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Global norm of national treatment for patent uncertainties: A longitudinal comparison between the U.S. and China

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ABSTRACT

Sporadic studies on the global norm of national treatment for patent uncertainties (NTPU) urge for insights of changes as well as for clarification to discrepancy. This global norm has been a concern for policy makers and practitioners for over a century, as a socially and strategically more significant matter than before for multilateral cooperation given the active technology transfer across borders. To fill in the void and extend prior studies, we examine the global compliance of NTPU from the perspective of patent pendency and granting by addressing three relevant questions: (1) Is NTPU upheld within countries? (2) How does NTPU diverge across countries? (3) How does NTPU change, as an outcome, over time? Based on the institutional theory, lagged regression modeling and longitudinal comparison of US and Chinese patenting, our findings reveal that: (1) NTPU is overall upheld because equality in pendency is demonstrated in both countries and in US granting, and foreigners are even favored for Chinese granting. (2) NTPU is comparatively divergent between the countries in pendency and granting due to national variations. (3) Regressive and progressive changes in NTPU are evidenced since both countries provide equal or higher granting, but longer pendency than before. Our findings contribute to theories by providing new insights to the global norm of national treatment and institutional theory from the perspective of patent uncertainties. We make novel empirical contribution to address NTPU changes of the top patent filing countries and methodological contribution to the longitudinal comparative study. The results also provide implications that concern policy makers and practitioners to handle patent uncertainties across borders.

1. Introduction

Facing patent uncertainties, how countries comply with the global norm of national treatment to deal with them is a significant policy, social and scholarly issue for clarity and new insights in the world business. We synthesize prior research (e.g. Harhoff & Wagner, 2009; Kotabe, 1992; Yang, 2008) to refer patent uncertainties as the uncertainties in applying for invention patents associated with pendency (i.e. uncertainty as to the duration from filing to granting a patent) and granting (i.e. uncertainty as to the decision to grant or reject a patent application). National treatment is defined as a global principle under which countries should reciprocate and assert equality to locals and foreigners (e.g. Aoki & Prusa, 1993; Horn, 2006; Scotchmer, 2004). It has become a global norm required by international organizations and an international expectation among countries, including issues from diplomacy, trade, technology exchange to intellectual property (IP). It obligates countries to exercise equality toward one another to enhance understanding and cooperation. The compliance of this principle is significant in the area of technology and patents for countries to eliminate protective concerns of free-riding and benefit from effective global innovation (e.g. Bosworth & Yang, 2000; Gans, Hsu, & Stern, 2008; Scotchmer, 2004).

Despite the significance of this topic, scholarly endeavor on the global norm of national treatment has been confined within the political economy. The emphasis centers on the legal interpretation of statute compliance with policy practice (e.g. Briggs & Brown, 2012; Scotchmer, 2004), and the economic implications on national innovation (e.g. Aoki & Prusa, 1993; Geng & Saggi, 2015; Hall, 2007). Insightful works of national treatment studies are demonstrated in trade (e.g. Costinot, 2008; Horn, 2011; Staiger & Sykes, 2011), investment (e.g. Liddel & Waibel, 2016; Pillai, 2002), taxation (e.g. Horn, 2006; Horn, Maggi, & Staiger, 2010; Saggi & Sara, 2008), tariffs (e.g. Bagwell & Staiger, 2001; Battigalli & Maggi, 2003), product standard settings (e.g.

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Battigalli & Maggi, 2003; Costinot, 2008; Gulati & Roy, 2008), and dispute resolution (e.g. Liddell & Waibel, 2016; Pillai, 2002).

Meanwhile, national treatment demonstrates little in the context of IP (Geng & Saggi, 2015) rationalizing the need for insights to address voids, ambiguities, and discrepancy. Sporadic studies in the national treatment of trademarks seem broadly consistent that countriesendeavor to meet the envisaged global norm (Charlier & Mai-Anh, 2007; Gillespie, Krishna, & Jarvis, 2002; Yang, 2007). In the area of patent uncertainties, however, three issues emerge for scholarly attention. Firstly, prior works have disagreements as to whether or not the global norm of NTPU is upheld despite the recognition that countries do make effort to comply with the principle. One camp of scholars argue that NTPU is unenforced because preferential treatment is given to locals (e.g. Kotabe, 1992; Liegsalza & Wagner, 2013; Webster, Jensen & Palangkaraya 2014). The other camp of scholars emphasizes that NTPU is enforced since equality or positive discrimination to foreigners is found within countries to handle patent uncertainties (e.g. Popp, Juhl, & Johnson, 2004; Wang, Shih, & Chuang, 2010; Yang, 2008). Secondly, existing studies have recognized the variations of NTPU among countries, but detailed disagreements in divergence making it the need for clarification and comparison. Advanced technologicalcountries (US, UK, Germany and Japan) demonstrate variations in their compliance of national treatment in patent uncertainties in the pre-1988 era (Kotabe, 1992). The uncertainty variations tend to be associated with national patent systems (Harhoff & Reitzig, 2004; Popp et al., 2004). Within the patent system,countries are the most diverse in patent administration (Yang & Sonmez, 2013), that is, dealing with patent applications generates varied pendency and granting uncertainties. Thirdly, howcountries have changed over time in enforcing NTPU seems a new issue for attention. Prior studies and practice impressions recognize changes under the tide of global integration (e.g. Popp et al., 2004; Yang & Sonmez, 2013). However, how and to what extent changes have taken place in NTPU, as an outcome, are new insights to add.

Given the above rationale, our study centers on the compliance with the global norm of national treatment in dealing with patent uncertainties (NTPU). Within this remit, we address three relevant questions: Q1) Is NTPU upheld within countries? Q2) How does NTPU diverge across countries? Q3) How does NTPU change, as an outcome, over time?

Within the above research remit in mind, we test relevant hypotheses to clarify disagreement (Q1), extend prior studies (Q2) and fill in a void (Q3). We formulate hypotheses based on national treatment principle and the institutional theory, as our theoretical foundations, prior empirical studies, practice impressions and our logical argument. To answer the first question, we hypothesize that countries enforce NTPU in the form of patent pendency within countries and that countries continue to provide equal treatment in granting in the US, but in China, locals continue to be favored. To answer the second question, we predict that countries diverge rather than converge because NTPU has not been achieved equally among countries . As for the third question, with the cross-national and international pressure and national effort toward global integration, progress toward NTPU is a desire and reasonable anticipation, but requires hard evidence.

To test the hypotheses and answer the questions, we use patent data in filing (9.28 million in the US and 5.27 million in China) and in granting (4.4 million in the US and 1.55 million in China), and conduct a longitudinal data analysis (1985 2014) of lagged regressions and comparative studies (1985 2002 and 2003 2014). We chose China and the US as our comparators to test these hypotheses due to the dominant role they play in the patenting world. According to the World IP Organization (WIPO), they account for 57% (22% US and 35% China) and 46% (20/26%) of the world total filing and granting of patents in 2014. As the world highest patent filers and grantors, they are also attractive countries for foreign patenting activities (i.e. 26/48% of total filing respectively for China and the US; 42/49% in granting; 1985 2014). Moreover, the US is the 2nd largest foreign filer (next to Japan) in China while China files far more patents in the US than in any other foreign countries. They also represent the most dynamic countries in making policy changes over the past three decades motivating us to evidence whether countries have progressed or regressed in NTPU.

By addressing these hypotheses, we contribute to theories, empirics and methodology. Theoretically, we enrich the central notion of national treatment for patent uncertainties by explaining and taking a stand as to the disagreement on its global compliance (e.g. Kotabe, 1992; Webster et al., 2014; Yang, 2008). We also demonstrate (seems to be the first time from the perspective of NTPU) that the institutional theory of universalism (e.g. Eden, 2010; Ruggie, 1992; Yang & Sonmez, 2013), functionalism (Scholte, 2001; Sgard, 1995; Wijk & Ramamma, 2007), and change (e.g. Bush, 1987; Oliver, 1992; Scott, 1995) are fundamental in interpreting NTPU. Institutions refer to the rules of the game in society (e.g. formal: rules and regulations and informal: value and cultural understanding; North, 1991; Scott, 1995) and are essential for effective functions of the market with reduced uncertainties (Dunn, 2000; Meyer, Estrin, Bahaumik, & Peng, 2009; Williamson, 1985). Institutions also help explain why IP systems are different and difficult to harmonize across nations (Peng, Ahlstrom, Carraher, & Shi 2017a, b; Yang & Clark 2005; Yang 2003). We are thus able to link the theory-empirics to check consistency and disagreement. In return, our findings also help contribute to explain the institutional theory as an implementation, in addition to a cause and process. Empirically, we extend prior studies to address the discrepancy in the two camps of arguments for or against compliance. We also extend the empirical understanding in spatial terms by addressing the two largest patenting countries. Addressing the changing nature of national treatment represents our novel empirical contribution in temporal terms as to how NTPU has improved. Methodologically, we model lagged regressions and conduct comparative analysis to analyze NTPU. The results help reveal the significant role that the two countries have for each other in patenting and provide implications for policy, practice and bilateral collaboration since rapid granting is a strategic goal for owners (Harhoff & Reitzig, 2004).

