Are Chinese Patent Applications Politically Driven?

Evidence from China's Domestic Patent Applications

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Summary

In this paper we study the seasonal characteristic of patent filings counts in China from 1986 to 2007. By comparing domestic filings with foreign filings at China's State Intellectual Property Office, we find a much stronger monthly pattern of domestic filings which peaks in December every year. The finding may suggest some of the domestic patent filings are policy or politically driven, rather than innovation or commercially driven. We provide further evidence on this hypothesis based on other patent application characteristics. The quality of the domestic patents filed in December, however, do not seem to be lower than those in other months. However, patent filings in December have significantly higher proportion of shared co-inventors compared to filings in other months. Pulling together the evidence, the analysis suggests that the higher number of filings are likely due to firms breaking up their inventions to come up with more applications. The findings have important implications to China's patent strategies.

1. Introduction

We have the application information for invention patents filed at China's State Intellectual Property Office (SIPO) from 1985, when China first enacted the patent law, to September 2009. We look at the domestic applications (patent applications filed by domestic entities)

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and foreign applications (patent applications filed by foreign entities) separately.[1] We aggregate the application data into monthly application counts. The data were obtained based on published applications, i.e., we have the information for patent applications that were published before September 2009. Since there is a lag of up to 18 months from application to publication, the application data for 2008 and 2009 are truncated. We drop these two years from the analysis thereafter. The applications in the first year may also distort the seasonality of the patenting activities because they reflect the cumulated stocks of patents waiting for the law to get passed. The data indeed confirm this possibility: in April 1985 there were around 1600 domestic invention patent applications, but very few applications (less than 10) in the first three months and not very many (between 200 to 300) after April either. Therefore we remove the year 1985 as well. After the data cleansing, we are left with 22 years of monthly application data, totally 264 time series data points for each type of applications (domestic and foreign).

Please see Figure 1 for a big picture of the domestic application quantity. The monthly applications seem to increase exponentially, thus I take the log of the application data (Figure 1b), which increases roughly linearly. In order to take a first look at the seasonality of the monthly application counts, we take the first difference of the log application counts, which is equivalent to the month-by-month growth rate (Figure 2a). We plot the growth rate against their lags (Figure 2b) to investigate seasonal correlations. Perhaps not surprisingly, there is a strong positive correlation at lag $= 12$, i.e. a yearly correlation. The correlations at other lags are not very evident.

Foreign applications enter China in two ways: through the traditional Paris Convention, by which foreign applicants file directly at China's SIPO; or the more recent (since 1994) Patent Cooperation Treaty (PCT), by which foreign applicants go through an international

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[1]For the purpose of this study, we classify applications from Hong Kong, Macao and Taiwan as foreign.
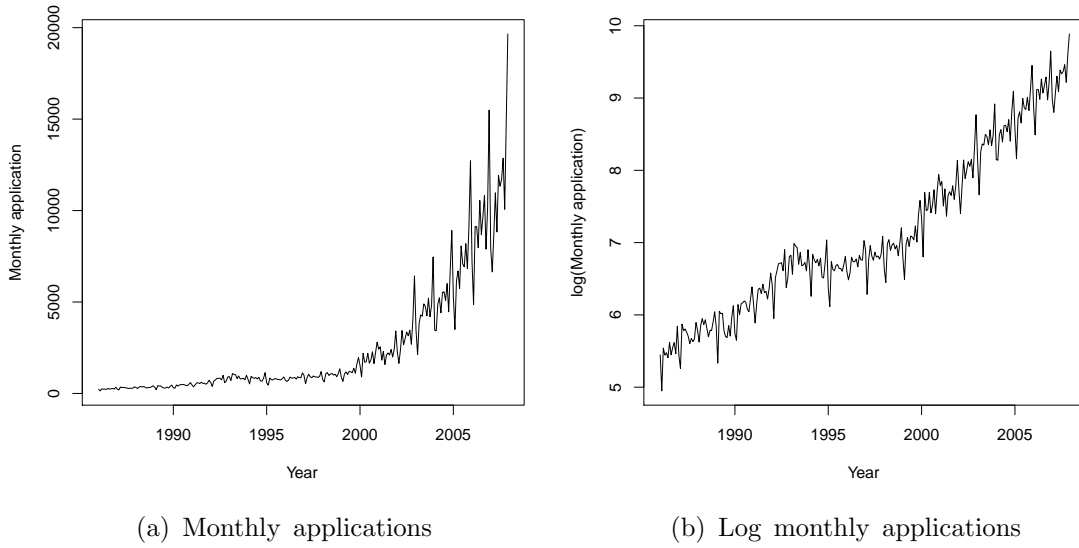
(a) Monthly applications

(b) Log monthly applications

Figure 1. Patent application growth from 1986 to 2007

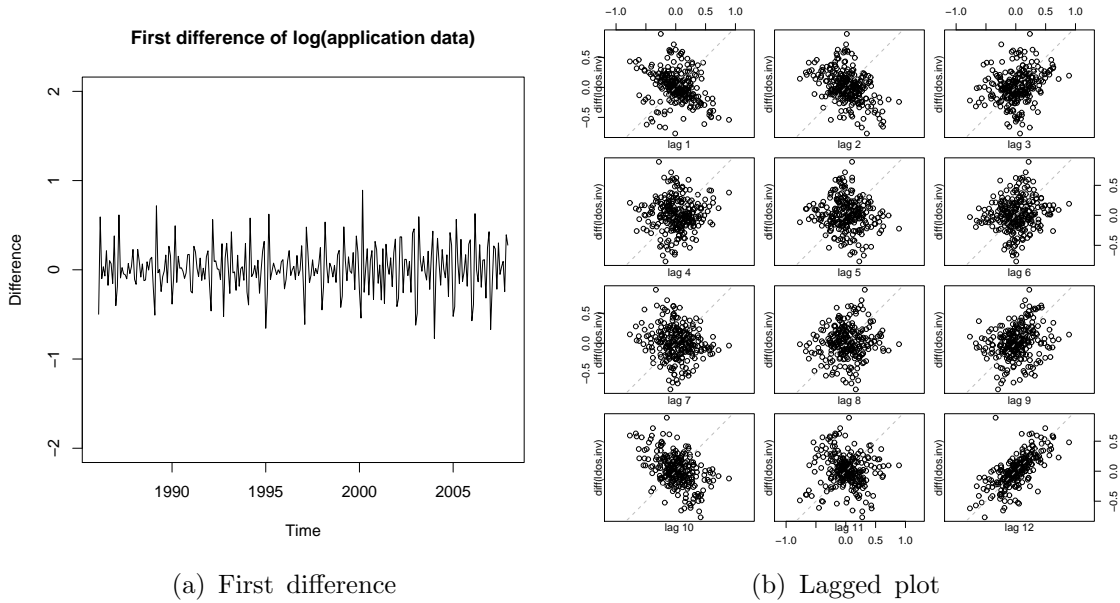

(a) First difference

(b) Lagged plot

Figure 2. A first look at the seasonality of the monthly application data

phase before entering China (the national phase). For a traditional foreign application, the

application date recorded in our database is the actual application date at SIPO; while for a

foreign PCT application, the application date is the date when an international application

is filed at a Receiving Office (usually in its original country). After the international patent application, an international search is conducted before the patent application enters China, which can take up to another 18 months. Therefore the application dates for foreign PCT applications are not the actual application dates at SIPO, but the international applications date at the Receiving Office. Thus hereafter we separate the two types of foreign applications and use only the traditional foreign applications for comparison with domestic applications.[2]

