Do fiscal incentives affect innovation? The effects of the Alberta Investor Tax Credit on patents

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The common knowledge that the positive spillover from research efforts disincentivizes private investment in research & development (R&D) by private agents has led to a widespread support for fiscal incentives for R&D expenditure. The literature has mostly found positive effects of these policies on innovation, but it is unclear whether fiscal incentives truly impact innovation outcomes. In this paper, I examine the impact of the Alberta Investor Tax Credit (AITC) on patent application counts, exploiting variation from a novel administrative dataset of intellectual property products in Canada, where the tax treatment on R&D has been recognized as one of the most generous in the world. Using two-way fixed effects difference-in-differences and event study regressions, I find that the AITC had an overall null effect on total patent application counts, but a positive effect on human necessity and textile patents, and a negative effect on fixed construction patents, hence creating an offsetting effect on total patent applications.

1 Introduction

2 Institutional context

In this section, I review the three main institutional factors of my empirical setting. These are the fiscal incentives for research and development (R&D) expenditures of Canadian federal and provincial governments, the intellectual property environment and the details of the Alberta Investor Tax Credit (AITC) program.

2.1 The Scientific Research and Experimental Development Credits

Canada has been characterized as one of the most generous jurisdictions for R&D credits (McKenzie, 2008) as well as a pioneer in their design (Mansfield & Switzer, 1985b). According to the Canada Revenue Agency (2023), Canadian firms could deduct 100% of current research expenditures as early as 1941[1]. In 1962, an experimental tax incentive was created after a change to the *Income Tax Act*. This program would undergo various changes over the years, taking the form of a full expenditure deduction plus a tax credit by 1984. The current program's name - the *Scientific Research and Experimental Development Credit* was given in 1986 after an amendment to the *Income Tax Act*. The tax credit has been place since then, with complex rules and regulations that have been updated over the years (Canada Revenue Agency, 2015).

Canada is unique in that most provinces offer additional incentives. The Provincial SR&ED tax credits are similar to the federal SR&ED tax credit, but they are administered by the provinces as a top-up (Warda, 2000). The provincial programs started being implemented in the 1980s, and by the early 2000s, most province's had adopted them (McKenzie, 2005; Warda, 1998). Alberta implemented the program in 2009 (Brouillete, 2013).

Given the well documented effects of these policies on R&D expenditures (Agrawal et al., 2020; Becker, 2015; Mansfield & Switzer, 1985a), it is sensible to believe that policy efforts like these have an ongoing impact on innovation. It is crucial to consider time trends to control for

[1]Mansfield and Switzer (1985b) contradicts the Canada Revenue Agency's official account, stating that it was only since 1961 that the federal government effectively allowed companies to fully deduct capital and current research expenditure from federal taxable income.

federal policy changes in any type of policy evaluation of other fiscal incentives like the AITC. Further, since the provincial programs are frequently reformed (McKenzie, 2005), provincial SR&ED tax credits pose threats to the identification of any other policy effects which targets innovation. The fact that Alberta imposed its own SR&ED tax credit in 2009 could pose a threat to the identification of the AITC's effect on innovation in a quasi-experimental setting, which makes the use of event study regressions critical to validate results from a difference-in-differences approach.

2.2 Intellectual property in Canada

The Canadian intellectual property environment, as other countries, allows firms to hold innovation assets, and thus is mostly determined by laws and regulations by government agencies. The Canadian Intellectual Property Office (CIPO) is the federal agency responsible for the administration of intellectual property rights in Canada. CIPO is responsible for the registration of patents, trademarks, copyrights, industrial designs and integrated circuit topographies. Specifically, patents protect new inventions or processes. The process of applying for a patent in Canada is similar to that of other countries. If granted, a patent will be valid within Canada for 20 years (Abbes et al., 2022), but can be owned by foreign parties. In fact, Beaudry and Schiffauerova (2011) determine that in the nanotechnology industry in Canada, 50% of patents are owned by foreign assignees.

The Canadian legal framework has recently transitioned from a system derived from British law to a system more aligned with the United States, partly in response to the North American Free Trade Agreement (NAFTA) and the United States-Mexico-Canada Agreement (USMCA), which required member countries to adopt harmonized intellectual property systems (Putnam, 2006). Apart from these, Canada, as other countries, must adhere to a number of international treaties and agreements which govern the level of intellectual property protection in the country. Notably, a key difference between the Canadian and the American framework is that the former is much less focused on patent and copyright quality, which means that an agent is much more likely to infringe on intellectual property rights in Canada, and that patent applications in Canada are more likely to be granted than in the United States

(Vaver, 2006).

Intellectual property plays an important role in the interaction of competing industries in global markets, with recent research showing Canadian firms underperform vs. American counterparts due to worse intellectual property frameworks (Carew et al., 2006), as well as in international trade, with firms preferring to trade with countries with stronger intellectual property rights (Rafiquzzaman, 2002). An accurate impact evaluation must consider the effects that foreign influences may have on the local intellectual property environment.

3 Empirical Strategy

3.1 Data

I employ a novel administrative dataset from the Canadian Intellectual Property Office, the IP Horizons Patent Researcher Datasets. The dataset identifies patents in Canada from 1860 to 2023, with information on when the application for the patent was filed, granted, the parties involved in the application and other information. Parties can be identified to provinces based on their location, which can be in Canada or other countries.

