedures of bootstrapping by the authors. These values are used in the actual empirical exercise and reproduced in the table footnotes of this work.

In order to identify changes in the patenting series, we execute regression equations (3) to (8) in a program in Gauss code. It works as follows. For each specification (3) to (8), the program assesses the potential one-time change (TB) and the appropriate value of k with the best adjustment. In the selection of the appropriate value of k , we follow the suggestion of Ng and Perron (2001) on the backward elimination strategy. We start with a maximum value for k (k_{max}) and estimate the regression. If this lag is non-significant, then k is reduced in 1 to determine whether this last lag is significant. This algorithm stops at any point when the significance is obtained. If any lag is significant, then $k = 0$. Once the optimum lag for each possible point of break is determined, then the program seeks the optimum point of break. The critical value we consider to determine the significance of the optimum lag is set at $t = 1.645$. Moreover, we consider $k_{max} = 8$ and the 10% of the limit points of the sample is trimmed. The algorithm also takes into account suggestions in relation to considering appropriate values of TB and k as unknown and therefore they are endogenously determined by the program.

Finally, regarding the possibility that two or more models reject the null hypothesis for the same time series, we decide to select the appropriate model seeking the greater t -value, in absolute terms, of the ADF coefficient ($\hat{\alpha}$ in the regression equations). This is a suggestion by Lumsdaine and Papell (1997) and similar results are also obtained when an information criterion, such as Akaike or Schwartz, is considered.

5 Description of data, countries and world regions

The discussion focuses on patent applications – for both residents and non-residents – and it considers worldwide patent applications filed through the Patent Cooperation Treaty (PCT) procedure (see World Bank, 2013). The data on patenting were obtained from the World Development Indicator database provided by the World Bank (2013).³ This institution publishes the annual count of patents for a very complete set of countries and world regions. It is possible to find data on patenting and other variables for more than 230 countries around the world and almost 31 world regions classified by the World Bank according to the per capita income level or geographic region. Unfortunately, data for patents are not always available in a long and homogenous period for all countries. Consequently, and with the purpose of accounting for the TRIPs breakpoints, we only consider 16 developed economies, 19 developing countries and seven world regions, which satisfy the requirements for a sufficiently long time series. Thus, the analysis period extends back to 1963 and finishes in 2011, covering a total of 35 individual countries and seven world regions. Table 1 reports these world regions and their members, according to the World Bank.

Table 1 The world regions and their countries

<i>Region</i>	<i>Countries</i>
All countries	All countries documented here.
European Union	Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain and Sweden.
High income	Andorra, Aruba, Australia, Austria, Bahamas, Bahrain, Barbados, Belgium, Bermuda, Brunei, Canada, Cayman Islands, Channel Islands, Croatia, Curacao, Cyprus, Czech Republic, Denmark, Equatorial Guinea, Estonia, Faeroe Islands, Finland, France, French Polynesia, Germany, Greece, Greenland, Guam, Hong Kong SAR, Hungary, Iceland, Ireland, Isle of Man, Israel, Italy, Japan, Republic of Korea, Kuwait, Liechtenstein, Luxembourg, Macao SAR, Malta, Monaco, Mariana Islands, Netherlands, New Caledonia, New Zealand, Norway, Oman, Poland, Portugal, Puerto Rico, Qatar, San Marino, Saudi Arabia, Singapore, Sint Maarten (Dutch part), Slovak Republic, Slovenia, Spain, St. Kitts and Nevis, St. Martin (French part), Sweden, Switzerland, Taiwan, Trinidad and Tobago, Turks and Caicos Islands, United Arab Emirates, the UK, the USA and Virgin Islands (US).
North America	Bermuda, Canada and the USA.
OECD members	Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the UK and the USA.
South Asia	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.
Latin America	Antigua and Barbuda, Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Lucia, St. Vincent and the Grenadines, Suriname, Uruguay and Venezuela.

Source: The World Bank

In spite of the fact that the World Bank reports figures on patenting for all the countries declared in Table 1, quite a reduced list of countries has data available covering a long period of time. Only the aforementioned set of countries has a sufficiently large time series reaching back to 1963. Tables 3 and 4 show that data is only available for 16 developed countries (Table 3) and 19 developing countries (Table 4), although some small incidences prevail that we must comment on and attend to. First, the time series for Belgium, Spain, Brazil and Latin America in fact start in 1965; as a consequence, their empirical results cover a shorter period: 1965–2011. On the other hand, in the World Bank database, there are a few missing data for some countries and regions: Latin America: 1969, 1975, 1976, and 1978; Japan: 1981 and 1982; Brazil: 1969, 1975, 1976, and 1978; Chile: 1964; Colombia: 1982 and 1990; Egypt: 1997 and 2006; Iceland: 1965; India: 1983; Indonesia: 1964, 1967, 1972, 1981, 1988, 1990, and 2007; South Africa: 1967 and 1969; and Turkey: 1972 and 1983. We do not know the reasons for the lost data, but we believe that excluding them can be more damaging to the analysis than estimating those missing data using a plausible criterion. With the aim of having a richer database, the missing data were replaced by calculating a mean of the registered patents

in the three nearest years. This method has the advantage of completing the sample without biasing the real trend of the time series because the estimated mean just builds a bridge over the existing long-term trend.