2. A Seasonal-trend Decomposition Analysis

In this section we study the seasonal characteristics of log monthly application data using a seasonal-trend decomposition procedure based on loess (STL). STL is a filtering procedure for decomposing a time series into three components: trend, seasonal, and remainder, using the loess smoother (Cleveland et al., 1990). Some of the key parameters to choose for the STL operations are: n_p, the number of observations in each cycle of the seasonal component, which is 12 in our study; n_l, the smoothing parameter for the low-pass filter, which is usually taken to be the smallest odd integer greater than or equal to n_p; n_t, the smoothing parameter for the trend component, the recommended value of which is given in Cleveland et al. (1990); and most importantly, n_s, the smoothing parameter for the seasonal component. Cleveland et al. (1990) recommends n_s to be an odd integer greater than or equal to 7, in order for it to smooth the data and remove low frequencies from seasonal frequencies. The larger n_s is, the more smoothing we have for the seasonal component (pooling the values for the same month across more years). In Figure 3, we report the results using $n_s = 15$. Nonetheless, the results are robust at other values.

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[2]For a more detailed comparison of these two types of foreign applications, please see Appendix A.
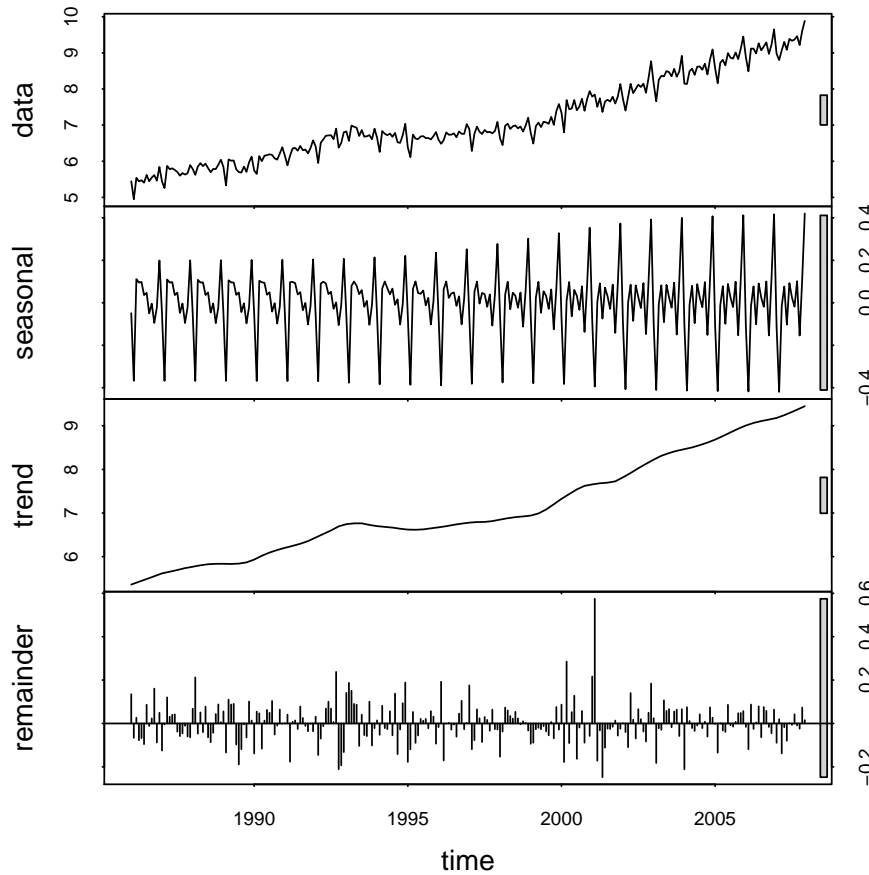
Figure 3. STL decomposition of log application data

2.1 The seasonal component

The plot confirms that there is a yearly seasonal component for domestic patent applications, with a peak in the last month. Though there are reasons to believe that firms may file more of their patent applications during the last month of the year to clear up the stock of innovations before the end of the year and the holidays (for both SIPO and the applicants), the large deviation from other months still merits more attention.

We look at the seasonality of foreign applications at SIPO to compare to the seasonality of domestic applications. Figure 4 plots the seasonal components of domestic applications

together with the seasonal components of foreign applications at SIPO. Both series show some seasonality, especially the low numbers in January and February due to holidays: the lowest number for domestic applications usually occurs in February, during which the Chinese New Year falls in; while the lowest number for foreign applications usually occurs in January, when employees leave for the new year break. However, from the comparison of the two figures, some distinctions still stand out: foreign applications do not have as strong an upward peak in December as the domestic applications. For foreign applications, though patent filings in December are usually higher than other months, which is expected due to reasons stated in the first paragraph, the gap between December and other months is much smaller compared to domestic applications.