With these data, I compute quarterly patent application counts at the province level from January 2001 to June 2021, based on the application filing date. This period corresponds to the modern Canadian intellectual property institutional context, as reviewed on Section 2. I assign patents to provinces based on where the majority of parties involved in a patent application report their location[2]. I only include the first two quarters of 2021 the last two quarters present an unusual downward trend for all provinces in late 2021, suggesting patent applications are yet to be updated. Further, I drop Newfoundland and Labrador, Prince Edward Island, Yukon and Nunavut due to missing observations on most explanatory variables.

The explained variable of interest is the count of patent applications. Further, to allow for heterogeneity in treatment, I separate patents by their International Patent Classification (IPC) section, which defines a broad classification of the technology being patented. The IPC sections are divided into eight categories: A (Human Necessities), B (Performing Operations;

[2]Patent applications without information of party provinces or with an equal number of interested parties from two provinces are dropped from the sample.

Transporting), C (Chemistry; Metallurgy), D (Textiles; Paper), E (Fixed Constructions), F (Mechanical Engineering; Lighting; Heating; Weapons; Blasting), G (Physics) and H (Electricity), as defined by the Canadian Intellectual Property Office (2023). I then consider the count of patent applications for each IPC section as separate explained variables for some models.

For my explanatory variables, I extract province-level data at the monthly frequency from Statistics Canada and later aggregate quarterly. These include data from the Labour Force Survey (LFS), such as labour force characteristics, employment wages, among others. Further, I also consider the consumer price index, international merchandise exports and imports, retail, wholesale and manufacturing trade sales, food services receipts, the new housing price index and electric power generation. I also include the number of business insolvencies as reported by Innovation, Science and Economic Development Canada (2024) (2024) and the number of foreign parties involved in patent applications, which I obtain from the IP Horizons data. I aggregate data at the quarterly level by summing all variables except the consumer and new housing indices, for which I take arithmetic averages. Table 1 presents descriptive statistics for patents and all explanatory variables.

3.2 Empirical Strategy

I implement a two-way fixed effects (TWFE) difference-in-differences (DD) design, where I define treatment and control groups based on the first period of eligible expenditures for the AITC intervention, which was April 2016 (Alberta Economic Development and Trade, 2017). The treatment group is Alberta, and the treatment period is composed of all periods after April 2016. The control group is all remaining Canadian provinces considered in my data. Thus, treated observations are those from Alberta after April 2016, where I believe the AITC affected Albertan patent applications. The DD design is implemented in a regression framework, according to the general specification below.

$$\ln(P_{it} + 1) = \theta_i + \theta_t + \beta\, T_{it} + \mathbf{x}_{it}^{'}\gamma + u_{it} \tag{1}$$

where P_{it} is the explained variable; in most specifications, P_{it} is the number of patents filed in a province i and period t. θ_i and τ_t are sets of province and period fixed effects. I use a natural

Table 1: Descriptive statistics for the province-quarter sample

	Mean	SD	Min	Median	Max
Ln +1 Patent applications	4.261	1.405	1.099	4.107	6.691
Ln Full-time employment	8.026	1.034	6.726	7.831	9.814
Ln Median wage	2.949	0.192	2.523	2.956	3.395
CPI	119.145	12.668	95.400	119.400	148.900
Ln +1 Business insolvencies	4.403	1.396	0.693	4.197	6.957
Ln Intl. exports	15.810	1.139	13.694	15.848	17.804
Ln Intl. imports	15.646	1.198	13.715	15.369	18.372
Ln Retail sales	15.963	1.028	14.424	15.774	17.913
Ln Wholesale sales	15.910	1.292	13.907	15.892	18.490
Ln Manufacturing sales	16.027	1.179	14.398	15.729	18.213
Ln International travellers	12.470	1.779	4.344	12.387	15.929
Ln Arriving vehicles	11.944	3.562	0.000	12.516	15.801
Ln Electric power generation	16.213	0.997	14.344	16.219	17.990
Ln Average actual hours	3.545	0.050	3.311	3.550	3.676
New housing price index	88.064	16.987	42.900	94.250	129.500
Ln Food services receipts	13.737	1.108	12.255	13.575	15.857
Ln Average job tenure	4.636	0.088	4.399	4.653	4.830
Ln +1 Foreign patent parties	3.609	1.918	0.000	3.842	6.671

Notes: All statistics based on a balanced panel of $N = 656$ province-quarter observations from 2001Q1 to 2021Q2. The sample includes all Canadian provinces except Newfoundland and Labrador, Prince Edward Island, Yukon and Nunavut.

logarithm transformation along with the addition of one to correct for provinces with small amounts of patent applications on some periods. T_{it} is a binary variable equal to unity for observations for treated observations and zero otherwise. Hence, the estimated parameter $\hat{\beta}$ is the coefficient of interest, which is my estimate for the average treatment effect of the AITC on the explained variable. $\mathbf{x}_{it}$ is a vector of time and province-varying controls, as described in the previous subsection, and γ is the associated vector of parameters. u_{it} is a stochastic error term which varies between provinces and periods. For my results, I cluster standard errors at the province and period level.