6 Description of the results

6.1 Database descriptive analysis: pre-TRIPs versus post-TRIPs

The database suggests that the TRIPs agreement has had a positive effect on non-resident and resident patenting levels. In the pre-TRIPs period (1963–1994), the all-countries region's patents averaged 274,366 for non-residents and 362,674 for residents, while in the post-TRIPs period (1995–2011), the non-resident and resident patents were 428,715 and 757,065, respectively; in other words, the new levels are 1.6 times for non-resident patents and 2.1 times for resident ones compared with the initial data (see Table 2).

Table 2 Patent applications ratio (1963–1994/1995–2011)

<i>Region/country</i>	<i>Residents</i>	<i>Non-residents</i>	<i>Region/country</i>	<i>Residents</i>	<i>Non-residents</i>
<i>All countries</i>	2.09	1.56	UK	0.87	0.40
European Union	1.09	0.28	USA	2.62	3.55
High income	2.11	1.48	<i>Developing</i>	4.52	2.56
North America	2.60	2.75	Brazil	1.21	2.73
OECD members	2.11	1.43	Bulgaria	0.17	0.59
South Asia	3.67	4.99	Chile	1.91	3.05
Latin America	1.09	2.19	Colombia	1.27	2.09
<i>Developed</i>	1.85	1.32	Greece	0.43	0.03
Austria	0.90	0.06	Hungary	0.43	1.07
Belgium	0.60	0.03	Iceland	2.49	4.20
Canada	2.04	1.27	Ireland	3.73	0.05
Denmark	1.60	0.04	Israel	9.78	2.16
Finland	1.47	0.11	India	1.95	5.63
France	1.05	0.15	Indonesia	2.03	5.50
Germany	1.44	0.52	Korea	21.69	5.69
Japan	1.90	2.05	Mexico	0.82	2.21
Netherlands	1.12	0.06	Philippines	1.74	2.08
New Zealand	1.63	1.96	Poland	0.51	1.84
Norway	1.36	1.06	Portugal	2.06	0.04
Spain	1.20	0.05	Romania	0.48	0.39
Sweden	0.77	0.08	South Africa	0.28	1.09
Switzerland	0.43	0.07	Turkey	9.06	1.61

Source: Own estimates based on the patenting level from the World Bank

South Asia showed the largest increment in the post-TRIPs period in comparison with the pre-TRIPs one, for both resident and non-resident patents. Note that non-residents patents rose by a factor of five and residents ones by a factor of 3.7. Nevertheless, it is important to remember that this is a region that had the lowest patenting level in the pre- and post-TRIPs periods. India is one of the South-Asian countries that increased its patent applications substantially.

On the contrary, the European Union is the only region that exhibited a decrement of the average non-resident patenting level; the new patenting level is 0.3 times the original one (Norway is the unique developed European country under analysis that increased the patent applications of non-residents). In addition, this region and the Latin American zone showed the lowest increment in average resident patents, by a factor of 1.1 (among the Latin American nations, Mexico is unique in showing a decrement in the residents' patenting level).

In general, the developed nations have shown larger patenting level than developing countries have had; on average, the developed nations exhibit a production of 241,933 and 442,707 patents for non-residents and residents, respectively; while the developing countries show a generation of 61,369 and 55,960 patents for non-residents and residents. Therefore, it is not surprising, in relative terms, that the developing countries have increased the patenting level considerably more than the developed nations have, especially in regard to residents' applications.

Korea is the developing country that exhibited the largest increment in residents' and non-residents' patents. The average non-residents' patents rose from 5,698 to 32,400 (5.7 times); similarly, the average patent applications of residents increased from 4,396 to 95,345 (21.7 times). Moreover, Korea is the developing nation that had the maximum average level of patent applications of non-residents and residents in the post-TRIPs and global periods.

With respect to developed nations, the US is the country with the highest increment in patent applications of non-residents and residents (3.6 and 2.6 times, respectively). Additionally, the US showed the maximum non-resident patent level in the three periods under analysis, as did Japan for the residents' patent applications. This exploratory analysis suggests that the changing conditions in patenting that must be formally investigated.

6.2 Impact and structural change analysis

For each resident and non-resident time series, the outcome was organised for developed countries, developing countries and world regions with the aim of appreciating the TRIPs effect in a similar manner – see Tables 3 to 8.