2. Theory, empirics and practice, and hypotheses: global norm of national treatment for patent uncertainties

In this section, we rely on the institution theory, empirical evidence and practice impressions to explain NTPU under patent systems and develop hypotheses. In this process, we also discover disagreements, inadequacy and void of NTPU surrounding the three research questions. Our logical arguments based on the above evidence help integrate the theory, empirics and practice, and position the hypotheses.

2.1. Is NTPU upheld within countries?

The institutional theory of universalism emphasizes the significance of international institutions and helps explain the global norm of NTPU (Eden, 2010; Ruggie, 1992; Yang & Sonmez, 2013). Due to the interdependence of countries (Eden, 2010), international institutions emphasize universalism to allowcountries to benefit from shared interests and address common issues (Ruggie, 1992). Despite the complexity, countries are obligated, and often willing to integrate because they recognize their own limitation in generating all needed technologies (Bosworth & Yang, 2000; Yang 2004). Under the universalism of international institutions, countries harmonize important rules to achieve broad integration. Therefore, global norm of national treatment should be in place, as a minimum standard for countries to comply with. One of the effort toward integration therefore is to look at how administratively efficient countries are to handle patent applications (Sherwood, 1997).

In addition to the theoretical support for NTPU, sporadic empirics seems congruent as to national treatment for pendency. That is, findings show equal pendency regardless of applicants country of origin, for example, in the US (Kotabe, 1992; Popp et al., 2004; Yang, 2008) and China (Liegsalza & Wagner, 2013; Yang, 2008). Meanwhile, these studies disagree on the extent of uncertainty within pendency: Kotabe (1992) and Popp et al. (2004) conclude that foreign applicants endure less uncertainty than their local peers within the equality in the US, which proves to be the opposite in China by Yang (2008) that local applicants can be more certain about their pending status than their foreign peers. Accordingly, we hypothesize that

H_{1a}

Domestic and foreign applicants have equal pendency for US patents, but the former enjoys less certainty than the latter in its pending status.

H_{1b}

Domestic and foreign applicants have equal pendency for Chinese patents, but the former enjoys more certainty than the latter in its pending status.

We justify the theoretical, empirical and methodological need for re-testing these hypotheses. The institutional theory of change emphasizes incremental changes of institutions (North, 1990). Countries make effort toward international integration gradually; thereby testing these hypotheses will help reflect changes. Empirically, prior studies, despite the overall congruence on NTPU in pendency, also reveals detailed variations in terms of the degree of uncertainty within equal pendency. Further testing therefore will help clarify these variations. Also empirically, prior studies derived their results from pre-2002 data. Fifteen years have passed, are applicants still treated the same? No studies seem to have followed up to find out. Methodologically, retests make significant contribution to clarify research (Tsang & Kwan, 1999). The 524 replication studies reveal that the average consistent rate for each study is at only approximately 30% (Tsang & Kwan, 1999).

Under the institutional theory of universalism, NTPU in granting is assumed, but empirics show discrepancy in findings against the theoretical supposition. On the one hand, most empirics emphasize non-compliance. With the increase of patent examiners, domestic grants for US patents speed up to clear backlogs, but foreign grants show little acceleration; thus, Kotabe (1992) infers preferential treatment in the U.S. toward domestic granting. Webster et al. (2014) infer similar conclusions based on their studies of patenting outcomes in the EU and Japan that national treatment in patent granting is unenforced. Meanwhile, Popp et al., (2004) deduce the positive discrimination that foreign applicants, with clearer and more valuable filings, are granted faster than their domestic peers for US patents. On the other hand, Yang (2008) concludes equal treatment to the two groups in the US because foreign and domestic granting has a probability of 96% and 95% respectively with no significant differences between the two independent samples.

The mixed findings above urge the need for testing this hypothesis to clarify the incongruence. In line with the theoretical argument of compliance, our logical argument also leans towards the equality of the two groups for two specific reasons: Firstly, the US has gained a good reputation and practice impression on their equal treatment toward the two granting groups (Harhoff & Reitzig, 2004; Yang, 2008). Secondly, the US is widely recognized as a lead market for talents and cutting edge technologies. Such a filing environment would have made discrimination in granting toward local applicants undermining US innovation. Accordingly, we hypothesize that

H_{1c}

Domestic and foreign applicants have equal treatment in granting for US patents.

Against the theoretical argument, sporadic studies also prove discrepancy for granting uncertainties in China. Early examinations on patenting activities seem to imply favoritism to foreign applicants because the improved institutional environment in China encourages patenting inflows from high-tech countries (Bosworth & Yang, 2000). That is, applications from advanced countries are more dynamic in the first ten years (1985 1995) accounting for 87% of the total foreign applications (including 30% each from the US and Japan). Foreign patenting activities center on invention patents demonstrating the inflow of high value technologies (Sun, 2003). A later patent analytics proves the opposite (Yang, 2008): foreign applicants are favored less than domestic applicants in granting for Chinese patents (1985 2002). We argue that the discrepancy is due to two reasons: one is that the authors examine the patent data in three different periods (1985 1995; 1985 1999; 1985 2002) when patent activities keep changing in China. The other reason is that the authors use entirely different methods to analyze the patent data (comparative analysis, simple regressions and lagged regressions), which may lead to variations in findings.

The mixed findings dictate the need to clarify the incongruence and we argue as follows to formulate our hypotheses. Firstly, foreign applicants role is changing in China. Despite the discrepancy, prior studies suggest the changing nature of patenting activities, including those by foreign applicants from dominating patenting applications in number to quality orientation. This suggests that foreign inflows of patenting activities may have changed from sharp surge to steady growth. Secondly, the national environment continues to encourage local innovative endeavor through incentives (e.g. financial support for invention patenting; Li, 2012). With the U.S. and EU stabilizing their R&D budget, China s spending keeps surging driven by its long-term commitment to science and technology, and is to top the R&D spender by 2019 (OECD, 2014). Accordingly, we hypothesize that

H_{1d}

Domestic applications are favored more than foreign applications in granting for Chinese patents.

2.2. How does NTPU diverge among countries?

Based on the institutional theory of functionalism, the global norm of NTPU diverge rather than converge among countries. Institutional functionalism continues to play its distinctive role in emphasizing national authority and interests (Scholte, 2001). That is, the variations in their needs for technology result in countries resistance to global integration when national interests are compromised. This suggests that divergence remains since global integration remains an enduring rather than transitional process for patent systems (Sgard, 1995). The difficulty in achieving convergence is due to domestication in countries because they need divergence (e.g. for seed and biotechnology) to be accepted by domestic stakeholders (Wijk & Ramanna, 2007). National institutions driven by functionalism is the main driver for the patent system since they are the adopters, adapters and implementers for global integration (Yang & Sonmez, 2013). Limitations in the universal jurisdiction remain from codifying rules, enforcing laws to ratifying treaties (Weismann, 2010). Both national and international institutions of patent systems thus co-exist and represent the height of complexity. As Sgard (1995) argued, IP is the no. 1 barrier for institutional convergence and the fragmentation of national institutions requires multilateral negotiations to coordinate state interests because patent systems remain the backbone of international economic integration.

Cross-border divergence under the argument of institutional functionalism seems supported by empirical evidence. A recent study demonstrates variations in pendency (Schultz & Madigan, 2016). The findings based on patent data (2008 2015) reveal the variation of eight-year average pendency in 11 patent systems (i.e. Korea: 2.8

years; China: 2.9; US: 3.5; Australia: 3.6; Egypt: 3.8; Japan: 5.3; EPO: 5.5; India: 6.3; Argentina: 6.4; Thailand 10; and Brazil 10.1). Schultz and Madigan (2016) conclude that pendency is an issue of the patent system across countries influencing all sectors rather than complex industries.