Tables 2 presents the difference in means between treated and control provinces for the province-quarter panel for all considered explained variables. This presents the simplest version of the DD model, where I compare the average number of patent applications between Alberta and the control provinces before and after the AITC intervention. This simple comparison suggests a small or null effect; the regression analysis described above will provide a

Table 2: Differences in means between treated and control provinces in province-quarter panel

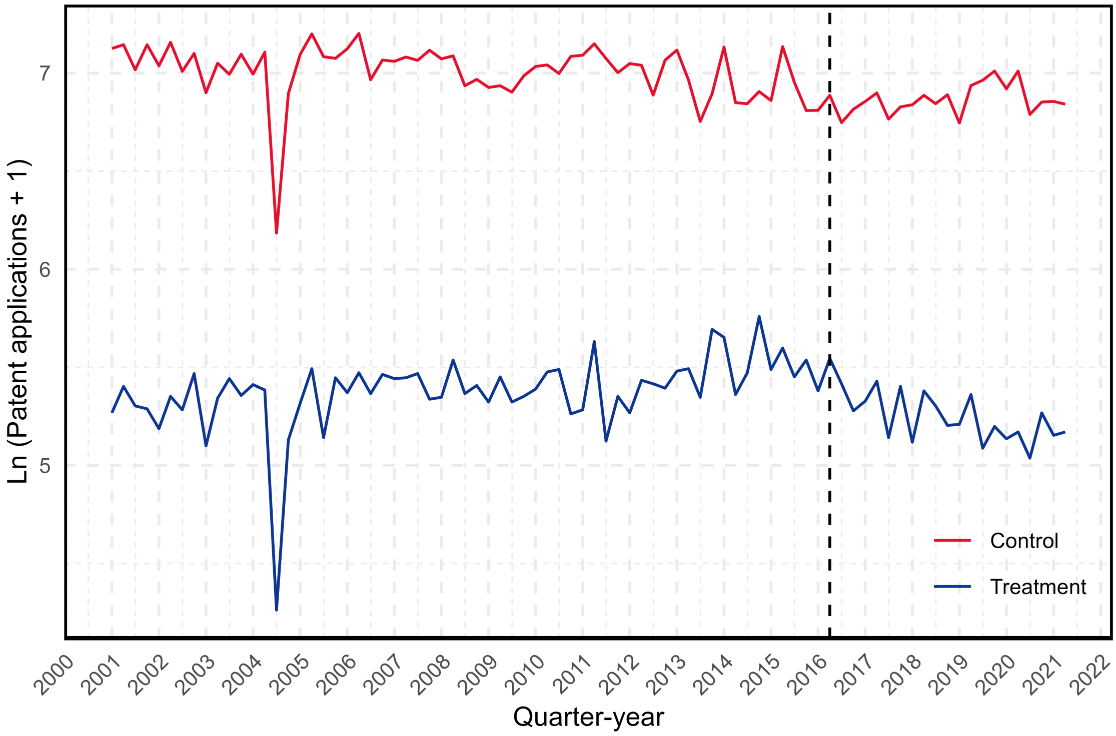
Treatment		Pre	Post
Control	Ln +1 Patent applications	4.122	4.059
	Ln +1 Interested parties	5.683	5.464
	Ln +1 Inventors	301.511	292.143
	Ln +1 Applicants	158.663	139.122
	Ln +1 Owners	330.344	150.204
	Ln +1 Total population	8.632	8.731
	Ln +1 Section A applications	2.550	2.596
	Ln +1 Section B applications	2.238	2.037
	Ln +1 Section C applications	1.464	1.306
	Ln +1 Section D applications	0.349	0.185
	Ln +1 Section E applications	1.496	1.512
	Ln +1 Section F applications	1.618	1.417
	Ln +1 Section G applications	1.840	1.993
	Ln +1 Section H applications	1.620	1.380
	Ln +1 Multiple section applications	2.879	2.972
Treatment	Ln +1 Patent applications	5.379	5.254
	Ln +1 Interested parties	6.800	6.665
	Ln +1 Inventors	314.787	383.571
	Ln +1 Applicants	219.607	194.810
	Ln +1 Owners	378.721	211.762
	Ln +1 Total population	9.043	9.236
	Ln +1 Section A applications	2.704	2.896
	Ln +1 Section B applications	2.927	3.020
	Ln +1 Section C applications	2.632	2.633
	Ln +1 Section D applications	0.190	0.258
	Ln +1 Section E applications	4.073	3.761
	Ln +1 Section F applications	2.510	2.406
	Ln +1 Section G applications	3.075	2.853
	Ln +1 Section H applications	1.950	1.789
	Ln +1 Multiple section applications	4.100	4.111

Notes: Calculations based on a balanced panel of N = 656 province-monthly observations from 2001Q1 to 2021Q2. The sample includes all Canadian provinces except Newfoundland and Labrador, Prince Edward Island, Yukon and Nunavut. The treatment group is Alberta, and the control group is made from all remaining provinces. Post-intervention periods are those after April 2016 (2016Q2).

more robust DD estimate.

The key identifying assumption of the DD design is that, absent the AITC intervention, the trend of patents in Alberta would follow a similar pattern to control provinces. Figure 1 shows the quarterly time series of patent applications between Alberta and control provinces from 2001Q1 to 2021Q2. This visual representation of the trends shows that Alberta's patent applications follow a similar pattern to control provinces before the intervention, however, some deviations are present before 2016Q2.

Figure 1: Quarterly time series of patent applications between treatment and control groups



Notes: The figure shows the quarterly time series of patent applications between the treatment and control groups from 2001Q1 to 2021Q2. The vertical line represents the start of the AITC intervention (first expense eligibility date) in April 2016. The treatment group is Alberta, and the control group is made from all remaining provinces except NL, PE, YT and NU.