All the Tables 3 to 8 show the individual regression results for each country and world region, except for those where no model was significant, which are marked with shadow. As is appreciated, the significance can be found in a wide majority of cases, at least under some specifications. The first four columns indicate the name, the model and the structural breakpoints (TB1 and TB2). Next, the estimates of the parameters, the t -value of α_i (the named *ADF* coefficient) and, finally, the optimum lag to control for serial autocorrelation (k) become visible. Several points can be seen from these tables that are worthy of comment.

Table 3 Residents' time series results for developed countries

Countries	Model	TB1	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_a	k
Austria	A	2002		4.443 (4.967)	-0.004 (-4.288)	0.132 (4.271)				-4.972 ^b	0
Belgium*	CC	1986	2005	20.052 (6.592)	-0.109 (-6.057)	-0.265 (-4.094)	-0.380 (-4.024)	0.079 (5.600)	0.057 (2.951)	-6.636 ^c	8
Canada	A	1996		4.302 (4.993)	0.009 (3.509)	0.224 (3.569)				-4.965 ^b	0
Denmark											
Finland	AAn	1974	2002	1.349 (5.927)		0.169 (5.572)		-0.178 (-5.852)		-5.816 ^b	5
France	AA	1973	1985	6.448 (7.156)	0.004 (4.898)	-0.171 (-4.643)		0.061 (2.649)		-7.287 ^a	5
Germany											
Japan	CC	1982	2001	9.328 (8.818)	0.034 (4.770)	0.328 (12.241)	-0.021 (-0.810)	-0.011 (-3.372)	-0.039 (-6.648)	-8.499 ^a	8

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TB1 and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts a, b, and c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model A -5.34 (1%), -4.80 (5%), and -4.58 (10%) – see Zivot and Andrews (1992); model AA -6.94 (1%), -6.24 (5%), and -5.96 (10%); model CC -7.34 (1%), -6.82 (5%), and -6.49 (10%) – see Lumsdaine and Papell (1997); model AAn -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004).

Source: Own estimates from the World Bank database

Table 3 Residents' time series results for developed countries (continued)

Countries	Model	TB1	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_a	k
Netherlands											
New Zealand	CC	1973	1992	8.830 (7.008)	0.156 (4.766)	-0.083 (-0.486)	0.504 (3.303)	-0.177 (-4.984)	0.048 (3.187)	-7.21 ^b	1
Norway	CC	1979	1998	13.699 (6.942)	-0.033 (-4.546)	-0.181 (-3.979)	0.222 (3.916)	0.079 (6.183)	-0.058 (-6.661)	-6.978 ^b	5
Spain*	CC	1975	1981	8.539 (7.194)	-0.112 (-7.096)	0.027 (0.367)	-0.150 (-2.452)	0.110 (4.832)	0.028 (1.740)	-7.210 ^b	0
Sweden											
Switzerland	AA	1979	1997	9.778 (7.045)	-0.025 (-5.499)	-0.229 (-4.452)		-0.229 (-5.163)		-7.085 ^a	7
UK	CC	1973	1998	10.786 (7.124)	0.014 (1.416)	-0.181 (-2.691)	0.243 (3.478)	-0.019 (-1.882)	-0.029 (-3.856)	-7.131 ^b	0
US											

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TB1 and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts a, b, and c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model A -5.34 (1%), -4.80 (5%), and -4.58 (10%) – see Zivot and Andrews (1992); model AA -6.94 (1%), -6.24 (5%), and -5.96 (10%); model CC -7.34 (1%), -6.82 (5%), and -6.49 (10%) – see Lumsdaine and Papell (1997); model AAn -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004).

Source: Own estimates from the World Bank database

Table 4 Residents' time series results for developing countries

Countries	Model	TB1	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_α	k
Bulgaria	CC	1984	1997	10.910 (44.89)	0.095 (12.812)	-7.970 (-64.682)	-0.244 (-2.067)	0.248 (14.299)	-0.367 (-23.715)	-44.448 ^a	7
Brazil*	AA	1976	1999	8.788 (14.22)	0.013 (4.125)	-0.531 (-6.983)		0.268 (3.611)		-14.510 ^a	0
Chile	CC	1985	2006	8.074 (6.917)	-0.042 (-4.867)	-0.532 (-3.330)	0.549 (3.134)	0.120 (7.052)	-0.143 (-2.925)	-6.743 ^c	6
Colombia	AA	1977	2000	16.700 (10.82)	0.185 (9.859)	-1.349 (-4.193)		-2.139 (-7.340)		-11.365 ^a	7
Greece	CC	1984	1987	5.998 (23.15)	-0.013 (-3.199)	-0.274 (-2.575)	-2.024 (-23.685)	0.176 (3.734)	-0.101 (-2.159)	-22.748 ^a	6
Hungary	AA	1979	2001	3.668 (6.312)	-0.007 (-1.785)	0.239 (2.778)		-0.284 (-3.201)		-6.281 ^b	7
Iceland	CC	1981	1997	2.396 (6.546)	-0.020 (-1.862)	0.626 (3.544)	0.673 (3.670)	0.010 (0.601)	0.020 (0.968)	-6.498 ^c	0
India											
Indonesia	CC	1973	1990	3.409 (4.027)	-0.169 (-0.345)	-2.152 (-4.506)	-1.298 (-4.088)	0.523 (1.069)	-0.141 (-4.897)	-7.985 ^a	8
Ireland											