In addition to the broad consistency of sporadic empirics and the institutional functionalism argument, empirics provide detailed variations as to how divergent in NTPU across countries. An early study of four patent systems (Japan, US, UK and Germany; 1963 1988) evidences divergent preferential treatment across countries (Kotabe, 1992). Specifically, foreign applicants endure longer pendency in Japan and lower granting in the US, UK and Germany. The findings by Schultz and Madigan (2016) clarify prior arguments that patents in complex industries (e.g. pharmaceutical, genetically modified crops) tend to be granted faster (Dranov & Metzler, 1994; Regibeau & Rockett, 2010) or more slowly (Popp et al., 2004). Harhoff and Wagner (2009) further clarify this incongruence that the variations of granting speed in the EU exist since British and German applicants enjoy faster patent decisions than their European peers due to valuable applications. Consistently, Taiwanese and Korean biotech patents (2000 2009) show shorter pendency in the US when they are valuable patents, and national treatment is no difference for the two foreign groups in the US (Wang & Lin, 2011).

Moreover, Liegsalza and Wagner (2013) recognize that pendency in China (1990 2002) is similar to that in the EU, but much longer than the U.S. Yang (2008) find that, despite the countries endeavor to exercise equality, variations in uncertainty exist for Chinese and US applicants. On the one hand, applicants for US patents seem to have a longer but more certain pendency for both groups than for those in China. Based on the findings, the two countries are similar in their higher certainty for domestic applicants than for foreign applicants. As a result, domestic and foreign applicants for patents in China endure shorter pendency, but the uncertainty is higher in pendency than their peers for U.S. patents. Both countries demonstrate variations in preferential treatment within pendency (Yang, 2008). The degree of preferential treatment differs significantly ($p < 0.001$). That is, the up to three-year pendency in the US for both groups shows higher value in explained variances (R^2 90%). China shows up-to-two year pendency for both groups, but lower explained variances (R^2 80% for domestic applicants in comparison to 65% 79% for foreign applicants). The equality test demonstrates significant difference between the two countries although they show a higher certainty for domestic applications than for foreign applications. The findings differ from Liegsalza and Wagner (2013) that the U.S. has the shortest pendency, and China and the EU are similar based on decision data from the EPO and USPTO (1990 2002).

In practice, the global norm of national treatment for IP remains an issue. Countries create origin-neutral legislations that tend to have concealed protectionism (Pillai, 2002). Such origin-neutral measures led to three theoretical struts: inconsistency and opacity in the application, interpretation to mandate the application, and national obligation (Pillai, 2002). Therefore, controversy remains among countries as to the law of prohibition and the law of justification (Pillai 2002: 22) thereby existing the de facto discrimination and the burden of proof on discrimination is high.

To sum up, NTPU is divergent across countries. The institutional theory of functionalism argues that countries, as the driver for international compliance evolve slowly for convergence. Empirical revelations seem to be broadly consistent to recognize the divergence rather than convergence in NTPU. However, discrepancy emerges as to the empirical detail of divergence across countries; that is, how countries differ remain an empirical inquiry for clarity and comparison. Prior studies also recognize that countries have been making effort to reduce pendency variations in line with practice impressions from patent offices. The most recent study seems to suggest the U.S. lags behind than China (Schultz & Madigan, 2016), but difference from prior studies discussed above warrant further examination. Accordingly, we hypothesize that:

H_{2a}

Domestic applicants experience shorter pendency in China than in the U.S.

H_{2b}

Foreign applicants endure shorter pendency in China than in the U.S.

In line with the theoretical argument of functionalism, prior empirics on grants for domestic and foreign applicants also demonstrate divergence across countries. Foreign applicants have lower grants for U.S. patents (Kotabe, 1992). The difference between China and the US in granting is wide since the fit models for granting in the US show smaller gaps (i.e. 1 3%) than China (i.e. 10%; Yang, 2008). The difference ($p < 0.001$) in grant ratios between the two countries evidences that China has higher preferential treatment for domestic applicants over foreign applicants while the U.S. provides equal treatment for the two groups (Yang, 2008). However, this was a test conducted based on pre-2002 data, as we will argue in detail in the next section, institutional changes have had significant impact on state behavior and performance. Has this changed with time? Our test will help answer this question. Based on prior studies though, we hypothesize that

H_{2c}

Domestic applicants have lower granting in China than in the U.S.

H_{2d}

Foreign applicants have lower granting in China than in the U.S.

2.3. How does NTPU progress, as an outcome, over time?

Our research question three: How does NTPU progress over time receives a broad explanation in theory, unproven empirics, but positive answer in practice impressions. The theory of institutional change has been long argued as a process and cause (e.g. Oliver, 1997; Scott, 1995; Townley, 2002). Prior works emphasize that institutional change is a process rather than an implementation (Yang & Sonmez, 2013) that requires process-based view rather than substantive views to explain national treatment (Gerhart & Baron, 2004). It is conditional of preferences and capabilities in consideration of national environments (Caporaso, 1992). The key to recognize institutional changes is to evidence the influence (Keohane & Martin, 1995).

Despite the emphasis on process, cause, and effects, early studies of economics do recognize the result of institutional changes. That is, the changing institution is in regressive or progressive forms (Ayres, 1944; Bush, 1987; Veblen, 1942); can be incremental (North, 1990) and revolutionary (Gersick, 1991). Institutions change as a result of human action, and the changes in expectations and process that result can exert profound effects on state behavior (Keohane, 1989: 10). The state behavior as national institution in the form of instrumental efficiency (or inefficiency) therefore affects the fundamental value structure of society (Bush, 1987) and drives positive or negative changes as a consequence, not a cause (Ayres, 1944). National institutions also change to respond to the conditions set out by international institutions in relevance to state interests (Keohane & Martin, 1995). Institutional change does not take place if the state instrumental structure lags behind technological progress (Bush, 1987) due to the connections between technology and institutions (e.g. Hodgson, 2004; Nelson, 2005). Therefore, instrumental (policy) efficiency (or inefficiency) signifies progressive (or regressive) institutional changes or remains unchanged. In other words, the introduction of efficient policy brings changes to solve problems leading to progressive institutional changes (Bush, 1987). However, such a change is cumulative (Veblen, 1942), in line with the incremental technological progress; thereby changes often appear unremarkable. Based on the economic arguments above, we expect that na-

tional treatment as an instrumental standard should serve as a process and a cause leading to progressive outcomes in the long run.

In practice, efforts toward national treatment in the areas of IP lead to instrumental changes at both national, international and global levels. Globally, national treatment itself has evolved in history, as a principle in the area of IP. In 1883, the Paris Convention under the auspices of WIPO stipulated the principle of national treatment for intellectual creations.[1] However, the international treaty provided no provision of enforcement (Scotchmer, 2004). Although this provision has been added into the conventions, judicial execution is often perceived weak under WIPO (Scotchmer, 2004; Yang, 2013; Li & Correa, 2009). Given the issue, in 1995, TRIPS agreement under the World Trade Organization (WTO) obligated members to comply with national treatment putting an emphasis on execution (Subramanian & Watal, 2000; Yang, 2013). The agreement stipulates: Each Member shall accord to the nationals of other Members treatment no less favorable than that it accords to its own nationals with regard to the protection of IP .[2] More importantly, TRIPs stipulates civil, administrative and criminal procedures and remedies to enforce the fair and equitable principle of national treatment.[3]

Internationally, global norm of national treatment is not based on unilateral willingness, but reciprocity, and bilateral dialogue and actions to achieve compliance (Scotchmer, 2004). Such effort toward compliance is also obligatory. In the process, national interests and variations create frictions and even conflicts among countries to hinder compliance. Countries thus confront, negotiate and compromise to resolve issues. A salient example of such a process has occurred between the US and China. The two countries were on the brink of trade wars in 1989 due to issues in IP protection. However, both sides realized their interdependence and made effort to resolve their disagreements. After 15 rounds of negotiations, they signed the *Memorandum of Understanding for IP Rights* (Yang, 2013).

We argue that the historic evolvement of national treatment from the perspective of patents evidences progressive changes in the US. The pro-patent approach is highly acknowledged and sometimes criticized in practice and research (Hall & Ziedonis, 1995; Henry & Turner, 2006; Teece, Pisano, & Shuen, 1997). As the most popular filing country for latest technologies, it faces the challenge of backlogs. An administrative shift is thus the increase of the number of patent examiners to handle the increasing applications from locals and foreigners (e.g. 9000 by 2015 representing a rise of 2500 examiners from 2011).[4] Another administrative change is the introduction of accelerated patent examination from 2006. This practice allows patent evaluation within 12 months by submitting additional information and interviewing with the examiner.[5] Introducing the *U.S. Invent Act* (effective, March 2013) recognizes the first to file patenting by the postal mark among applications of similar inventions; thus helping accelerate granting.