A very plausible explanation is that in China, patent applications may be policy or politically driven, rather than innovation or commercially driven. Many local governments have set goals for patent applications in each year, i.e., they need to file a certain number of patent applications in a given year. These numbers can be important for assessment of the local officials. They may check the progress periodically and most likely a check in the early fourth quarter reveals that they are far behind the goal. Then firms or research institutions may be required or encouraged (with financial support, for example) to file more patents to make up for the deficit.
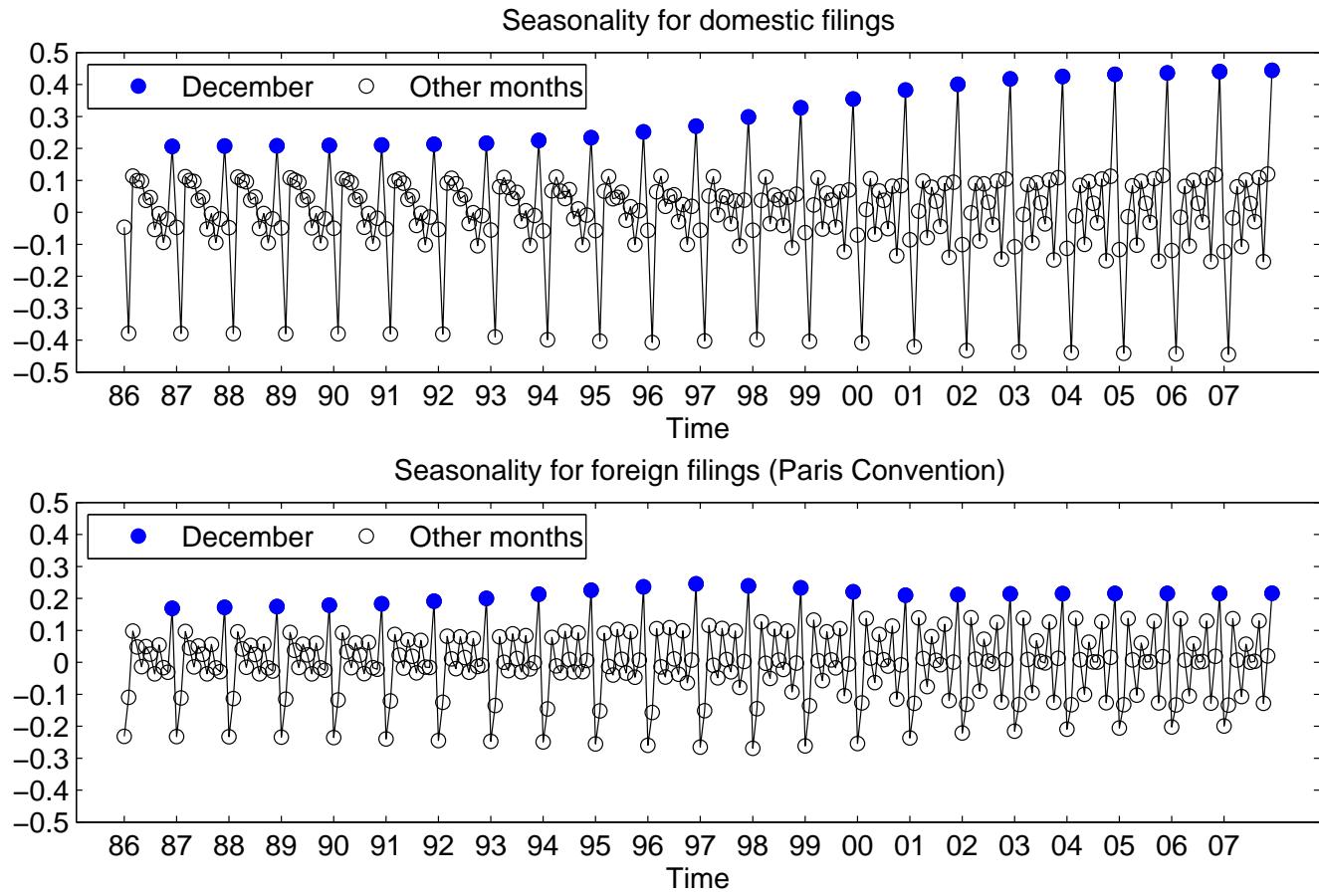
Seasonality for domestic filings

Seasonality for foreign filings (Paris Convention)

Figure 4. Comparison of seasonality between domestic and foreign patent filings

To investigate this explanation, we further separate domestic applications by two applicant categories: individuals and firms. The rational is that individuals should be less likely to respond to political/administrative pressure than firms; while they should both be responsive to financial incentives (for example, patent subsidies and rewards), which have been increasingly adopted by central and local governments. Shanghai implemented China's first patent subsidy policy in 1999. Almost all provinces have had some subsidy policies in place since around 2003, and in addition many cities have their own subsidies for patent applications. The majority of the subsidies compensate the applicants for the application fees; while others also have a prize awarded to the granted patents. We plot the seasonality component of applications filed by individuals and firms in Figure 5. The plots roughly agree with our explanation: before 2000, the December application peak was not very clear for individual applications; while it has been quite evident from the very early years for firm applicants. After around 2000, both types of applications show strong December peaks, which may partly be due to the increasing financial support for patenting in China since 1999. Considering the different seasonality characteristics of the two types of applications, in the following section we separate them and focus mainly on the firm applications (more accurately, non-individual applications). [3]

We also observe a clear pattern that the domestic application peak in December has grown more evident in recent years, while the seasonality of domestic applications in other months and the seasonality of foreign applications have remained relatively stable. This may be caused by the increasing importance of using patent applications as a criterion to assess local government's achievement in recent years in China. However, accompanying this trend is a decrease in filings in the first quarter, i.e., domestic filings in January, February and March seem to be falling in recent years (the trend is mainly for firm

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[3]Correspondingly, we also use only foreign firm applications for comparison. However this does not change the characteristics of foreign applications by much since only 4.78% of the foreign patent applications are filed by individuals; while for domestic applications, the proportion is 37.9%.