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TB1 and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts a, b, and c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model AA -6.94 (1%), -6.24 (5%), and -5.96 (10%); model CC -7.34 (1%), -6.82 (5%), and -6.49 (10%) – see Lumsdaine and Papell (1997); model AAn -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004); model C -5.57 (1%), -5.08 (5%), and -4.82 (10%) – see Zivot and Andrews (1992).

Source: Own estimates from the World Bank database

Table 4 Residents' time series results for developing countries (continued)

Countries	Model	TB1	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_a	k
Israel	AA	2001	2004	16.259 (12.63)	0.156 (12.412)	-0.724 (-6.557)		-1.749 (-9.752)		-12.548 ^a	7
Korea	CC	1977	1994	5.406 (8.090)	0.035 (3.641)	-0.789 (-5.877)	0.611 (4.581)	0.144 (6.784)	-0.131 (-8.445)	-8.494 ^a	0
Mexico	C	1994		5.802 (5.051)	0.009 (1.570)	-0.460 (-3.159)	0.026 (2.357)			-5.150 ^b	6
Philippines	CC	1975	1989	2.966 (8.117)	0.113 (7.380)	0.305 (2.035)	0.673 (5.388)	-0.167 (-7.967)	0.065 (4.503)	-9.661 ^a	0
Poland	AAAn	1989	2006	2.524 (5.572)		-0.275 (-6.199)		0.163 (3.624)		-5.508 ^b	0
Portugal											
Romania	CC	1978	1991	14.716 (8.385)	0.459 (5.787)	-0.875 (-2.136)	-1.926 (-4.739)	-0.346 (-4.649)	-0.222 (-4.222)	-8.058 ^a	3
South Africa	CC	1985	1999	5.868 (7.789)	0.022 (2.714)	0.564 (3.219)	1.532 (8.207)	-0.231 (-7.509)	0.172 (4.564)	-7.790 ^a	0
Turkey	CC	1979	1999	4.796 (6.766)	0.005 (0.053)	0.209 (2.333)	-0.082 (-0.786)	0.026 (2.755)	0.235 (6.584)	-6.592 ^c	1

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TB1 and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts a, b, and c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model AA -6.94 (1%), -6.24 (5%), and -5.96 (10%); model CC -7.34 (1%), -6.82 (5%), and -6.49 (10%) – see Lumsdaine and Papell (1997); model AAAn -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004); model C -5.57 (1%), -5.08 (5%), and -4.82 (10%) – see Zivot and Andrews (1992).

Source: Own estimates from the World Bank database

Table 5 Residents' time series results for world regions

Countries	Model	TB1	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_a	k
All countries	AA	1980	1982	9.411 (13.98)	0.016 (8.102)	-0.667 (-16.45)		0.846 (20.043)		-13.833 ^a	2
European Union	AA _n	1974	1995	8.310 (5.498)		-0.101 (-4.422)		0.103 (5.002)		-5.497 ^b	1
High income	AA _n	1980	1982	4.497 (13.85)		-0.637 (-15.597)		0.959 (20.033)		-13.654 ^a	8
Latin America											
North America	A	1997		3.497 (4.564)	0.007 (3.691)	0.116 (2.831)				-4.580 ^c	8
OECD members	AA	1980	1982	9.331 (14.69)	0.016 (8.238)	-0.700 (-17.23)		0.894 (21.011)		-14.522 ^a	2
South Asia											

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TB1 and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts a, b, and c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model A -5.34 (1%), -4.80 (5%), and -4.58 (10%) – see Zivot and Andrews (1992); model AA -6.94 (1%), -6.24 (5%), and -5.96 (10%) – see Lumsdaine and Papell (1997); model AA_n -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004).