To allay the concern of unobservable factors impacting patent application trends across provinces, I estimate event study regressions following Equation 2 below and provide supporting evidence for causal identification of $\hat{\beta}$.

$$\ln(P_{it} + 1) = \theta_i + \tau_t + \beta_{\mathfrak{t}}(t \cdot A_t) + \mathbf{x}_{it}^{'}\gamma + u_{it} \quad (2)$$

$\theta_i, \tau_t, \mathbf{x}_{it}, \gamma$ and u_{it} represent the same as in Equation 1. t is a set of binary variables for each of the periods for which there is data available, with the reference level set to one period before AITC eligibility (March 2016). A_t is a binary variable equal to unity if the observation is mapped to Alberta and zero otherwise. $t \cdot A_t$ is the interaction term between these two variables, and β_t is the associated vector of coefficients, which will show the difference between the treatment and control groups in the explained variable for all t. For these regressions, I show the values of the interaction terms in event study plots, along with their 95% confidence intervals. I cluster standard errors at the province and period level.

Evidence in favour of the identifying assumption will be observed if the interaction terms before April 2016 are not statistically significant. This supports the idea that Alberta had no significant differences in the trend of patent applications to other provinces before the intervention. Thus, I use the event study regressions to provide evidence of the causal identification of the average treatment effect of the AITC on patent applications. In section 4, I justify the causal identification of the AITC effect by showing that the interaction terms before the intervention are not statistically significant. Further, I use event study regressions in the form of 2 examine the effectiveness of the AITC by looking at post-treatment interaction terms, which should show statistically significant differences if the AITC affected Albertan patent applications.

3.3 Patent parties and province-month panel

I perform two main robustness checks on DD and event study analyses to ensure the validity of my results. First, to the extent that results may be driven by the arbitrary mapping of patents to provinces, I consider the number of Canadian parties involved in a patent application as an alternative explained variable. I separate parties by type (all parties, inventors, owners and applicants[3].) to understand the effect of the AITC on the innovative capacity of different groups. Table 2 also presents the difference in means between treated and control provinces for the province-quarter panel for parties involved in patent applications.

Second, I reestimate models on a province-month panel, to ensure that the results are not driven by the aggregation of data at the quarterly level. This panel allows for a more

[3] I do not consider agents as a separate category due to them typically being hired legal professionals, which may not be informative about the innovative capacity of who files for the patent.

granular analysis of the effects of the AITC on patent applications, however, it is susceptible to noise due to the smaller number of observations, especially for the event study regressions. I present descriptive statistics of the monthly data in A.

4 Results

4.1 Patent applications

Table 3 presents results the estimation of Equation 1 using patent applications as the explained variable with the province-quarter data. Specification (1) includes a baseline result with no control variables. Specification (2) includes economic controls included to account for factors which may affect the comparability of the treatment and control groups regarding firm activity and overall economic trends which vary across time and provinces. The number of foreign parties in all the province's patent applications is also included, to control for effects that foreign interested parties (particularly U.S.) can have as strategic actors for patent applications. Specification (3) considers additional controls, which are included in case that the previous ones did not account for differences in trends due to reasons other than economy, or that economic activity is not well captured by standard economic variables in Specification (2).

The DD estimate for the effect of the AITC intervention is the coefficient on Treatment ×Post, showing that the intervention led to an -6.1% to +2.3% change in Albertan patent applications. The baseline specification shows a negative effect, while the other two specifications show positive effects. However, these are not statistically distinguishable from zero. Standard errors for this coefficient on all three specifications are small compared to those of the controls, showing that $\hat{\beta}$ is estimated with a fairly good level of precision. This implies that it is the small magnitude of $\hat{\beta}$ which drives the low p-value of the hypothesis test, leading to the preliminary conclusion that the AITC intervention had no effect on innovation in the studied period.

I display the results of the event study regressions in Figure 5, which plots the $\hat{\beta}_t$ interaction coefficients in 2 with the same controls as the specifications in Table 3. These results

Table 3: Difference-in-differences specifications for quarterly patent applications

	(1)	(2)	(3)
Treatment x Post	−0.061	0.028	0.023
	(0.043)	(0.065)	(0.074)
Ln Full-time employment		0.825	1.104
		(0.651)	(0.664)
Ln Median wage		1.200**	1.078**
		(0.378)	(0.432)
CPI		−0.015**	−0.007
		(0.005)	(0.008)
Ln +1 Business insolvencies		−0.065**	−0.052*
		(0.027)	(0.023)
Ln Intl. exports		−0.087	−0.089
		(0.093)	(0.119)
Ln Intl. imports		0.018	0.023
		(0.125)	(0.125)
Ln Retail sales		−0.272	0.084
		(0.421)	(0.495)
Ln Wholesale sales		−0.139	−0.222
		(0.164)	(0.150)
Ln Manufacturing sales		0.276	0.216
		(0.150)	(0.140)
Ln +1 Foreign patent parties		0.142***	0.136***
		(0.015)	(0.016)
Ln International travellers			−0.129***
			(0.034)
Ln Arriving vehicles			0.007
			(0.005)
Ln Electric power generation			0.070
			(0.118)
Ln Average actual hours			0.109
			(0.275)
New housing price index			−0.003
			(0.002)
Ln Food services receipts			−0.067
			(0.205)
Ln Average job tenure			−0.448
			(0.372)
Explained variable		ln(Patents + 1)	
N	656	656	656
Adj. R^2	0.975	0.980	0.980
Adj. within R^2	0.000	0.205	0.210
RMSE	0.206	0.182	0.180

Notes: Clustered standard errors at the province and quarter level shown in parentheses. All specifications include fixed effects for provinces and quarters. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

show that when controlling for time and province-varying factors, there is not a statistically significant difference between Albertan and control provinces patent applications before the intervention. This supports the key identifying assumption of the DD design. The baseline model shows several pre-policy periods where the treatment and control groups diverge, underscoring the importance of including controls in the model. However, in all specifications 2015Q4 presents a statistically significant difference in patent applications between the treatment and control groups. This can be due to random noise or to a temporary real effect, however, since it is only one period which is significant, it does not greatly threaten causal identification of the AITC effect.