filings). A plausible explanation is that the surge of patenting in December slows down the patenting in the early months of the following year. If this is the case, the total quantity of patenting may not have increased because of the late year push.
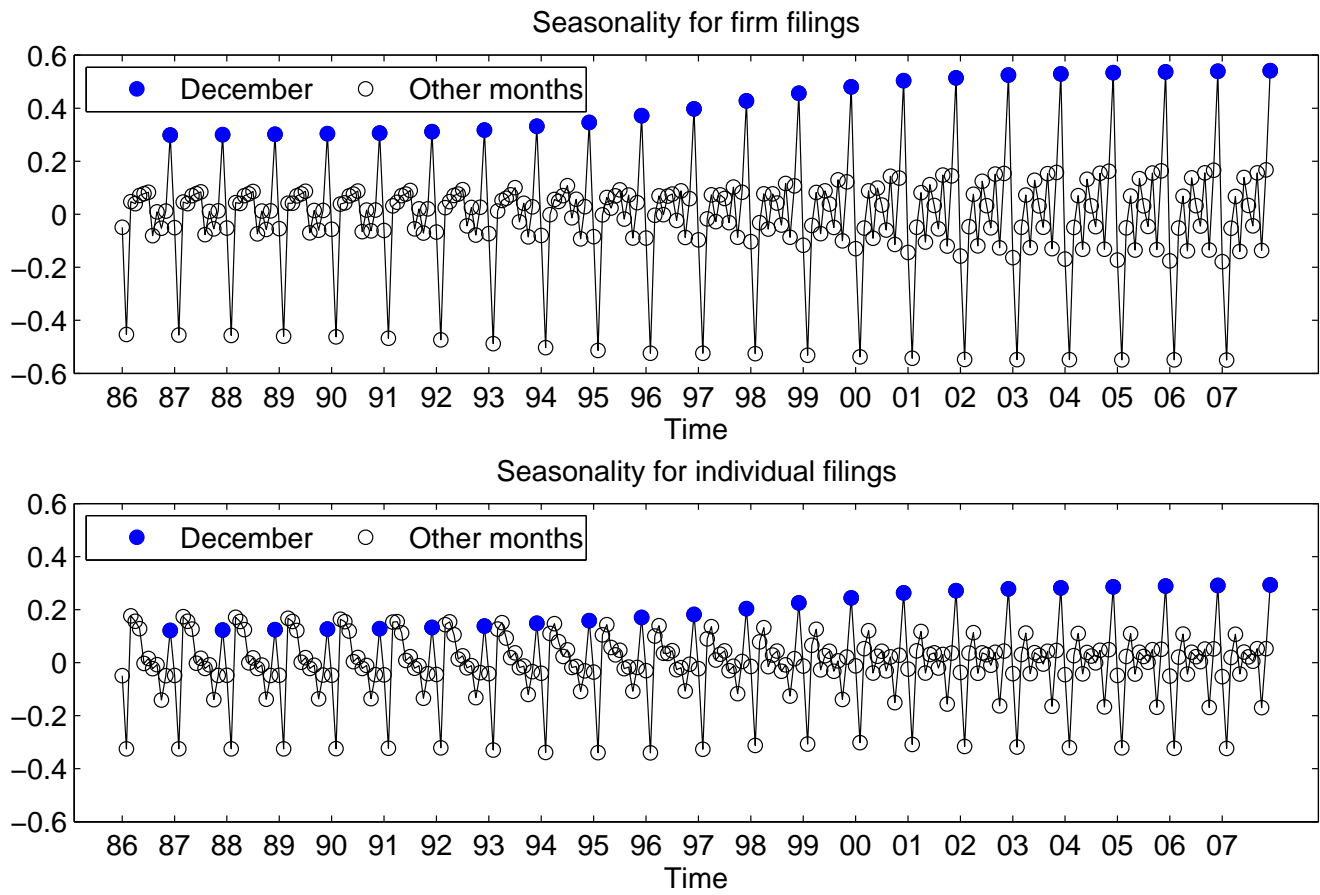
Seasonality for firm filings

Seasonality for individual filings

Figure 5. Comparison of seasonality between individual and firm patent filings

2.2   The trend component

The trend seems roughly linear (Figure 3). An analysis of the trend is useful because the slope of the trend can approximate the monthly growth rate of the patent applications. An OLS regression reveals that the average monthly growth rate is roughly 1.38% (for comparison, the average growth rate for the total foreign applications, including the PCT, is 1.49%). The growth rates after 2000 are higher, but this level of growth rate had been observed in the early 1990s too. Nonetheless, the average pre-2000 growth rate is only 0.91% while the average post-2000 (including the year 2000) growth rate is around 2.24% (the corresponding growth rates for total foreign applications are 1.51% and 1.28%, respectively). Therefore, if we assume an exponential growth model for patent applications (which seems reasonable), the growth rate of domestic patent applications in China has increased greatly in recent years despite a slowdown in foreign applications.

3. Econometric Analysis

Based on the visual analysis in Section 2, we conduct a more rigorous econometric study in this section to analyze the application patterns. We use IPC to classify the applications into 31 groups. Firstly we use a difference-in-differences model to investigate whether domestic applications in December are significantly higher than those in other months and than foreign December applications. The model to be estimated is:

$$\log y_{itd} = \alpha_0 \cdot d_{IPC} + \alpha_1 \cdot d_{domestic} + \alpha_2 \cdot d_t + \beta \cdot d_{domestic \times month} + \varepsilon_{itd} \tag{1}$$

where y_{itd} is the domestic $(d = 1)$/foreign $(d = 0)$ application for IPC number i at the t_{th} month $(t = 1, \ldots, 264)$. The observation is treated as missing if $y_{itd} = 0$. We control for IPC dummies for each of the 31 IPCs and month dummies for each of the 264 months.

From Figure 4, there are no abnormal seasonal patterns during the middle of the year for either domestic or foreign applications. Therefore we pool April-September as one dummy variable in the monthly dummies and use it as the "base month". The results are reported in "Model 1" column of Table 1. We get a within R^2 of 0.683, indicating a good fit of the model to the data. In order to control for possible correlations within IPC classes and within years, we use a multi-way clustering method proposed by Cameron et al. (2008) to calculate the standard errors.

The coefficients for the interaction terms indicate that compared to foreign applications and domestic applications in "base months", domestic applications in December are significantly higher; and domestic applications in February and March are significantly lower. While the pattern is expected for February when Spring festival usually falls in, the significantly lower applications in March is intriguing. It seems that foreign applications have recovered from the holiday breaks while domestic applications still have not. The slow down in applications in early year may be related to the surge if applications in the end of previous years. We will investigate this phenomenon further in the next model.

In the second model we study the trend of these monthly patterns. Based on the observations in Section 2 and Model 1, we want to know whether the surge in December for domestic applications has been growing larger, and whether this trend is accompanied by a decreasing trend of applications in the early months of the following year. To this end, we use the following model:

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\begin{aligned}
\log y_{itd} =& \alpha_0 \cdot d_{IPC} + \alpha_1 \cdot d_{domestic} + \alpha_2 \cdot d_t + \beta_1 \cdot d_{domestic \times month} + \\
& \beta_2 \cdot d_{domestic} \times t + \beta_3 \cdot d_{month} \times t + \gamma \cdot d_{domestic \times month} \times t + \varepsilon_{itd}
\end{aligned}
\tag{2}
$$

where the monthly dummies are defined in the same way as in model 1. We still control the IPC group fixed effect. The results are shown in "Model 2" column of Table 1.