Source: Own estimates from the World Bank database

A couple of interesting questions regarding the TRIPs convention are, firstly, and as expected, did it really mean a radical change in the technologies' transfer of the countries? Secondly, was there a further expansion of technologies to less developed countries? The empirical exercises answer both questions positively. The majority of structural breaks were identified after the TRIPs agreement (i.e., the post-TRIPs stage). In some cases, the time break is located at dates relatively close to the signature of the agreement – from 1994 to 1998, approximately, considering that some countries were subsequently added.⁴ Some examples are Canada, Switzerland, the UK, Bulgaria, Iceland, Korea, Mexico, the European Union, and North America for the residents' time series (see Tables 3, 4 and 5). For the non-residents' series, the evidence is wider: Belgium, Finland, Japan, New Zealand, Brazil, Hungary, Iceland, India, Israel, Mexico, the Philippines, Poland, South Africa, Turkey, All countries, the European Union, and South Asia (see Tables 6, 7 and 8). In terms of the developed and developing countries classification, there seem to be more cases for this last group, a finding that would favour the TRIPs convention objectives.

The examples for which the estimated time break was located before the TRIPs stage could be cases in which the TRIPs agreement did not foster innovation or perhaps these nations experienced another stronger structural change than the TRIPs effect. In any case, the time points located before 1994 indicate that structural change had already effectively occurred in those countries. This is the estimated situation for France, New Zealand, Spain, Greece, Indonesia, the Philippines, Romania, All countries, High-income countries and OECD members with the residents' time series (see Tables 3, 4 and 5). Meanwhile, the non-residents' time series reports the next cases: Austria, Denmark, Spain, Sweden, Switzerland, the USA, Greece, and Korea (see Tables 6, 7 and 8). There are some countries that exhibit a structural breakpoint that almost coincides with the joining of the PCT.⁵ That is the case for Norway, Sweden, Switzerland, Bulgaria, Brazil, Hungary, Poland, Romania, and Japan for the residents' patents time series and the Netherlands, Sweden, Switzerland, Bulgaria, Ireland, Portugal, Canada, the USA, Brazil, and Romania for the non-residents' patents. Moreover, all countries non-residents' patents show a structural change in 1977, a year before ten nations signed the PCT.

A careful analysis shows that patenting has been fostered since the TRIPs agreement and also that its greatest augments have occurred in countries' non-resident series. This says a lot about the spread of technology internationally. As we can see, a notable exception is Latin America, because the lack of significance of the ADF coefficient indicates that the TRIPs agreement has not represented a structural change for this world region. It can be seen in Tables 5 and 8 that none of its time series was significant. However, individually, some cases are highlighted because the structural change was indeed documented. For instance, Brazil, Chile, Colombia, and Mexico are highlighted for the residents' series (see Table 4), while only Brazil and Mexico (see Table 7) stand out for the non-residents' series. Unexpectedly, in the South Asia group, not only there is a high level of significance, but also its structural changes were estimated in the post-TRIPs era (see Table 8). In this region, the time series for India and the Philippines (see Table 7) seem to be driving this result.

Table 6 Non-residents' time series results for developed countries

Countries	Model	TB1	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_α	k
Austria	AAAn	1974	1979	1.194 (5.571)		-0.115 (-1.843)		-0.379 (-4.727)		-5.664 ^b	1
Belgium*	AAAn	1978	1994	2.246 (5.410)		-0.470 (-4.081)		-0.424 (-3.333)		-5.743 ^b	8
Canada	CC	1993	1999	8.949 (6.531)	-0.004 (-2.068)	-0.438 (-4.174)	0.016 (0.177)	0.137 (5.353)	-0.142 (-5.343)	-6.525 ^c	0
Denmark	An	1989		6.143 (11.72)		-2.478 (-11.74)	1.456 (6.044)			-11.759 ^a	2
Finland	CC	1986	1995	7.386 (9.668)	0.010 (1.983)	0.463 (3.686)	-1.429 (-8.536)	-0.106 (-5.146)	0.019 (0.872)	-9.670 ^a	2
France											
Germany											
Japan	AA	1994	2000	9.765 (7.624)	-0.004 (-2.118)	0.393 (8.232)		0.459 (5.396)		-7.573 ^a	8

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TB1 and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts a, b, and c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model An -5.51 (1%), -4.76 (5%), and -4.42 (10%) – see Perron and Vogelsang (1992); model C -5.57 (1%), -5.08 (5%), and -4.82 (10%) – see Zivot and Andrews (1992); model AA -6.94 (1%), -6.24 (5%), and -5.96 (10%); model CC -7.34 (1%), -6.82 (5%), and -6.49 (10%) – see Lumsdaine and Papell (1997); model AAn -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004).