Meanwhile, the revolutionary changes of patent system in China is apparent due its frequent, fundamental and sometimes dramatic changes; thereby evidencing policy changes and progress. It commenced in 1980 upon setting up the patent office and introducing the Patent Law, and Regulations in 1984. The short history privileges this latecomer to learn from advanced countries and aligns its policy with international standards. Its patent system becomes whole when the Special People s Court was introduced in 1996 to handle patent-related disputes (Liu, 1996; Wegner, 1996; Yang & Clarke, 2005) It revises the patent law and its regulations three times (1992, 2000 and 2008) to achieve international alignment. It ratifies the treaties, conventions and agreements under the auspices of two global IP authorities (WTO and WIPO). It has also hosted or organized visits from and to patent offices to facilitate exchange of knowledge and experience. Since the 1980s, the patent office has been training patent examiners, and other IP experts.[6] Such training matters for a new patent country like China with backlogs because knowledge and experience do decide the speed and quality of patent examination (Liegsalza & Wagner, 2013). Its number of patent examiners increases from below 3000 in 2011 to 10302 in 2015.[7] Nonetheless, like the U.S., China has to handle severe backlogs of patent applications, as the most recently ranked world no. 1 filing country.

To sum up, the discussions above affirm apparent changes as well as the need for enriching detail and addressing voids. Firstly, theoretical void should be filled and enrichment extended in explaining the changing nature of NTPU, as an outcome. The theory of institutional change aids explanation on the changing nature of the patent systems that manage patent uncertainties, but whether or not countries actions has enhanced NTPU over time remains an area for explanation. Secondly, whether or not countries have enhanced their NTPU over time also remains an empirical void to fill. Prior studies on NTPU are insightful but reveal only the broad changes of patent systems (e.g. Lerner, 2002; Yang & Clark, 2005; Khan & Sokoloff, 2001), and the status quo of patent uncertainties at a particular period (e.g. Kotabe, 1992; Yang, 2008). That is, no comparative studies seem to take place in temporal terms to evidence any changing outcome. Thirdly, historical evolvement puts great emphasis on the process and sometimes causes of institutional change, and emphasizes the significance of state as an enforcer. However, this is inadequate because institutional changes require understanding of the consequences (Greif & Laitin, 2004)

Nonetheless, broad theoretical argument of institutional change and practice impressions seem to suggest or recognize the overall progress toward NTPU over time. Accordingly, we formulate two broad hypotheses, and allow the data results to drive the detail. Thus, we hypothesize

H_{3a}
Countries progress over time towards NTPU in reducing pendency.

H_{3b}
Countries progress over time towards NTPU in increasing granting.

3. Method

3.1. Data characteristics

3.1.1. Patent data

We collect raw data from WIPO, State IP Office of China (SIPO) and the USPTO (including annual reports). WIPO compiles patent statistics based on the response to a statistical questionnaire from national patent offices across the world. The time series raw dataset is simple, systematic and relatively uniform. Invention patents: applications, grants and in force are broken down by residents (i.e. domestic applicants) and non-residents (i.e. foreign applicants). Such a consistency of data compilation across countries set foundations for sophisticated data analysis. In recent years, WIPO also categorizes the data based on the technology and industry to overcome the weakness of aggregate data. Nonetheless, the nation-dependent database may compromise the uniformity of data incorporation. For example, countries like Germany, Japan and China encourage and grant utility models (i.e. petty patents), but countries like the US and most EU countries do not. Consequently, two issues emerge: non-protective countries have petty

[1] Articles 2 and 3 of the Paris Convention.
[2] WTO (1995) Trade-Related aspects of IP Agreements, Article 3.
[3] WTO (1995) TRIPS, Part III.
[4] USPTO Annual Report 2015.
[5] See www.uspto.gov/patent.initiatives/accelerated-examination.
[6] SIPO annual report 2015.
[7] SIPO annual reports in 2012 2016.

patents granted under invention patents, and utility models show as missing data in the time series compilation.

We also compile the USPTO and SIPO time-series data for two purposes. One is to verify the consistency of datasets between WIPO and the national offices. The other is to compile patent data by country of origin. As a result, we are able to understand that both the US and China file invention patents heavily to each other suggesting their interdependence.

We also collect annual reports (1985 2015) from both patent offices. These reports are fundamental for qualitative, comparative analysis and help corroborate statistical findings with policy practice. We compare and contrast the two countries, including their changing nature of patenting activities. The background information provided in the annual reports aid our analytical explanation on the statistical results.

The above context decides our focus on invention patents between the US and China. This concentration allows in-depth comparison between the two countries, appreciation of the sophistication of invention patents among IP rights, and avoidance of the WIPO data variations across countries. We use raw data from 1985 to 2014 since China only started compiling its patent data from 1985.

We have only used the aggregated data without industrial differentiation for several reasons. Firstly, this study intends to have in-depth focus on comparison between the two countries, and between domestic and foreign applicants. That is, aggregated data from both countries and divided by groups are sufficient for us to generate holistic findings. Such a focus is logical since a holistic understanding of NTPU is essential to provide the next step of studies. However, such a focus compromises the study of other comparators, including industrial variations. Secondly, several prior studies have examined industrial differentiation in terms of patent uncertainties and generated broadly consistent findings that the more complex and newer the industrial patents, the longer it takes for a patent to be granted (e.g. Harhoff & Wagner, 2009; Popp et al., 2004). Thirdly, we have used aggregated data in consideration of the academic continuity of the study. Prior studies have used aggregated data and the same method to examine patent pendency and granting issues in triad powers in the 1980s (Kotabe, 1992) and China until 2002 (Yang, 2008). To ensure a longitudinal comparison, aggregated data analysis helps consistency in data organization and analytical method. More importantly, the findings allow authors to conduct a longitudinal comparison. Finally, we also use aggregated data to reflect on the effect of policy changes. Therefore, the whole dataset without industrial differentiation will help generate analysis reflecting this impact in the two countries.

3.1.2. Comparative patenting characteristics

Surrounding Table 1 and Fig. 1, we highlight the similarities and differences between China and the US in their patenting characteristics. Firstly, both countries demonstrate more dynamic patenting activities for both types of applicants in 2003 2014 than in 1985 2002. Local applications change from lower to far more than foreign applications in China while the US shifts from higher local applications to almost balanced filing between the two groups. Moreover, both groups in China have a quarter of a million applications in 1985 2002, but increase to over one million for foreign applicants and over 3.6 million for local applications. Meanwhile, the US has also experienced an increase of one million for both groups. Such dynamism is apparent in 2003 2014 for both countries because their filings account for 91% of the total 30-year activity in China and 60% in the US. Further, there are far more grants in 2003 2014 than in 1985 2002 (i.e. 94% of the entire 30-year grant in China; 55% in the US). Foreign applications and grants for Chinese patents (1985 2002) account for less than 5% of the total (30 years), but they surge to 21% and 38% respectively (2003 2014). Despite China s dramatic increase in patenting activities and no. 1 filing country status in the past five years,[8] the US receives more applications and grants more patents than China for the same period. This signals the leading (leader) and emerging (follower) role that the US and China play respectively in attracting technology owners.

Secondly, both countries seem to make effort to balance the two types of applications. They show a better balance in 2003 2014 than in 1985 2002 in granting. The US has almost 50/50 splits in filing and granting (2003 2014) and the gaps between local and foreign holders turn from 8% in 1985 2002 to 2% in 2003 2014. Meanwhile, China shows a disproportion between local and foreign filing (74/26%), but the gap in granting between the groups is smaller (59/41 vs 38/62). It demonstrates more dynamic local applications (from 47% to 76% for the comparative periods) while the US shows almost equal speed of growth for the two groups.

Finally, both countries show imbalance between the two types of applicants. The U.S. demonstrates more growth in foreign activities (from 46% to 49% in applications and from 46% to 51% in granting) and China in local activities (from 47% to 76% and 38% to 59%) between the two comparative periods. Both countries demonstrate higher grant ratios for foreign applications than for local ones although relatively the US is almost balanced. China grants 47% to foreign applications (grant ratios), but 23% to locals for the entire period and the ratios show much larger a gap in 2003 2014 (52% vs. 24%). In comparison, the US shows a much better balance and higher ratios for the two periods and the entire 30 years than China. Overall, the US grants almost 50% of the applications for both types of applicants (47% and 48%) in comparison to 29% for the total 30 years in China. This shows that the US remains a pro-patent country. The high grant to foreign owners (47%) in China suggests that foreign applications have overall higher quality than local ones. When looking at the patents in force, the percentages between 2004 and 2008 and 2009 2014[9] remain unbalanced and changed little for both countries. Domestic patents in force are high and more so for China (94/6% split). The US foreign patents in force shows a slight increase from 27% to 32%, but local patents lead 70% in 2004 2014.