Table 1. Estimates of monthly applications

	Model 1		Model 2	
domestic	-0.470**	(0.227)	-1.205***	(0.244)
dom×Jan	0.0568	(0.0577)	0.286***	(0.0868)
dom×Feb	-0.384***	(0.0631)	-0.159	(0.107)
dom×Mar	-0.227***	(0.0500)	-0.0125	(0.0950)
dom×Oct	-0.0289	(0.0463)	-0.127	(0.103)
dom×Nov	0.0998*	(0.0510)	-0.0654	(0.101)
dom×Dec	0.234***	(0.0613)	-0.0309	(0.125)
dom×t			0.00548***	(0.00171)
dom×Jan×t			-0.00155***	(0.000567)
dom×Feb×t			-0.00160***	(0.000588)
dom×Mar×t			-0.00149***	(0.000547)
dom×Oct×t			0.000557	(0.000562)
dom×Nov×t			0.000989*	(0.000559)
dom×Dec×t			0.00170***	(0.000639)
R^2	0.683		0.704	
N	15400		15400	

Standard errors in parentheses (adjusted for clustering by IPC and year)

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Compared to foreign applications, domestic applications have significantly increasing trends in December, followed by, unfortunately, significantly decreasing trends in the first quarter (coefficients dom×month×t). The results confirm our hypothesis. The late year surge has been growing because of the increasing importance of using patent applications as assessment for local government performance. However, this does not occur without consequences. The monthly applications in the first quarter of the year tend to be lower and this lower trend has been growing more significantly during the study period. We can more convincingly rule out the first hypothesis in Section 5 that firms patent more from their existing innovation stock, which they would choose not to if there is no political pressure. Under this hypothesis, we should not see the "starving effect" in the first quarter of the following year. The finding also indicates that the surge in applications in December due to political pressure or policy incentives may not be sustainable as it slows down the

patenting in the following months.[4]

4. Some Anecdotal Evidence

Though there is no national level policy that sets yearly quota for patent applications or requires local government to do so, some search in online news can still find many new outlets that mention about the yearly quota. They are usually set by province or city level government to lower level governments or enterprises, or sometimes set by state-owned enterprises to their subsidiary firms. Some of the requirements are in terms of growth rate, instead of quantity, but they should have a similar effect.

For example, in September 2009, Dali city of Yunnan province reported that it had accomplished the 2010 quota for patent applications during the first half of the year, ahead of time. The quota were set by the province government and consisted of total patent application and invention patent application. In another announcement dated on November 25th 2011, Guangxi Province issued its "Assessment scheme of patent application growth 2011" to all cities in the province. It says an assessment will be conducted in Jan 2012 to evaluate the patent application performance of all cities during 2011. Even though the evaluation should be expected, this announcement would give impetus to cities in Guangxi to come up with more applications before the year ended. A basic requirement of this evaluation is a 25% increase in patent applications from the previous year. Other examples include: Anhui province's patent application requirement for its cities in 2012 asked for an yearly increase between 20% and 40% for different cities; Shanxi province issued its "Assessment of patent applications 2011" to the local city governments in April 2011; *Shanxi Taiyuan Electronic Power Company* reported on June 28th that they have achieved the 2012 patent application quota set by the *State Grid–Shanxi Company*. Some earlier

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[4]A very rough comparison (not shown here) pooling October–March together indicates the overall quantity of domestic applications in this half year is even lower compared to foreign applications.

examples include: Liaoning province included "meeting the patent application quota" as one of the criteria in its yearly "Assessment rules for city governments" since at least 2002; Beijing included "the number of patent applications" as an assessment criterion for leaders of enterprises since at least 2003, and so on and so forth.

Because most of these policies are reported as news and government online news archive was not very well maintained in China, it is difficult to search for old information corresponding to the period of our study. Nonetheless, it seems using patent applications as a assessment criterion was wide spread and had been in place explicitly or implicitly for some time. Although most of the news reports are "good news", i.e., the quota have been met ahead of time, it's very likely that these are selected reports and those late birds do not get themselves on news. Therefore, we treat these news reports as anecdotal evidence for our hypothesis in previous sections.

5. Is There a Monthly Pattern in Patent Quality?

A following question we want to ask is whether the domestic patents filed in December are of lower quality, since they are more likely to be filed to meet political pressure. We look at two quality characteristics of patent applications in different months: the grant rate (Figure 6), and average number of co-inventors per patent application (Figure 7). The general consensus is that granted applications have higher quality than not granted ones; and applications that have more co-inventors have higher quality than those that have less co-inventors. Since there are no significant trends in these two measures, we do not need to decompose the data to look for the monthly pattern. We plot the monthly measures of the three characteristics against year and check whether December data stands out from other months. To make the comparison clear, we also plot the one-standard-error bars for the measures of December.
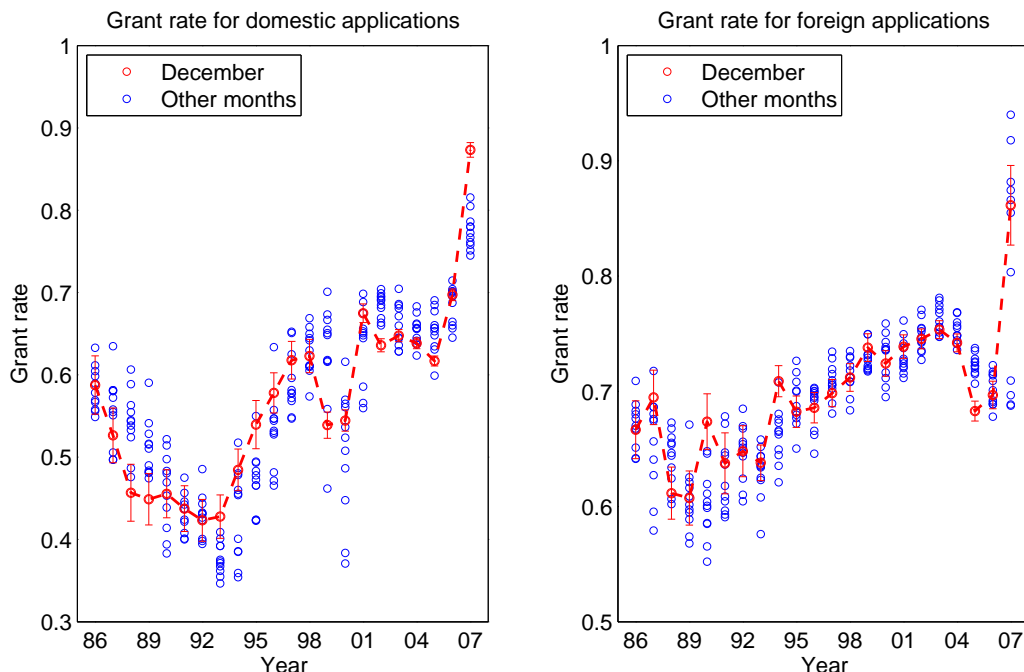
Figure 6. Comparison of monthly grant rates

The grant rate for each month is calculated as the ratio of the granted patent applications over total applications that have final decisions (granted, rejected, withdrawal, etc). We leave out the applications that have not been decided.[5] Figure 6 plots the average grant rate for each month for the two types of applications.Though the overall grant rates for domestic applications are lower than their foreign counterparts, the quality of applications in December are not shown to be lower for either the domestic or foreign applications.[6] From this comparison, we can reject the first hypothesis that firms make some dubious applications in a short period of time.