Source: Own estimates from the World Bank database

Table 6 Non-residents' time series results for developed countries (continued)

Countries	Model	TB1	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_α	k
Netherlands	AAn	1978	2005	1.285 (5.782)		-0.352 (-4.450)		-0.215 (-3.739)		-6.066 ^a	8
New Zealand	AA	1983	1995	6.949 (6.709)	-0.012 (-2.795)	0.409 (4.205)		0.635 (5.404)		-6.673 ^b	0
Norway	CC	1974	2006	7.241 (7.450)	0.0004 (0.035)	-0.140 (-1.789)	0.709 (4.457)	0.010 (0.934)	-0.554 (-8.215)	-7.400 ^a	0
Spain*	CC	1986	1989	8.610 (12.66)	-0.004 (-1.542)	-1.301 (-13.108)	-0.975 (-10.607)	0.117 (1.620)	-0.183 (-2.719)	-12.672 ^a	7
Sweden	CC	1976	1990	17.773 (6.977)	-0.036 (-1.022)	0.334 (2.653)	-0.593 (-4.427)	-0.239 (-4.592)	0.173 (6.684)	-6.967 ^b	8
Switzerland	An	1977		0.935 (4.526)		-0.353 (-5.113)	0.135 (1.135)			-4.601 ^c	1
UK											
US	C	1982		13.978 (5.477)	0.056 (4.704)	-0.122 (-2.775)	0.023 (4.022)			-5.443 ^b	7

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TB1 and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts a, b, and c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model An -5.51 (1%), -4.76 (5%), and -4.42 (10%) – see Perron and Vogelsang (1992); model C -5.57 (1%), -5.08 (5%), and -4.82 (10%) – see Zivot and Andrews (1992); model AA -6.94 (1%), -6.24 (5%), and -5.96 (10%); model CC -7.34 (1%), -6.82 (5%), and -6.49 (10%) – see Lumsdaine and Papell (1997); model AAn -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004).

Source: Own estimates from the World Bank database

Table 7 Non-residents' time series results for developing countries

Countries	Model	TB1	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_a	k
Bulgaria	AA	1983	2003	3.188 (6.474)	0.016 (1.884)	-0.620 (-3.250)		-1.645 (-6.902)		-6.778 ^b	3
Brazil*	AAn	1981	1996	5.698 (9.743)		-0.331 (-6.657)		0.999 (10.637)		-9.703 ^a	8
Chile											
Colombia											
Greece	AAn	1986	1992	2.682 (6.132)		-0.938 (-6.257)		-0.716 (-3.808)		-6.078 ^a	6
Hungary	CC	1995	2001	10.327 (10.22)	-0.001 (-0.225)	-0.996 (-4.912)	0.923 (2.531)	0.298 (5.546)	-0.883 (-8.761)	-10.238 ^a	5
Iceland	AA	1996	2006	3.216 (7.62)	0.019 (3.161)	1.106 (6.122)		-2.054 (-8.042)		-7.753 ^a	4
India	AAn	1994	2003	6.781 (5.350)		0.729 (5.510)		1.239 (5.377)		-5.376 ^c	8
Indonesia	AA	1991	2003	6.836 (7.675)	0.062 (5.333)	1.019 (5.715)		-0.145 (-1.452)		-7.429 ^a	5
Ireland	AA	1992	2001	5.457 (13.01)	0.022 (5.037)	-2.592 (-13.847)		-0.651 (-5.491)		-13.230 ^a	4

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TB1 and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts a, b, and c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model AA -6.94 (1%), -6.24 (5%), and -5.96 (10%); model CC -7.34 (1%), -6.82 (5%), and -6.49 (10%) – see Lumsdaine and Papell (1997); model AAn -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004).

Source: Own estimates from the World Bank database

Table 7 Non-residents' time series results for developing countries (continued)

Countries	Model	TBI	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_a	k
Israel	AA	1995	1997	5.940 (7.210)	0.014 (3.763)	-0.520 (-6.231)		0.819 (9.418)		-7.074 ^a	7
Korea	CC	1973	1985	5.025 (8.038)	0.203 (5.724)	0.595 (3.722)	0.525 (3.848)	-0.079 (-2.954)	-0.065 (-3.420)	-7.663 ^a	0
Mexico	AAn	1973	1998	5.941 (5.598)		-0.167 (-1.351)		0.802 (4.881)		-5.638 ^b	0
Philippines	CC	1995	2001	18.650 (11.88)	0.071 (10.824)	0.396 (3.750)	-1.576 (-10.240)	0.089 (3.085)	-0.007 (-0.235)	-11.822 ^a	5
Poland	AA	1996	2005	6.968 (8.700)	-0.021 (-3.853)	1.089 (7.153)		-1.301 (-7.393)		-8.802 ^a	8
Portugal	CC	1992	2006	6.085 (8.050)	0.018 (2.988)	-2.490 (-8.694)	-0.627 (-2.213)	-0.089 (-3.517)	0.299 (3.635)	-8.020 ^a	0
Romania	AAn	1982	2004	4.652 (5.310)		-0.551 (-4.000)		-1.105 (-5.086)		-5.416 ^b	6
South Africa	CC	1992	1998	21.744 (8.074)	-0.015 (-4.094)	-0.339 (-3.184)	-0.752 (-7.196)	0.121 (4.682)	-0.027 (-1.102)	-8.069 ^a	7
Turkey	CC	1977	1996	6.696 (7.600)	0.019 (0.507)	-0.432 (-2.472)	1.053 (5.559)	0.015 (0.375)	-0.016 (-5.538)	-7.795 ^a	7

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TBI and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts a, b, and c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model AA -6.94 (1%), -6.24 (5%), and -5.96 (10%); model CC -7.34 (1%), -6.82 (5%), and -6.49 (10%) – see Lumsdaine and Papell (1997); model AAn -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004).