Fig. 1 displays the (im)balance in specific years. Gaps in applications for US patents show between the two groups before 2008, but these become blurred after. Meanwhile, China starts to show wide gaps in applications from 2005 and granting from 2000 between the two groups. The figure also shows the overall trend of increase for both countries in patenting. There is an obvious surge of Chinese patent applications relative to the steady growth of other applications (US local and foreign, and Chinese foreign applications). However, when looking at granting, both countries seem to demonstrate a surge for both types of applications. Comparatively, the increase is more steady and balanced in the US than in China.

3.2. Models and variables

We use three models to generate statistical results. The lagged regression model (model 1 below) helps discover patent grants and pendency. Prior studies adopt this model to analyze patent uncertainties in Japan, Germany and Britain (Kotabe, 1992) and China (Yang, 2008). Therefore, we use this model to discover original information: patent pendency and grants in a particular year to the patent applications in a lagged year (0, 1, 2, 3 .) for the two patent offices.

$$\gamma_t = \alpha_{t-L} + \beta_{t-L} X_{t-L} + \varepsilon_t \quad (1)$$

Here Y_t: The number of patent grants in year t;

[8] WIPO annual report 2015

[9] We only find data available between 2004 and 2008 and 2009 2014 for China. For comparison, we use the same time period for the US.

Table 1
Patent Applications, Grants and in Force in the U.S. and China.

Comparators		US			China		
Patent Applications	**Comparative Period**	**1985 2002**	**2003 2014**	**1985 2014**	**1985 2002**	**2003 2014**	**1985 2014**
	Total Applications	**3704244**	**5571701**	**9275945**	**477834**	**4792811**	**5270645**
	Local Filing (% of Period)	1993561 (54)	2837411 (51)	4830972	226442 (47)	3665372 (76)	3891814
	Local% of Total	21	31	52	4	70	74
	Foreign Filing (% of Period)	1710683 (46)	2734290 (49)	4444973	251392 (53)	1127439 (24)	1378831
	Foreign% of Total	18	29	48	5	21	26
Patent Grants	**Comparative Period**	**1985 2002**	**2003 2014**	**1985 2014**	**1985 2002**	**2003 2014**	**1985 2014**
	Total Grants	**1994387**	**2409093**	**4403480**	**95223**	**1452892**	**1548115**
	Local Grants (% of Period)	1074414 (54)	1191700 (49)	2266114	35730 (38)	861490 (59)	897220
	Local% of Total	24	27	51	2	56	58
	Foreign Grants (% of Period)	919973 (46)	1217393 (51)	2137366	59493 (62)	591402 (41)	650895
	Foreign% of Total	21	28	49	4	38	42
Grant Ratios	**Comparative Period**	**1985 2002**	**2003 2014**	**1985 2014**	**1985 2002**	**2003 2014**	**1985 2014**
	Total Grant Ratio	**54**	**43**	**47**	**20**	**30**	**29**
	Local	54	42	47	16	24	23
	Foreign	54	45	48	24	52	47
Patent in Force	**Comparative Period**	**2004 2008**	**2009 2014**	**2004 2014**	**2004 2008**	**2009 2014**	**2004 2014**
	Total Patents in Force	**6397275**	**10050389**	**16447664**	**300022**	**2709377**	**3009399**
	Local (% of Period)	4661390 (73)	6836401 (68)	11497791	279631 (93)	2557593 (94)	2837224
	Local% of Total	28	42	70	9	85	94
	Foreign (% of Period)	1735885 (27)	3213988 (32)	4949873	20391	151784 (6)	172175
	Foreign% of Total	11	20	30	1	5	6

Notes: * %of period: refers to the percentage for the period total (e.g. 1985 2002 or 2003 2014 total filing or granting); % of total: the percentage of all the years studied (e.g. 1985 2014) in filing or granting.

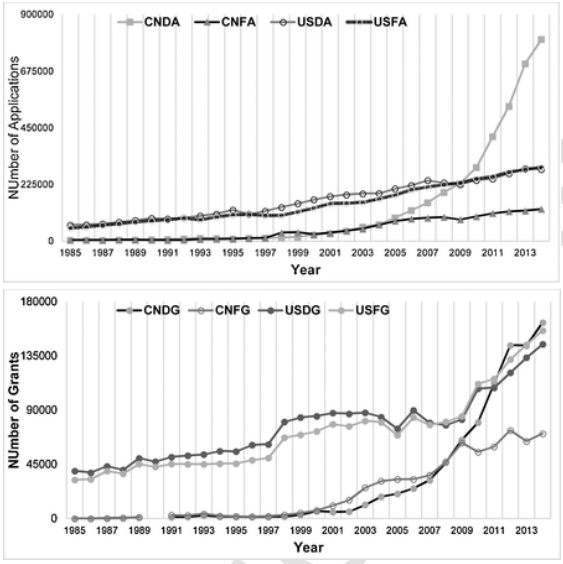

Fig. 1. Patent Applications and Grants in China and the U.S. (1985 2014).Notes: DA: Domestic Applications; FA: Foreign Applications; DG: Domestic Grants; FG: Foreign Grants.

t: The year of filing a patent application;
L: The number of years that patent grant lags behind the application;
$X_{t\text{-}L}$: The number of patent applications; and
: The residual error term.

Based on this model, we first generate descriptive data and lagged results for each patent office. Subsequently, we compare and contrast the changes in terms of pendency and grant within each patent office but between two different eras (1985 2002 and 2003 2014) and as a whole (1985 2014).

We test the equality of correlation coefficients from the independent samples using formula (2) below (Bryant, 1966: 140 142).

$$\eta = \frac{0.5 \ln \frac{1+r_1}{1-r_1} - 0.5 \ln \frac{1+r_2}{1-r_2}}{\sqrt{\left\{ \frac{1}{n_1 - 3} + \frac{1}{n_2 - 3} \right\}}} \quad (2)$$

: The test statistics based on the normal curve;
r: The correlation coefficient;
n: The sample size; and
1 or 2: Two independent samples.

We further conduct comparison between local and foreign applications within each patent office and for applications between the two offices by testing the equality of slope coefficients using formula (3) below (Cohen and Cohen, 2002: 111):

$$t = \frac{\beta_{(t-L)1} - \beta_{(t-L)2}}{\sqrt{S.E._{\beta(t-L)1}^{2} + S.E._{\beta(t-L)2}^{2}}} \quad (3)$$

t: The year filing a patent.
$_{(t\text{-}L)1}$ and $_{(t\text{-}L)2}$: Two slope coefficients for local and foreign applications within each patent office or for applications between the US and China.
S.E.: The standard error consistent with the slope coefficients under comparison.
1 or 2: Two independent samples

3.3. Analytics and validation

We adopt two analytical techniques to conduct data analyses: lagged regression analytics, and case comparison. Lagged regression modeling is an appropriate analytical technique for this study because it helps measure variables and factors simultaneously, and the results set foundations for us to conduct comparative studies between the two countries. The robustness of the findings is evaluated through measurements generated by the statistical results.

We also adopt cross-case syntheses and comparison to evaluate the above results due to its strength to develop robust argument (Yin, 2003). Cross-case syntheses allow researchers to evaluate findings by in-depth qualitative analysis (e.g. word displays) based on theoretical assumptions to identify the unique characteristics between groups (e.g. countries), features within subgroups (e.g. domestic and foreign applicants), and between subgroups of two different groups (e.g. foreign applicants between the U.S. and China) and between two different longitudinal periods (1985 2002 vs. 2003 2014), and the whole dataset. Insightful outcomes among multiple comparators can thus be compared and contrasted to develop fair and plausible arguments and support the statistical findings. To present our findings, we have followed Ahlstrom (2015a, 2015b) to frame and structure the contents and achieve clarity and simplicity.