Figure 7 plots the average number of co-inventors for each month for the two types of applications. The average number of co-inventors per patent application in December

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[5]The comparison result is qualitatively similar if we use total application as the denominator in the calculation of grant rates, though the data truncation works in the other direction since many applications after 2000 do not have final decisions.

[6]Note the very high grant rate in the last year may be due to data truncation, since granted patent applications usually take less time to be examined than the rejected applications.
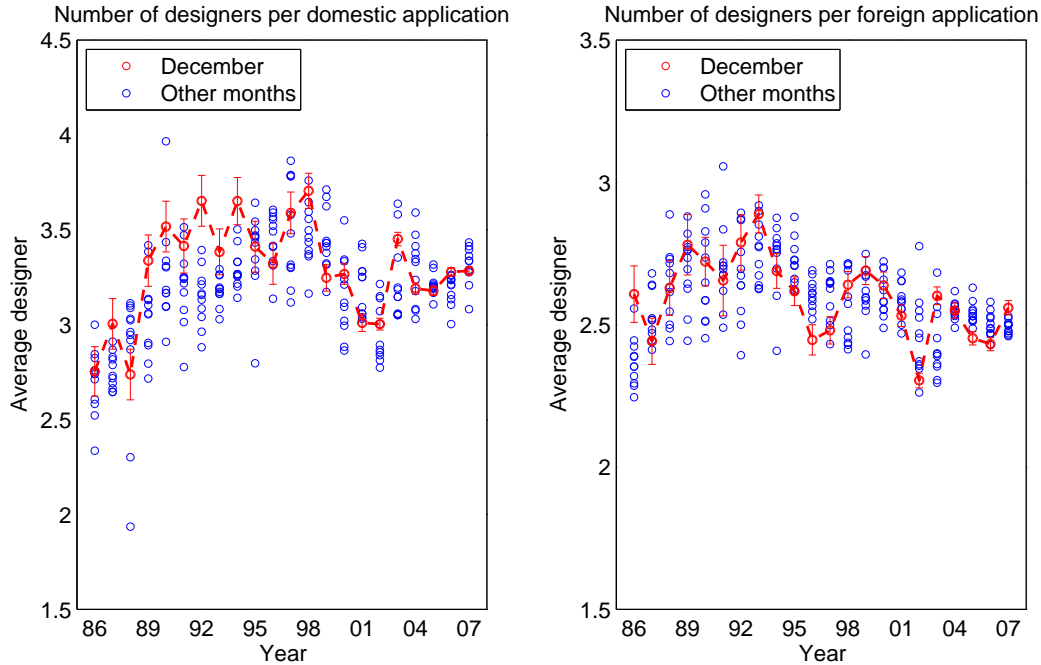
Figure 7. Comparison of monthly average number of co-inventors per patent application

for domestic applications is not lower compared to other months. For a few years (1987, 1992-1994), it is actually the largest. Therefore, based on the two criteria, the quality of domestic applications in December does not seem to be low.

6. Where Do the Extra Applications Come From?

Since the quality of the domestic applications in December based on grant rate and the number of co-inventors is not lower, a natural following question would be: where do those "extra" applications come from? The possibility that firms come up with some dubious applications under administrative pressure is certainly rejected by the quality analysis in Section 5. Because in this case we expect the quality of patent applications in December to be lower. Also it does not seem to be plausible that firms can produce a significantly larger amount of innovation output in a short period of time.

One possibility is that firms file more "small" patents in December under the political

or administrative pressure. By "small" I mean firms file patents that cover narrower scope or less claims. Unfortunately, we do not have the number of claims for each application in our dataset. We need to look for an approximate for patent scope. Given the quantity of innovation output, the only way to file more applications is to come up with more applications per unit of output. In other words, firms can "split" each innovation product (normally one patent application, for example) into two or more applications to increase the total filings. In this way, the quality of the application (in terms of grant rate and number of co-inventors) may not drop, but the quantity increases. This way of filing patents does not make sense under normal condition since it leads to higher application cost and longer examination time for the firms. However, under political or administrative pressure, coupled with financial incentives, splitting innovation output to come up with more applications may become the preferred way.

How to detect this, if it is true? Assume that a group of R&D personals have worked on this project before they decide to file, then naturally, these employees, or at least some of these employees, will become the co-inventors for the filed applications. Therefore these two (or more) applications will share some or all of their co-inventors. Since we have the names of the co-inventors for each application, we can use the number of shared co-inventors as an approximate of the patent scope. We define a co-inventor to be "shared" if he/she is also a co-inventor for another patent application filed in the same month within the same firm.[7] We run a regression model using the number of shared co-inventors (s_i) for each patent application as the dependant variable, and test whether domestic applications filed in December have more shared co-inventors compared to other months and foreign applications.

For a given firm, the more R&D personals it has, the more likely its patent applications have shared co-inventors. Since firms have very different number of R&D personals, while

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[7]The situation that one inventor works for multiple firms during one month is rather rare.

this number is relatively stable for a give firm, we need to consider firm heterogeneity in the analysis. Table 2 provides some summary statistics for the inventors of domestic and foreign firms. The number of inventors for each firm is constructed as the total number of unique co-inventors from all of the firm's patent applications. The heterogeneity of firms can be attested from the large standard deviation. On average, foreign firms have more inventors, but this is mainly due to large firms. The two types of firms have similar distribution in the number of inventors based on the percentile comparison and the majority of the firms have less than 10 inventors.

Table 2. Summary statistics for inventors of firms

	mean	standard deviation	p-10	p-25	median	p-75	p-90	firm number
domestic	9.5	84.6	1	1	3	6	11	55521
foreign	14.1	160.8	1	1	2	5	14	35955

p-10 means the 10 percentile, and so forth.

We control for firm heterogeneity by firm fixed effects. Moreover, since a patent application that has more co-inventors is more likely to have more shared co-inventors as well, we also control for the total number of co-inventors (n_i) for each application.[8] Therefore, we use the following model:

$$s_i = \alpha_0 \cdot d_{firm} + \alpha_1 \cdot t + \alpha_2 \cdot d_{domestic} + \alpha_3 \cdot d_{month} + \alpha_4 \cdot n_i + \beta \cdot d_{domestic \times Dec} + \varepsilon_i \quad (3)$$

where $d_{domestic}$, d_{month}, and t are the domestic dummy, 12 month dummies and t^{th} month. The coefficient of interest is the coefficient of the interaction term β.