Source: Own estimates from the World Bank database

Table 8 Non-residents' time series results for world regions

Countries	Model	TB1	TB2	μ	β	θ_1	γ_1	θ_2	γ_2	t^*_a	k
All countries	AAn	1977	1994	2.987 (5.146)		-0.067 (-2.303)		0.185 (5.165)		-5.217 ^c	6
European Union	C	1994		6.390 (4.808)	-0.047 (-5.294)	0.211 (3.227)	0.030 (4.054)			-4.819 ^c	8
High income											
Latin America											
North America											
OECD members											
South Asia	AAn	1994	2003	5.930 (6.035)		0.631 (5.674)		0.984 (5.863)		-6.061 ^a	8

Notes: Estimates are only reported for those countries that rejected the null hypothesis of unit root with structural change. * indicates that the time series starts in 1965. TB1 and TB2 denote the estimated break points. t-values are reported in parentheses. Superscripts ^a, ^b, and ^c stand for rejection of the null hypothesis of unit root at the 1, 5, and 10% levels of significance, respectively. Critical values are: model C -5.57 (1%), -5.08 (5%), and -4.82 (10%) – see Zivot and Andrews (1992); model AAn -5.86 (1%), -5.39 (5%), and -5.15 (10%) – see Carrion-i-Silvestre et al. (2004).

Source: Own estimates from the World Bank database

The estimated coefficients can give us an idea of the size and direction of the innovation activity – summarised in the count of patents – after of the structural changes experienced by the countries. Among all those cases for which the model with one structural break has been selected, it can be seen that model A was the best specification only for Austria, Canada, and North America.⁶ The estimated coefficients of both the time trend and the constant term are positive and significant, which indicates that they have registered an increase in their patenting level after experiencing the structural break estimated in 2002, 1996, and 1997, respectively. Although the trend function was negative and significant only in Austria, the positive constant term highlights an increase in its patenting level after 2002. In other countries (Denmark and Switzerland), it was not necessary to include the trend function to estimate the change in the intercept (i.e., model An).⁷ Although the structural break was downwards – see the negative and significant constant term after the change – they were experiencing a positive growth path in the patenting level because the time break was positive and significant – see the estimated coefficient of the D(TB) term.

Similar behaviours seem to prevail for the non-residents' series of the USA and the European Union, although differently this couple of cases highlights a different growth path after the shift – as model C prescribes. The estimated breakpoints suggest that the structural change had already occurred in the USA (by 1982) and it took place only with the TRIPs convention (by 1994) in the European Union. The year 1994 is also the time break identified for Mexico's residents' time series, in which the selected model C indicates a negative intercept after the shift.

The same analysis can be conducted for the two-structural-break case. For the residents' time series, Finland, Poland, the European Union and high-income countries are the cases for which model AAn was selected. Looking at these estimates, we can observe that the effects of their second structural change were upwards, except in Finland, where they were negative, indicating a reduction of its residents' patenting after 2002. Note that the second structural break for most cases is located after 1994, except for the high-income series, for which the model estimates that the two structural changes occurred in 1980 and 1982. The same model AAn was the best specification for ten cases of the non-residents' series (Tables 6 to 8): Austria, Belgium, the Netherlands, Brazil, Greece, India, Mexico, Romania, All countries, and South Asia. They all exhibited a structural change after 1994, except Austria and Greece, where both breakpoints occurred before 1994. Moreover, in Brazil, India, Mexico, All countries and South Asia, positive effects of the structural change (the second one) were estimated.

We can extend our analysis to models AA and CC and these tell similar stories, but we prefer to concentrate on the TRIPs convention-innovation relationship. Specifically, what can be said, from the results, about the TRIPs convention as a prompt of innovation in developed and developing countries? Again, an analysis with all the attempted models would be helpful in this direction.