For longitudinal comparisons, we analyze the results between 1985 and 2002 and 2003 2014 as well as the whole dataset due to the empirical and methodological consideration and the need for practice. Empirically, the most relevant studies were based on the data until the turn of the century (Liegsalza & Wagner, 2013; Popp et al., 2004; Regibeau & Rocket, 2010; Yang, 2008). In order to demonstrate the continuity of scholarly contributions, such data comparison divided into the pre-2002 and post-2003 seems logical. Methodologically, we conduct equality tests of different sample sizes based on the models explained. Therefore, despite the differences in sample sizes for all the comparisons between the two periods, the equality tests have made the sample difference irrelevant. From policy and practice perspective, 2002 2003 serves as a watershed for both countries because they have some incentive policy in place to boost patent activities. For example, the US Federal Trade Commission introduces new policy in 2003 to promote balances of competition and IP (FTC, 2003). Meanwhile, China identifies IP rights as a priority policy for international collaboration.[10]2003 marks the year that the incentive policy of subsidy for patent applications and reward for grant is in place across all provinces within the country (Li, 2012). However, how NTPU has been since 2003 is a mystery for both countries, let alone in comparison, making our study timely to provide insights as to how the policy changes have affected (in)efficiency of patenting activities.

4. Results

Tables 2 and 3 summarize our findings and we confirm or refute each hypothesis below.

4.1. National treatment for patent uncertainties within countries

Our findings support Hypothesis$_{1a}$: Domestic and foreign applicants have equal pendency for US patents, but the former enjoys less certainty than the latter in its pending status. The two groups of applicants have equal pendency for the best models (i.e. 0, 3 and 0) for the three comparative periods. Moreover, all foreign applications show higher certainty than their local peers within the same pendency in 2003 2014, and the entire 30 years. However, such a difference reverses between 2003 and 2014 and 1985 2002. The equality tests of the degree of pendency uncertainties generate significant values for all the fit models (at least $p < 0.002$). For example, the fit models in 2003 2014 shows that both types of applicants can expect applications to be granted in zero, two and three years, but more so in year three (the best model). The degree of certainty is 70 71% for local applicants, but higher for foreign applicants (78 81%) in 2003 2014.

Our results support H_{1b}: Domestic and foreign applicants have equal pendency for Chinese patents, but the former enjoys more certainty than the latter in its pending status. The best models show that domestic and foreign applicants have zero-year pendency in 1985 2002, but changes to two-year pendency in 2003 2014. Both types of applicants endure less uncertainty in 2003 2014 (i.e. variances for the best models increase from 0.87 to 0.99 for locals and 0.79 to 0.93 for foreigners) evidencing the improved patenting environment. However, comparatively, locals enjoy more certainty than foreigners due to the higher variances (98 99% vs 84 93%). Our equality tests confirm their significant differences ($p < 0.000$) suggesting the two groups endure different degrees of uncertainty within equal pendency, and foreign applicants more so.

We support H_{1c}: Domestic and foreign applicants have equal treatment in granting for US patents. The best fit models show gaps of 3% (1985 2002) and 23% (2003 2014) respectively in their slope coefficients between domestic and foreign applicants. The other fit models also show widened gaps between the groups and within the group for the different time periods suggesting accelerated grants for both groups in 2003 2014, but more so for local applicants. Regardless, such differences are tested insignificant across all fit models, including the whole dataset.

We refute H_{1d}: Domestic applicants are favored more than foreign applicants in granting for Chinese patents. The result is reversed: Foreign applicants are favored more than local applicants in granting for Chinese patents. This is because in 2003 2014, foreign grants demonstrate much higher slope coefficients than local grants (a gap of nearly 80% for the best model). The equality tests of all fit models generate significance ($p < 0.000$). The findings are consistent with those of the whole dataset, but reverse the findings in 1985 2002.

4.2. Comparative national treatment between countries

We support H_{2a}: Domestic applicants experience shorter pendency in China than in the U.S. and H_{2b}: Foreign applicants endure shorter pendency in China than in the U.S. The best models for both types of applicants demonstrate shorter grant lags in China than in the US (0 vs. 1 in 1985 2002; 2 vs. 3 in 2003 2014). Although the best model for the whole dataset in the US local applications show a zero lag relative to one year lag in China, the variance is far higher for China than the US (97% vs 86% for the zero year and 99% vs 84% for the one-year lag). The equality test generates consistent results that all the comparators are significant ($p < 0.000$).

Our findings support H_{2c}: Domestic applicants endure lower granting in China than in the U.S. The results are consistent for all the fit models generated across different time periods. The slope coefficients for the best models of local applications in the three different periods show gaps (i.e. 20, nearly 90 and 16) between China and the US. The equality tests confirm such significant differences ($p < 0.000$).

Finally, our results refute H_{2d}: Foreign applicants endure lower granting in China than in the U.S. Our adjustment is: Foreign applicants enjoy equal granting in China and in the U.S, but it seems that foreign applicants are trending toward higher granting in China than in the US. The hypothesis is true in 1985 2002 when the slope coefficients display much lower level of granting in China than in the US (0.08, 0.05 and 0.03 versus 0.38, 0.35 and 0.33; $p < 0.000$). However,

[10] For example, dialogues with the OECD to enhance collaboration in IP.

Table 2
Modelling Results of Patent Pendency and Granting.

US	US Patents by Local Owners			US Patents by Foreign Owners		
	1985-2002	**2003-2014**	**1985-2014**	**1985-2002**	**2003-2014**	**1985-2014**
0-year lag						
ß	**0.39**	**0.60**	**0.36**	**0.38**	**0.57**	**0.41**
R^2	0.93***	0.70***	0.86***	0.93***	0.78***	0.89***
1-year lag						
ß	**0.38**	0.79	**0.36**	**0.35**	0.70	**0.39**
R^2	0.96***	0.62**	0.84***	0.95***	0.75***	0.87***
2-year lag						
ß	**0.36**	**0.97**	**0.35**	**0.33**	**0.79**	**0.37**
R^2	0.95***	0.70***	0.82***	0.94***	0.79***	0.86***
3-year lag						
ß	**0.32**	**1.05**	0.36	0.30	**0.82**	0.35
R^2	0.93***	0.71***	0.80***	0.91***	0.81***	0.84***
China	**Chinese Patents by Local Owners**			**Chinese Patents by Foreign Owners**		
	1985-2002	**2003-2014**	**1985-2014**	**1985-2002**	**2003-2014**	**1985-2014**
0-year lag						
ß	**0.18**	0.21	0.22	**0.08**	0.63	**0.56**
R^2	0.87***	0.95***	0.97***	0.79***	0.73***	0.93***
1-year lag						
ß	**0.16**	0.20	**0.20**	**0.05**	**0.83**	**0.53**
R^2	0.86***	0.98***	0.99***	0.73***	0.84***	0.92***
2-year lag						
ß	**0.14**	**0.18**	**0.17**	**0.03**	**0.97**	**0.49**
R^2	0.80***	0.99***	0.99***	0.65***	0.93***	0.90***
3-year lag						
ß	0.07	**0.14**	**0.13**	0.02	**0.92**	0.43
R^2	0.62***	0.98***	0.99***	0.54***	0.88***	0.88***
4-year lag						
ß	0.05	**0.10**	0.09	0.02	0.86	0.39
R^2	0.40**	0.98***	0.99***	0.45**	0.78***	0.83***

Notes: Dark and light grey highlight the best and fit models respectively. ***$p < 0.001$; **$p < 0.01$.

dramatic changes occur in both countries in 2003 2014 (China: 0.83, 0.97 and 0.92 vs. US: 0.57, 0.79 and 0.82 for the fit models). The equality test generates no significance between the two foreign groups. When comparing the whole datasets, China shows overall higher levels of granting (0.56, 0.53 and 0.49 versus 0.41, 0.39, and 0.37) and the comparators are significant ($p < 0.001$). Therefore, both countries

Table 3
Results: Hypothetical Responses and Longitudinal Comparison.