We remove from the dataset those firms that only had applications in one month. These observations do not affect the estimation of β. In order to be sure that the observed

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[8]We also control the total number of applications in the month (not reported here). The more applications a firm has in a month, the more likely the applications share co-inventors. The results are similar.

effect for December is not due to other factors (for example, some systematic difference in domestic and foreign applications), we run placebo tests for other months as well. The results are reported in the "model 1" row of Table 3. In the "model 2" row of Table 3, we report the results using monthly dummies (a dummy for each of the 264 months) instead of the 12 month dummies and a linear time trend. This specification can provide stronger control over time trends.

Table 3. Regression estimates for β

	Jan	Feb	Mar	Apr	May	Jun
model 1	-0.023	-0.072**	-0.036	-0.049*	-0.036	-0.033
	(0.324)	(0.049)	(0.119)	(0.052)	(0.128)	(0.163)
model 2	-0.029	-0.055	-0.035	-0.044*	-0.028	-0.027
	(0.209)	(0.131)	(0.111)	(0.070)	(0.209)	(0.257)
	Jul	Aug	Sep	Oct	Nov	Dec
model 1	-0.019	-0.027	0.019	0.033	0.027	**0.117*****
	(0.426)	(0.241)	(0.379)	(0.158)	(0.205)	(0.000)
model 2	-0.013	-0.024	0.014	0.043*	0.023	**0.098*****
	(0.556)	(0.268)	(0.521)	(0.063)	(0.288)	(0.000)

Model 1 controls for 12 month dummies and a linear time trend; model 2 controls for monthly dummies for each of the 264 months. P-values are reported in parenthesis, adjusted for clustering at the firm level. $R^2 = 0.189$ for regressions in model 1; $R^2 = 0.191$ for regressions in model 2. The total number of observations is 675094 (320879 for domestic and 354215 for foreign) and the total number of firms is 33971 (20481 domestic firms and 13490 foreign firms). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The number of shared co-inventors for domestic applications in December is significantly larger compared to applications in other months, using foreign applications as controls. From the comparison with the placebo tests, we believe the observed effect in December cannot be due to coincidence: the estimates of December are much larger than those of other months and are also much more significant. Model 2 produces slightly smaller estimates and significance compared to model 1, but the two models generally agree with each other. This gives us more confidence in interpreting the results.

In Appendix B we run the same model using the total number of co-inventors for

each application as the dependant variable. We confirm that domestic applications in December do not have significantly more co-inventors compared to other months, using foreign applications as controls. Therefore, domestic applications filed in December have more shared co-inventors, but not more total co-inventors, which may imply that firms indeed "split" more of their applications in December to meet the quota set by different levels of governments.[9]

The finding has important implications to the current patent policies in China. Due to political pressure and financial subsidy, firms choose to file patents in an economically inefficient way, which leads to a waste of administrative resource for both the patentees and the SIPO. If firms indeed response to the policy by splitting more of their existing applications, the patent subsidies will become merely a lump sum transfer without becoming a true incentive for firms to innovate. Therefore the finding has interesting mechanism design implications for the R&D subsidy programs in China and other countries. What should the subsidy contract on (patent applications/grants, other output, or R&D input?) and the levels of the subsidy can be important in achieving the desired goal. From the analysis of this paper, it seems contracting on patent applications or even patent grants may not be very effective. More research in this direction is needed.

There is another explanation for the surge in patenting: firms patent more of their existing innovation stock, which they had no plan to patent otherwise. This is in general not likely since if firms plan to protect these innovation output in some other way (commercial secret, for example), political pressure is not likely to induce firms to patent them. Moreover, if this is the case, these applications should have some fundamental difference from the other applications, in terms of, for example, grant rate and total number of co-inventors. However, we do not observe any significant difference in these quality criteria

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[9]Using the share of co-inventors (a proportion) as the dependent variable gives similar results, except that the placebo tests for February and March turn out to be significantly negative. I am not sure how to reconcile the two types of regressions.

for domestic applications in December.

7. Summary

By looking at the seasonality characteristics of domestic invention patent applications and comparing them with foreign applications, we find an intriguing surge in patenting behavior in Decembers for domestic application. One plausible explanation of this phenomenon is that these applications are made under administrative pressure to meet yearly quotas set by the local governments. These quotas are important assessment criteria for the performance of some officials. We then compare the grant rate of patent applications by month but do not find the grant rate for domestic applications in December to be low. Therefore, applications made in December to fulfill the yearly goals do not seem to be of lower patentability. A further look at the shared co-inventors for each application reveals that domestic applications in December have significantly more shared co-inventors compared to other months, using foreign applications as controls. This suggests that firms under political pressure may split their innovation output to come up with more applications, such that these applications share a higher number of co-inventors compared to the normal filings. If this is the case, it put doubt to the effectiveness of China's political promotion of innovation and the innovation subsidy policies in general. More research is needed for better designed innovation policies.

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A. Foreign applications in China through Paris Convention vs PCT

Since 1994, the year China joined the PCT, a growing number of foreign applications enter China through PCT. From 1986 to 2007, there are roughly equal number of PCT applications and the traditional Paris Convention applications (400 thousand Paris Convention applications compared to 380 thousand PCT applications). However, since PCT only started from 1994, its growth has been phenomenal and has surpassed Paris Convention applications in recent years. Figure 8 plots the yearly quantity of the two types of foreign applications.
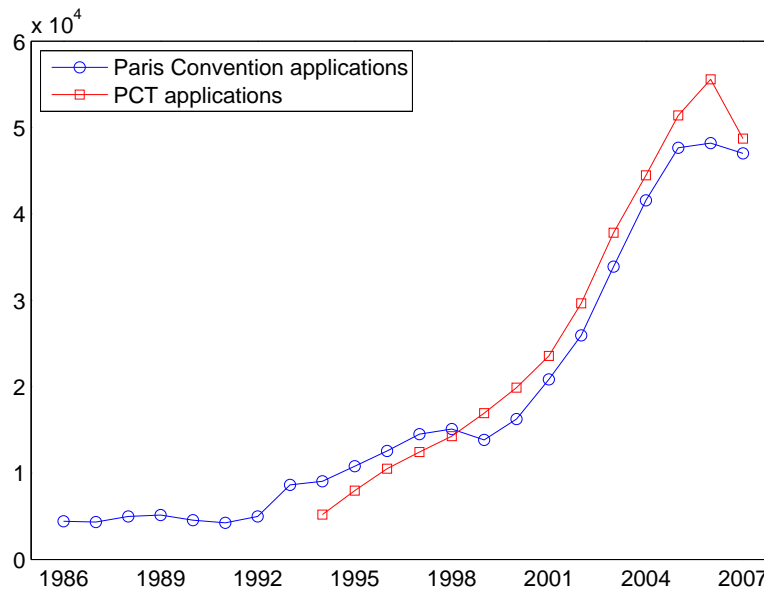