Looking at the estimates of the breakpoints and the dummy coefficients, there are two facts to highlight in favour of the TRIPs convention. Firstly, there is wide evidence of structural changes occurring in the post-TRIPs era. For the residents' time series, the models suggest that 22 out of the 42 studied cases select one date, at least, after 1994; meanwhile, for the non-residents' time series, the evidence is greater because in this case there are 25 countries, of which 15 are developing countries. This result says much about the TRIPs convention as the inciting cause of innovation around the world. Secondly, the estimated coefficients of the breakpoints are positive and significant in a great majority of

cases, mainly in developing countries, suggesting considerable evidence on increased innovation due to the TRIPs convention. The empirical results on residents' series report 19 situations in which the last structural change averaged a positive effect, of which nine are developing countries.

An analysis of the world regions indicates mixed results for developed and developing countries. It seems clear that for residents' series (Table 5), developed countries have been favoured because they all report positive changes after the estimated breakpoint, although only for the European Union (1995) and North America (1997) was the breakpoint located in the post-TRIPs era. However, with respect to Latin America and South Asia, no model was able to capture a structural change in the residents' series, so we conclude that domestic patenting has not yet been stimulated in those world regions. In the case of the non-residents' series (Table 8), only for all countries, the European Union and South Asia can the evidence on structural change be documented. These all registered breakpoints in the post-TRIPs era; additionally, the second structural break was estimated as positive and significant. This result can be related to the TRIPs convention because it constitutes empirical evidence indicating a larger international transfer of technologies. Therefore, the TRIPs convention prompted innovation but with mixed effects. Some developing regions have been pushed to take advantage of this agreement – mainly in the non-residents' series; meanwhile, some developed regions have also improved their innovation level – mainly in the residents' series.

7 Conclusions

In terms of innovation and the protection of IPRs, the meetings celebrated by the international community in the last few decades have represented huge efforts to reach mutual agreements on behalf of society. Especially, as a result of the TRIPs agreement, signed in 1994, there were large expectations of stimulating innovation activity and disseminating technology among countries, mainly to developing areas. There remains a weak consensus on the patenting impact in developing countries. In this investigation, we analyse the statistical properties of the patents' time series as a way of measuring the results of this agreement and the empirical results suggest mixed effects from the TRIPs agreement. Developed countries have increased their patenting level in the residents' time series, while it has not been favourable at all in the developing countries. However, positive effects are appreciated in some countries of Latin America and South Asia for the non-residents' time series. In both cases, the estimated coefficient was superior and positive after the structural change in favour of the TRIPs effect. It is possible that global technology transfer is likely to be limited to multinational enterprises (MNEs) whose subsidiaries located in developing economies benefit from technology generated in more developed countries. Bilir (2014) finds that this class of phenomenon is happening in sectors with long product life cycles.

Results leave some recommendations of public policies. The fact that stronger IPR effects vary by country size, developing level and economic sector suggests that a single global level of IPR is in general sub-optimal (Hudson and Minea, 2013; and Campi and Dueñas, 2016). For example, Harhoff et al. (2009) analyse the European patent system. The results show that the implementation of cost-reducing policy interventions like the London Protocol will, therefore, induce a significant increase in the number of patents validated in each European country. Kim et al. (2012) propose for developing economies,

a minor form of IPRs, namely utility models. Indeed, they find that utility model innovations contribute to firm performance, which could be a learning device to develop more patentable inventions.

Of course, our study is not free of some limitations. First, our measure of innovation, patenting, could be restricted, because it is possible that a wider way of innovation dissemination is happening. However, to have data on richer concepts of innovation often is complicated, mainly for the long-term analyses. Second, the limitations of the techniques of estimation also apply here. It is possible that some presence of serial correlation and more of two structural breaks could be affecting the estimates. They could motivate the not reject of the unit root hypothesis reported in this study. A future research direction is to apply tests of panel data unit roots, which will complement the evidence of this work.

Finally, although patenting constitutes a gross measurement of innovation, the trend towards reinforcing IPRs through international agreements is expected to be reflected in significant increments in patents, and thus in economic growth, one of the objectives of the TRIPs agreement.

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Notes

- 1 Available from the web page: http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm7_e.htm.
- 2 Recently, Correia de Souza and Chami (2011) found that under asymmetric IPR protection, innovative nations might produce and export goods for which they do not have a comparative advantage. They named this result a comparative advantage breakpoint or invasion effect.
- 3 Available from the web page: <http://data.worldbank.org/indicator>.
- 4 Some countries had an extra term to implement the TRIPs agreement (see Nain, 2006).
- 5 The PCT was made in Washington, DC in 1970, entering into force in 1978, initially with 20 member states. Afterwards, more countries jointed this treaty; currently there are 149 contracting states that constitute the International Patent Cooperation Union. The list can be consulted on this site: http://www.wipo.int/pct/guide/en/gdvol1/annexes/annexa/ax_a.pdf.
- 6 All these are for the resident series because model A was not selected for the non-resident series.
- 7 Model An only was the best specification for the non-resident series.