Hypothesis		Result	Correction to Hypothesis*	Longitudinal Comparison		
				1985 2002	2003 2014	1985 2014
H_{1a}: Applicants have equal pendency for US patents, but locals enjoy less certainty in pendency than foreigners				1/1	3/3	0/0
				0.96/0.95***	0.71/0.81**	0.85/0.89***
H_{1b}: Applicants have equal pendency for Chinese patents, but locals enjoy more certainty in pendency than foreigners				0/0	2/2	1/0
				0.87/0.79***	0.99/0.93***	0.99/0.93***
H_{1c}: Applicants have equal treatment for US patent grant				0.38/0.35	1.05/0.82	0.36/0.41
H_{1d}: Locals are favored more than foreigners for Chinese patent grant.			Reversed	0.18/0/08***	0.18/0.97***	0.22/0.56***
						0.20/0.53***
H_{2a}: Locals experience shorter pendency in China than in the U.S.				0/1	2/3	1/0
				0.87/0.93***	0.99/0.70***	0.97/0.85***
				0.86/0.96***	0.98/0.71***	0.99/0.84***
H_{2b}: Foreigners endure shorter pendency in China than in the US				0/1	2/3	0/0
				0.79/0.93***	0.93/0.79***	0.93/0.89***
				0.73/0.95***	0.88/0.81***	
H_{2c}: Locals endure lower granting in China than in the U.S.				0.18/0.39***	0.18/0.97***	0.22/0.36***
					0.14/1.05***	0.20/0.36***
H_{2d}: Foreigners endure lower *granting in China* than *in the U.S.*			enjoy equal granting, but trending higher in both countries, but more in China	0.08/0.38***	0.97/0.79	0.56/0.41***
				0.05/0.35***	0.92/0.82	
Longitudinal Comparison						
H_{3a}	Countries Progress over time towards NTPU in Reducing Pendency		Countries regress overtime than towards NTPU in reducing Pendency			
	Locals endure longer pendency and higher uncertainty for US Patents			1/0.96	3/0.71	***
	Foreigners endure longer pendency and higher uncertainty for US Patents			1/0.95	3/0.81	***
	Locals endure longer pendency but lower uncertainty for Chinese Patents			0/0.87	2/0.99	***
	Foreigners endure longer pendency but lower uncertainty for Chinese Patents			0/0.79	2/0.93	***
H_{3b}	Countries Progress over Time towards NTPU in Increasing Granting					
	Locals enjoy higher granting for US Patents than before			1/0.38	3/1.05	**
	Foreigners enjoy higher granting for US Patents than before			1/0.35	3/0.82	***
	Locals enjoy equal granting as Before for Chinese Patents			0/0.18	2/0.18	/
	Foreigners enjoy higher granting for Chinese Patents than before			0/0.08	2/0.97	***

Notes: The best models (year and value) are shown. Support; Refute; partial support. When pendency is not in the same year for the two countries, both best models coefficients are shown. *** $p < 0.001$; ** $p < 0.01$. The correction to hypothesis only corrects the underlined words in the original hypothesis indicating other words remain the same.

trend toward higher granting than before for foreign applications, but China demonstrates more overall dramatic changes.

4.3. Progressive or regressive national treatment for patent uncertainties

Table 3 summarizes the key longitudinal comparisons and allows us to address progress or regress in pendency and granting in the two countries surrounding the two broad hypotheses. The analysis details the finding consistency or discrepancy. It also emphasizes integrative observations.

We reject H_{3a}: Countries progress over time towards NTPU in reducing pendency. On the contrary, we conclude consistently that countries regress over time towards NTPU in reducing pendency. The longitudinal findings in the US show that both groups of applicants endure longer pendency and higher uncertainty in 2003 2014 than in 1985 2002. They expect one-year pendency in 1985 2002, but this prolongs to three years in 2003 2014. The equality tests confirm consistency of significant differences for all fit models between the two comparative periods

In addition, we have three detailed longitudinal observations relevant to the US. Firstly, the inequality role in pendency certainty reverses between locals and foreigners for US patents. In 1985 2002, domestic applicants enjoy more certainty, but in 2003 2014, foreign applicants do so, but both have reduced certainties than before. Secondly, another consistency for the two different periods is that zero-year lag is one of the fit models, and the best model for the whole dataset. We interpret this finding that valuable applications may expect shorter pendency (zero year), and foreign applicants endure slightly less uncertainty than their local peers, but equal in 1985 2002. The observations above suggest that foreign applicants probably have overall higher quality patents to offer. Finally, observing the whole datasets, the pendency becomes zero-year lag for the best model and the degree of uncertainty has increased in comparison to 1985 2002, but decreased from 2003 to 2014. We interpret this as the overall progress in the past 30 years to deal with pendency uncertainty despite the backlog.

The longitudinal comparison in China also rejects the hypothesis since countries regress over time in reducing pendency. Specifically, locals and foreigners endure longer pendency but lower uncertainty in 2003 2014 than in 1985 2002. Pendency has increased in 2003 2014 from zero to two years for both groups. Moreover, China shows progress in dealing with pendency uncertainty for all applicants. The variances for all the fit models have increased to up to 99% and 93% respectively for domestic applicants and foreign applicants. Consistently, local applicants enjoy much higher certainty than their foreign peers within the equal pendency for all the comparative periods. The whole dataset shows narrower gaps between local and foreign applicants in variances (4%, 7%, and 9%). This suggests the overall progress of balancing for the two groups with reduced gaps. The whole dataset also shows shorter pendency for foreign applicants (zero vs 1 year). This is probably because technology leaders (US, Japan, major EU countries and Korea) consistently account for 92% of the applications and granting in China for the past 30 years.[11] They tend to file valuable applications for processing, as a priority.

The results support H_{3b}: Countries progress over time towards NTPU in increasing granting. Applicants for US patents enjoy higher granting than before as well as foreign applicants for Chinese patents, but locals show no difference in granting for Chinese patents between the two different periods.

The inequality of patent granting reverses in China with time for the two groups. In 1985 2002, domestic applicants are favored since local slope coefficients are consistently higher than foreign applications. In 2003 2014, gaps for the fit models widen to 63% 80% with foreign grants being higher in its slope coefficients. This demonstrates that foreign applicants are favored more than local applicants in granting in recent years. Moreover, the whole dataset (1985 2014) shows consistent findings to the results in 2003 2014 demonstrating the trend in favor of foreign applications.

The above longitudinal analysis also allows us to generate integrative and comparative observations. Firstly, both countries have experienced longer pendency than before and such extended pendency is equal within both types of applications. Despite the longer pendency for both countries, China demonstrates higher certainty in pendency in 2003 2014 than in 1985 2002 for both groups. The US shows lower certainty within the longer pendency than before for both groups. Secondly, both countries show progress in granting. The US shows higher granting in 2003 2014 than before for domestic applications, but China shows equal granting for the two periods to local filing. Moreover, both countries show higher grants than before for foreign applicants. The results suggest that both countries administrative efforts are showing positive effects to appreciate foreign filing and recognize its quality. The results also implies that both countries welcome foreign applications without discrimination in granting.

5. D iscussion

5.1. Theoretical, empirical and methodological contributions

This study contributes to theoretical understanding of national treatment and institutions from the perspective of patent uncertainties. We contribute to explain the principle of national treatment from the perspective of patent uncertainties by specifying our argument as to the global compliance of NTPU. Different from previous disagreement (e.g. Kotabe, 1992; Webster et al., 2014; Yang, 2008), we confirm the overall compliance of NTPU, but specify that the difference is in the degree of uncertainty within equality rather than equality itself.

Our argument is fundamental in the institutional theory, and as a result, we seem to venture as the first authors to explain NTPU based on the foundations of universalism, functionalism and change; thereby we also contribute to three theoretical frontiers of the institutional theory centering on NTPU. Firstly, we enrich the understanding of institutional universalism argument (e.g. Eden, 2010; Ruggie, 1992; Yang & Sonmez, 2013) to explain the global norm of NTPU within countries. Institutional universalism determines that countries are expected to treat local and foreign applicants equally when confronted with pendency and granting uncertainties. Such an expectation seems overall upheld since the results demonstrate either equality in pendency or positive discrimination despite that the degree of uncertainty remains within equality toward local and foreign applicants.

Secondly, we also enrich the understanding of institutional functionalism argument (Scholte, 2001; Sgard, 1995; Wijk & Ramamma, 2007) by detailing the comparative variations of NTPU between countries. According to the institutional functionalism, countries are bound to show variations in their national treatment due to state interests. We confirm such arguments, but we also enrich theoretical understanding on national variations by revealing how countries compare and contrast in NTPU.

Thirdly, we fill in a void of examining NTPU based on the institutional change. The institutional change argues that countries may progress, regress or remain unchanged with time due to the policy efficiency (or inefficiency). Contributing to prior theoretical focus on change, as a cause and process (e.g. Bush, 1987; Oliver, 1992), we as-

[11] Based on the foreign filing and granting in China by country of origin from 1985 to 2014, our calculation shows that Japan, US and Germany are the top filers and grantees accounting for nearly 70% of total foreign filing and granting (35%, 24% and 10% for filing, and 40%, 21 and 9% for granting). Another 22% goes to South Korea, France, Netherlands, Switzerland, UK, Sweden and Italy. The rest of the world accounts for 8%.

sess its outcome after 30 years of institutional efforts in NTPU. Our findings help contribute to the institutional theory, as an implementation and we are able to inform the theory thatcountries both progress and regress in handling detailed NTPU.