Figure 8. Comparison of foreign applications through Paris Convention vs PCT

We conduct a similar decomposition as in Section 2 for the two types of applications and look at their seasonal components (Figure 9). There are a number of interesting observations. Firstly, December no longer stands out as the month with the highest

number of applications for PCT filings. This is because in many countries where the Receiving Offices for the PCT filings locate, Christmas holidays are important and the working intensity drops at the second half of December. Moreover, February also ceases to be the second lowest month in terms of applications for similar reasons (most foreign countries do not observe the Spring Festival holidays). The differences suggest that filings through Paris Convention indeed follow the calendar in China and are therefore good comparison group for domestic filings.
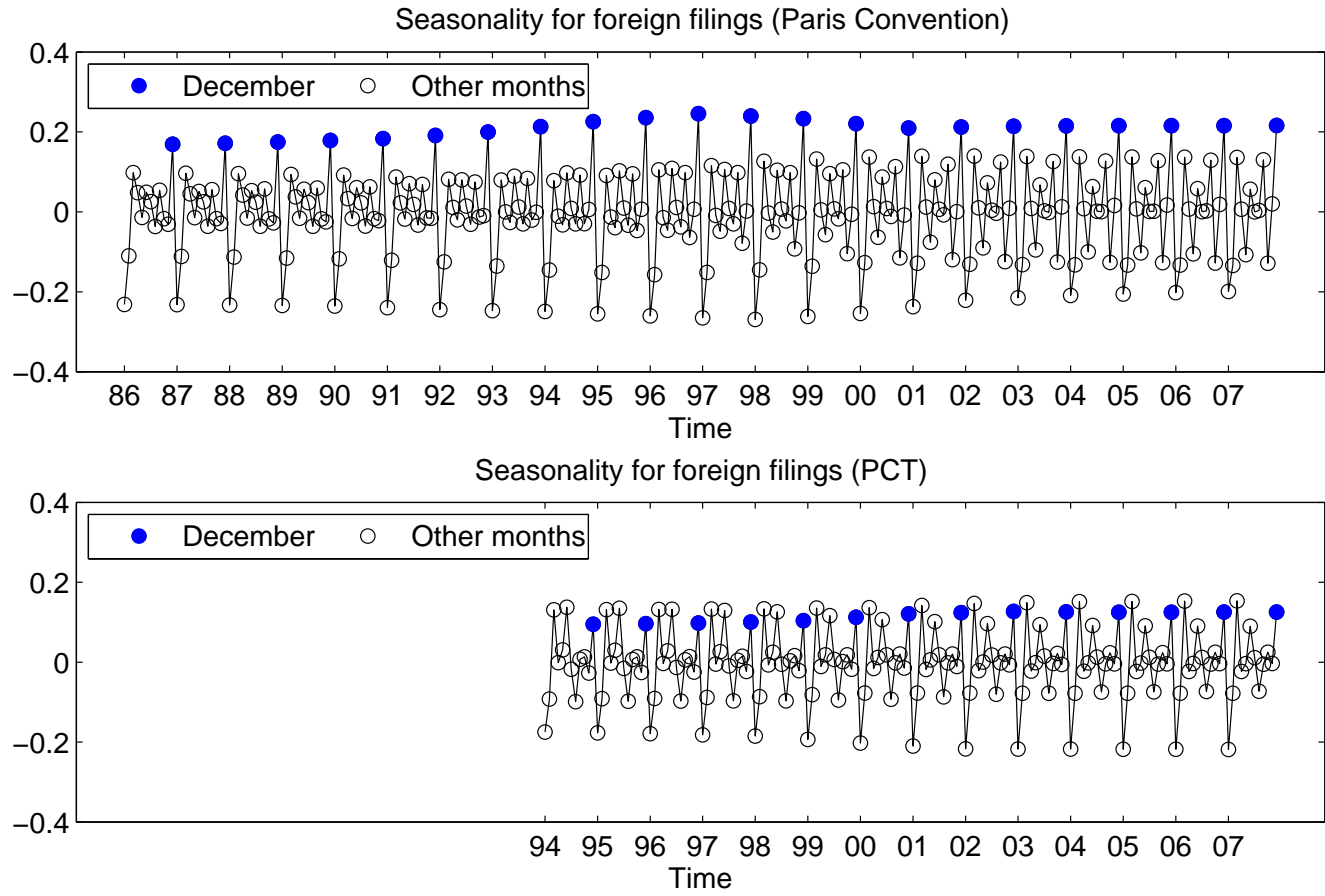
Figure 9. Comparison of seasonality between PCT and Paris Convention patent filings

B. Estimates for total number of co-inventors

Similarly we control for firm heterogeneity by firm fixed effects. We run two models. Model 1 uses the following specifications:

$$n_i = \alpha_0 \cdot d_{firm} + \alpha_1 \cdot t + \alpha_2 \cdot d_{domestic} + \alpha_3 \cdot d_{month} + \beta \cdot d_{domestic \times Dec} + \varepsilon_i \qquad (4)$$

where $d_{domestic}$, d_{month}, and t are the domestic dummy, 12 month dummies and t^{th} month. The coefficient of interest is the coefficient of the interaction term β. Model 2 replaces the 12 month dummies and linear time trend with 264 month dummies, a dummy for each month in the dataset.

The results, together with the estimates from the placebo tests, are reported in Table 4. The results confirm that domestic applications in December do not have a significantly larger number of co-inventors compared to other months, using foreign applications as controls.

Table 4. Regression estimates for β

	Jan	Feb	Mar	Apr	May	Jun
model 1	0.006	0.061	-0.014	-0.016	-0.029	-0.052**
	(0.807)	(0.102)	(0.555)	(0.509)	(0.177)	(0.034)
model 2	-0.003	0.057	-0.009	-0.013	-0.020	-0.049*
	(0.899)	(0.145)	(0.726)	(0.569)	(0.372)	(0.051)
	Jul	Aug	Sep	Oct	Nov	Dec
model 1	-0.005	-0.031	0.020	0.037	-0.008	**0.036**
	(0.824)	(0.203)	(0.367)	(0.198)	(0.734)	(0.139)
model 2	-0.003	-0.030	0.020	0.032	-0.002	**0.027**
	(0.874)	(0.206)	(0.388)	(0.278)	(0.916)	(0.311)

Model 1 controls for 12 month dummies and a linear time trend; model 2 controls for monthly dummies for each of the 264 months. P-values are reported in parenthesis, adjusted for clustering at the firm level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.