Regarding the effect of the policy itself, results point toward an overall null effect. While there is a small positive effect in 2016Q4, it is unlikely that this is due to the policy, as the effect is not present in the following quarters. There is also no evidence of a negative effect of the policy on patent applications, as preliminarily shown by the time series plot in Figure 1.

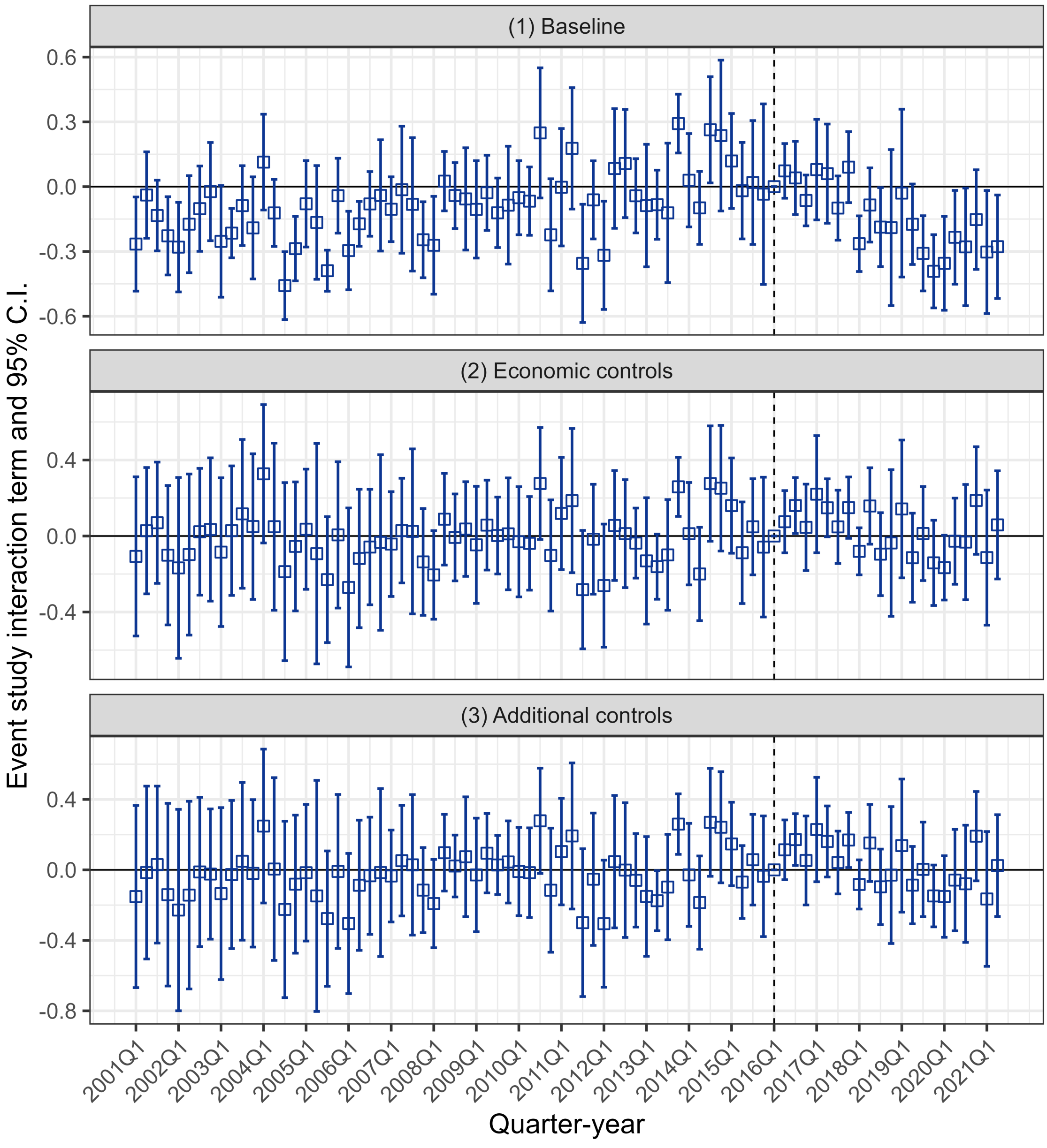
4.2 Patents by IPC section

In Table 4.2, I present the results of estimating Equation 1 allowing for heterogeneity by IPC patent section and including the controls of Specification (3) in Table 3. The results show that the AITC intervention had a null effect on most of the IPC sections except A and E, corresponding to human necessities and fixed constructions. The effect on section A is positive while on section E it is negative. The two coefficients are of similar magnitude (between 42.7% to 53.0% in absolute value), thus justifying the null effect on total patent applications.