We also make empirical contributions in three fold. Firstly, we extend prior studies to address the discrepancy as to whether or not NTPU is upheld (e.g. Kotabe, 1992; Webster et al., 2014; Yang, 2008). While we confirm such a compliance differentiated by the degree of uncertainty, we also affirm the significant role played by foreign owners of invention patents (Harhoff & Wagner, 2009; Popp et al., 2004; Regibeau & Rockett, 2010). Secondly, we enrich the sporadic studies of NTPU in spatial terms. While affirming prior arguments (e.g. Kotabe, 1992; Webster et al., 2014; Yang, 2008), we extend prior studies as to the disagreement of divergence and address spatial comparison between the US and China, the two most active patenting countries in the world. Thirdly, we fill in an empirical void in temporal terms to reflect the changing nature of countries in NTPU. As a result, it seems to be the first time to address how countries have progressed or regressed in the process of NTPU compliance.

Our methodological contributions are reflected in two aspects. Firstly, we conduct a longitudinal comparison of NTPU. This is one step further to prior studies that are based on the pre-2002 data (Liegsalza & Wagner, 2013; Yang, 2008). This longitudinal comparison helps us evaluate the changing nature of patent environments between the two countries with relatively recent data. Secondly, our methodological merit is in the effort of combining two analytical techniques to generate new findings. We conduct lagged regressions, and comparative syntheses to allow these techniques excel in their strengths and overcome each other s weaknesses. Such effort helps overcome mono-method bias and strengthen the robustness of the findings. The comparative syntheses focus on in-depth analysis and fleshes out the results from lagged regressions. They also allow clearer discussions as to the similarities and differences between the two systems in treating equality.

5.2. Implications for policy and managerial practice

This study provides implications for policy makers to improve the efficiency of national patent systems for technology owners and for bilateral cooperation. Firstly, despite the overall compliance in NTPU, different degrees of uncertainty within equality continue for locals and foreign applicants. With national treatment for local and foreign applicants, countries will align their policy and actions with the WTO standard and encourage diverse technological activities to boost economic development. Preferential treatment to local applicants may encourage dynamic local innovation meanwhile it may discourage owners of cutting edge technologies from foreign countries to apply for patents. The US adopts a balanced approach to grant local and foreign patents while China has made effort to increase foreign invention patents. Both countries practice will help attract talents and latest technologies. Patent certainties also evidence countries attractiveness and owners commitment for technological investment. Countries thus face challenges to harmonize differences in policy and practice for cooperation among patent offices, given the intensity of cross-border patenting. Patent uncertainties signal the deficiency of nation-based patent systems and affect owners decision to transfer technology across borders; thereby carrying social, economic and innovative connotations.

Secondly, national variations in NTPU remain despite the concerted effort among countries. Given the findings, policy makers are able to compare and contrast strengths and weaknesses of national patent systems with detailed pendency and granting. Consequently, they can have directions to improve national patent environments for technology owners. For example, the delay and indecision of patent granting will result in foreign investors having a second thought in their business commitment in a country. After all, foreign owners play a significant role for US and Chinese patents.

Finally, the findings also help policy makers recognize the changing nature of NTPU and provide them with directions of further improvement to boost innovation. Despite the effort and progress toward equality, regress is also revealed suggesting direction for improvement with time. This improvement is vital since both countries inflows of foreign patents are from technology leaders and the foreign inventors role in the countries is significant.

The findings also have implications for managerial practice of technology owners. Firstly, despite the equality for local and foreign owners, harder work should be anticipated to obtain patents overseas. Such increased workload includes dealing with expected delay since both countries have longer pendency than before and complexity in granting. Secondly, the grant delay, despite being unpredictable, can be anticipated. This is because both countries demonstrate major grants within short lagged periods. Such anticipation can help practitioners plan ahead for patent-related commercialization. Thirdly, be prepared to be differentiated not necessarily discriminated. Under the global norm of national treatment and obligation, it can be difficult to have deliberate national discrimination. However, it seems that all countries have differential treatment to local and foreign grants although the degree of differentiation varies across countries. Therefore, patent practitioners have to face this reality and seek effective strategic solutions.

Finally, in a broader sense, the findings will help both policy makers and practitioners gain a critical understanding of the patenting environments in the top two filing countries. The differential treatment (e.g. local vs. foreign, foreign vs. foreign patent applicants) will help policy makers and practitioners recognize the relative strengths and weaknesses to practice patenting. As a result, it will also help resolve international tension and enhance collaboration between patent offices. After all, US technology owners patent substantially in China while Chinese applicants treat the US as the no. 1 filing destination overseas. The pendency and granting uncertainties provide patent owners with detail of patent delays and possible outcomes so that they can anticipate what to expect in the process of applications. The findings could also be insightful for invention owners from the US and China to file patents in these two countries because the granting equality may encourage future foreign filing.

5.3. Research limitations for future studies

This study has limitations warranting future research. Firstly, using institutional theory as a foundation for argument aids our understanding of NTPU. However, such theoretical and empirical linkage is just the beginning to explain NTPU within two most dynamic patenting countries . Further linkage with othercountries can help enrich empirics and inform the theory. This is especially important when we adopt the institutional change to explain NTPU outcomes. Secondly, informal institution and its significant role in patent systems attracted sporadic scholarly attention (e.g. Briggs & Brown, 2012; Moore, 2003; Yang, 2005). However, as Bush (1987) argued, fundamental value structure change of society matters to institutional change. As far as informal institutions and NTPU are concerned, prior studies do recognize applicants experience in patenting, cultural familiarity in patent environments and the local language and translation may all play an important role to advantage local applicants (e.g. Liegsalz & Wagner, 2013; Popp et al., 2004). Thirdly, empirical studies in both spatial and temporal terms can help enrich our findings. Our findings suggest that national variations continue in NTPU. This implies the inevitability of inconsistency in pendency and granting across countries. The two top filing countries represent the patenting world well, but given the national variations, widening the empirical verification and comparison across countries in different time periods is a direction for further study, particularly regarding NTPU in developing countries.

Next, the other important empirics to consider is the industrial and ownership variations. The aggregate data in this study provides us with inherent advantages in conducting national studies; thereby setting foundations to understand institutions from the perspective of patenting environment. Meanwhile, industrial and ownership variations in patenting behaviors are also highly recognized, and should be on our research agenda. For example, how do the complex and traditional industries fare in terms of NTPU? How do large and small owners/firms differ? How does NTPU compare and contrast across different industries in a particular country? Moreover, NTPU in a particular industry worldwide can provide insights and detail of global consistency and national variations in similar technological fields.

Finally, some methodological directions should also be deliberated in the future. One consideration is the fine-tuning of the data. For example, the joint US UK report emphasizes three different stocks of backlogs in pendency (Mitra-Kahn et al., 2013). Such detailed data can help increase the precision of findings although our aggregated estimates are based on logic and statistics, and relevant qualitative analysis. The other consideration is to use a different dataset to verify our findings since our study requires clarification of the error terms that influences the efficiency of national patent systems given our model restrictions.

6. CConclusion

This paper studies the global norm of national treatment for patent uncertainties (NTPU) and addresses three relevant questions: is NTPU upheld within countries? How does NTPU diverge across countries ? How does NTPU change as an outcome over time? Adopting the foundation of institutional theory, based on lagged regression of 30-year patent data and multiple comparators in the US and China, we address the central tenet of national treatment from the perspective of patent uncertainties. Our findings show that overall NTPU is upheld because both countries provide equality in dealing with pendency and granting (or positive discrimination toward foreigners). We also confirm that comparative variations continue to exist, but we detail comparative variations between the two countries since applicants experience shorter pendency in China than in the US regardless of the type of applicants meanwhile domestic applicants endure lower granting in China, but foreign applicants enjoy equal granting in both countries . The longitudinal studies of 1985 2002 and 2003 2014 demonstrate progress (higher or equal granting) and regress (longer pendency) experienced for all applicants in the two countries .

The study asserts that NTPU is upheld broadly demonstrating the national endeavor to comply with the international treaty. Despite the broad compliance, the difference is in the varied degree of uncertainty within the equality to locals and foreigners. Countries differentiate, not necessarily intentionally discriminate. National variations remain, thereby detecting comparative variations will aid bilateral cooperation. Moreover, NTPU shows both progressive (granting) and regressive changes (pendency) as an outcome. The findings provide owners with evidence to patent strategically at home and abroad and policy makers to understand the similarities and differences of cross-border patenting activities to enhance cooperation.

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