Given that there is a smaller number of patents per IPC section for all provinces in every period, I am underpowered to detect small effects on other sections. The event study regressions in Figure 3 provide additional insight about the intervention's effect on patent applications by IPC section. The figure displays the same coefficients and confidence intervals as those of in Figure 5 now separating by IPC section and restricting to the additional controls specification.

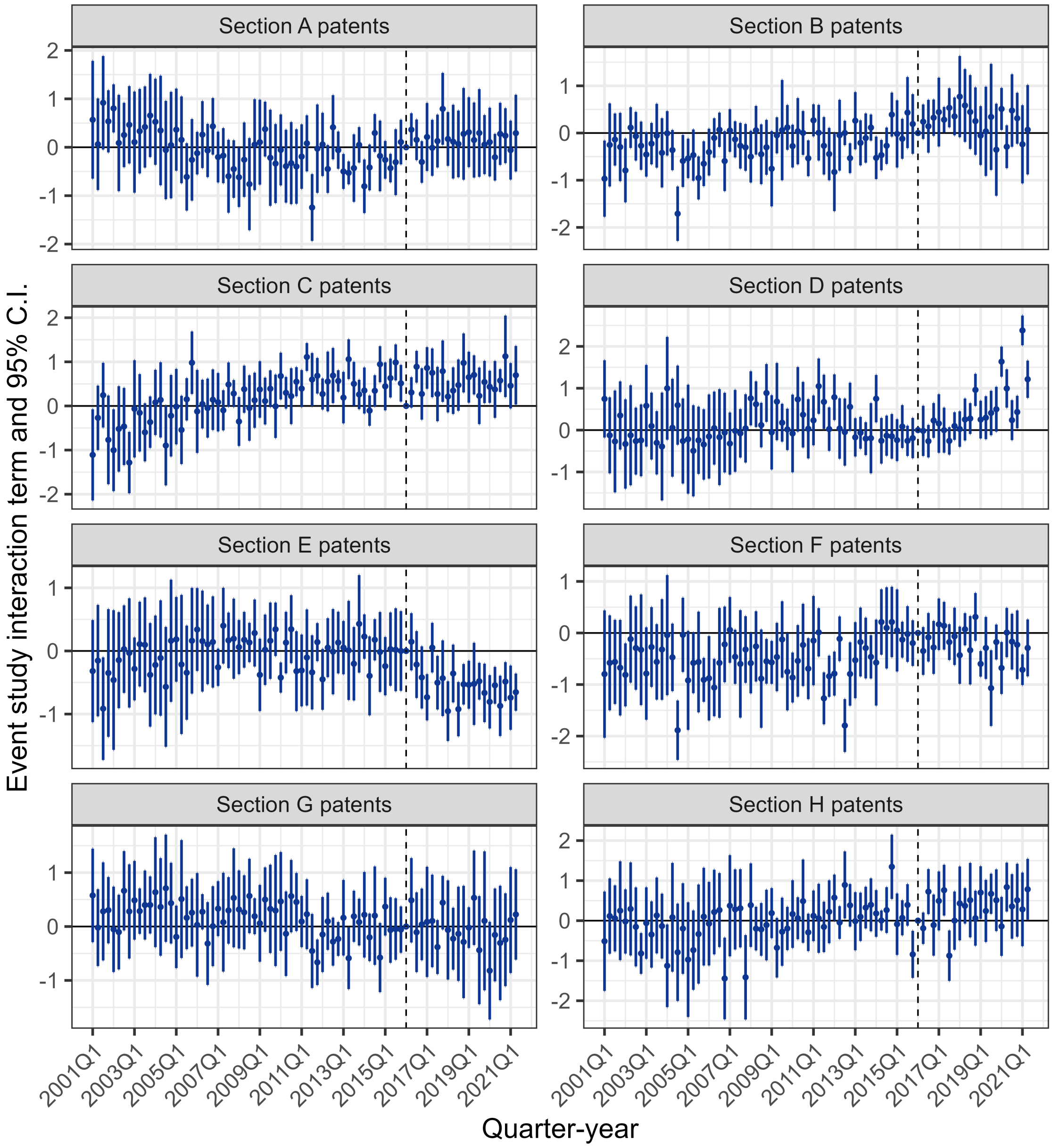
Human necessity (A) patents, which include agriculture, medicine and apparel related

Figure 2: Event study plot for quarterly patent applications



Notes: The figure shows the estimated coefficients of the interaction term between period and treatment binary variables in Equation 2 for each quarter. The points represent the point estimate, while the error bars represent the 95% confidence cluster-robust interval. The vertical line represents the start of the AITC intervention (first expense eligibility date) in April 2016, with the reference level being the quarter before the intervention. Baseline, economic, and additional controls specifications include the controls seen in specifications (1) through (3) in Table 3.

Figure 3: Event study plot for quarterly patent applications by IPC section



Notes: The figure shows the estimated coefficients of the interaction term between period and treatment binary variables in Equation 2 for each quarter, separating by IPC section. The points represent the point estimate, while the error bars represent the 95% confidence cluster-robust interval. The vertical line represents the start of the AITC intervention (first expense eligibility date) in April 2016, with the reference level being the quarter before the intervention. Controls are the same as those in Specification (3) in Table 3.

Table 4: Difference-in-differences results for quarterly patent applications by IPC section

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment x Post	0.427***	0.366	0.066	0.235	−0.530***	0.167	−0.083	0.209
	(0.071)	(0.195)	(0.171)	(0.132)	(0.045)	(0.106)	(0.187)	(0.135)
Patent section (IPC)	A	B	C	D	E	F	G	H
N	656	656	656	656	656	656	656	656
Adj. R^2	0.913	0.911	0.879	0.353	0.914	0.875	0.910	0.908
Adj. within R^2	0.111	0.056	0.082	0.033	0.061	0.021	0.060	0.063
RMSE	0.324	0.355	0.381	0.356	0.361	0.394	0.395	0.409

Notes: Sections of the IPC are A: Human Necessities, B: Performing Operations; Transporting, C: Chemistry; Metallurgy, D: Textiles; Paper, E: Fixed Constructions, F: Mechanical Engineering; G: Physics, H: Electricity. Patents with multiple sections are not included. All specifications include controls in Specification (3) of Table 3, not shown for brevity and fixed effects for provinces and quarters. Clustered standard errors at the province and quarter level shown in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

inventions, show only one significant deviation from the pre-policy trend, five quarters after the intervention (2017Q3). These patents increased by approximately 79% relative to 2016Q1. However, pre-intervention coefficients are less stable for this section, potentially due to its broad definition.

Fixed constructions (E) patents, which include patents related to buildings, roads, and bridges, do show a significant decrease in most quarters after the intervention. Pre-policy coefficients are stable, and the effect is present in the first quarter after the intervention. This suggests that the AITC may indeed have had a negative effect on this type of patent applications. Because the policy did not particularly target this type of innovation, section E inventions may have been crowded out by other types of products which were more incentivized by the AITC.

Other notable results which were not picked up by the DD specification are the Section D patents, which include patents related to textiles and paper. While less stable than other sections in the post-policy trend, these patents show the most important increases, the highest being 238% more patent applications 19 quarters after the intervention (2020Q3). The pre-policy trend is mostly common across the treatment and control groups (with the exception of 2015Q4, same as in the total patent event study). The DD may not capture this effect due to increases being present next to quarters without increases.

4.3 Robustness checks

Appendix B presents the results of the DD specifications and event studies for number of parties in patent applications as explained variables. I consider the total amount of type of parties in patent applications and also separate by specific types: inventors, owners and applicants.

Table 3 shows the results of the DD estimation for all four explained variables. All specifications show a null effect, except the inventors specification, which shows a significant positive effect. Event study plots show that the effect is null for most quarters in post-policy periods for total parties, inventors and applicants, however, pre-policy trends are much less stable for these variables than for owners. Notably, there are negative effects in most pre-policy interaction terms for inventor parties, which may be driving the positive effect in the post-policy period. The positive difference for 2015Q4 is present on all four explained variables, which shows that this difference is not due to the mapping of patents to parties.

The owners specification does show an increasing trend in the last four quarters of the data, and very stable pre-policy trends. This suggests that the AITC may have had a positive effect on the number of owners in patent applications, which may be due to the policy incentivizing firms to apply for patents. Potentially, this effect may be driven by the increases in section A and D patents, as seen in the previous subsections. On all but the last quarter, the interaction terms for applicants shows a negative effect, which may explain the overall null effect of the policy on total parties.

Overall, these results present similar results to the patent applications results. This suggests that my mapping of patents to provinces is not driving the effect to zero, which could be a potential concern, especially due to the elimination of some patents which presented an equal number of parties from different provinces.

Appendix C reproduces the DD specifications and event study regression using the province-month panel, constructed as described in Section 3. DD specifications also show a null effect of the AITC intervention on the log of patent applications, considering all three specifications in Table 3 (baseline, economic and additional controls). The additional precision does not change my results, which further disproves the possibility of an underpowered statistical analysis driving the null effect. The event study plot shows a similar post-intervention pattern, showing a small positive effect shortly after the first month of elegibility, which is not present in the following months. The finer granularity of the data allows to identify small positive effects in the last months of 2020, which disappear in 2021. The pre-policy trend is less stable than the quarter panel, notably around 2004. Results are similar for the IPC section disaggregations, yet with considerably more instability in the pre-policy trend.

5 Conclusions

6 Acknowledgements

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A Appendix: Descriptive statistics for province-month panel

Table A.5: Descriptive statistics for variables in the province-month panel

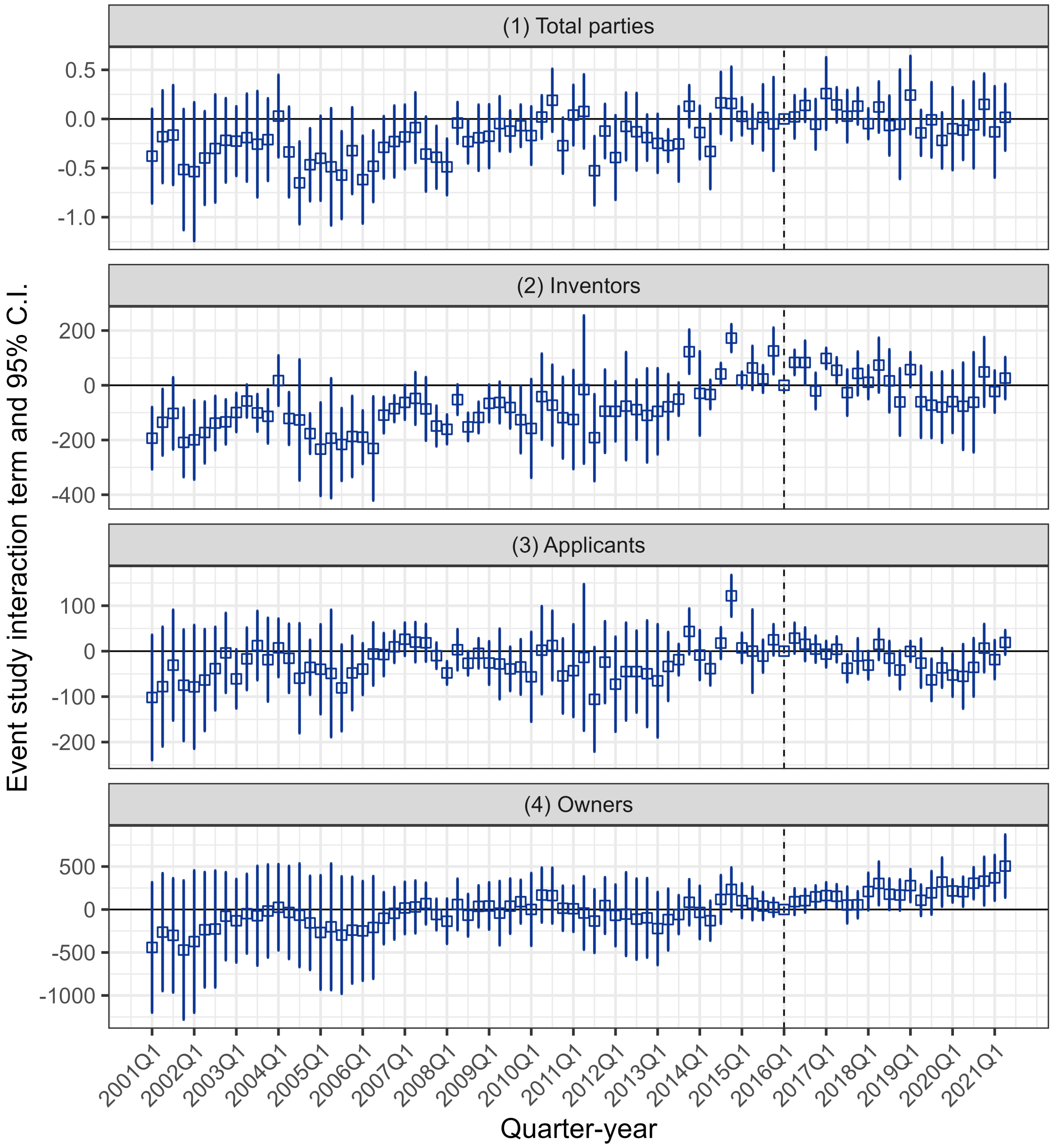
	Mean	SD	Min	Median	Max
Ln +1 Patent applications	3.187	1.400	0.000	3.178	5.714
Ln Full-time employment	6.927	1.034	5.614	6.733	8.722
Ln Median wage	2.945	0.193	2.487	2.956	3.411
CPI	118.994	12.717	93.400	119.000	148.900
Ln +1 Business insolvencies	3.327	1.388	0.000	3.135	5.974
Ln Intl. exports	14.709	1.141	12.585	14.754	16.767
Ln Intl. imports	14.543	1.204	12.453	14.274	17.340
Ln Retail sales	14.864	1.028	13.312	14.691	16.902
Ln Wholesale sales	14.811	1.292	12.762	14.785	17.400
Ln Manufacturing sales	14.928	1.179	13.241	14.689	17.127
Ln International travellers	11.367	1.790	2.944	11.293	14.833
Ln Arriving vehicles	10.784	3.625	0.000	11.436	14.855
Ln Electric power generation	15.112	0.999	13.197	15.088	16.981
Ln Average actual hours	3.514	0.059	3.235	3.517	3.676
New housing price index	87.826	17.020	42.500	94.100	129.500
Ln Food services receipts	12.638	1.107	10.911	12.462	14.766
Ln Average job tenure	4.634	0.089	4.373	4.651	4.847
Ln +1 Foreign patent parties	2.545	1.862	0.000	2.773	5.927

Notes: All statistics based on a balanced panel of N = 1,968 province-monthly observations from January 2001 to June 2021. The sample includes all Canadian provinces except Newfoundland and Labrador, Prince Edward Island, Yukon and Nunavut.

B Appendix: Patent parties models

C Appendix: Province-month panel results

Figure 4: Event study plot for quarterly parties in patent parties



Notes: The figure shows the estimated coefficients of the interaction term between period and treatment binary variables in Equation 2 for each quarter. The points represent the point estimate, while the error bars represent the 95% confidence cluster-robust interval. The vertical line represents the start of the AITC intervention (first expense eligibility date) in April 2016, with the reference level being the quarter before the intervention. Baseline, economic, and additional controls specifications include the controls seen in specifications (1) through (3) in Table 3.

Table A.6: Differences in means between treated and control provinces in province-month panel

Treatment		Pre	Post
Control	Ln +1 Patent applications	3.051	2.988
	Ln +1 Interested parties	4.535	4.316
	Ln +1 Inventors	3.603	3.609
	Ln +1 Applicants	3.078	3.013
	Ln +1 Owners	3.633	3.084
	Ln +1 Total population	7.533	7.632
	Ln +1 Section A applications	1.640	1.661
	Ln +1 Section B applications	1.388	1.272
	Ln +1 Section C applications	0.832	0.730
	Ln +1 Section D applications	0.138	0.069
	Ln +1 Section E applications	0.842	0.836
	Ln +1 Section F applications	0.945	0.808
	Ln +1 Section G applications	1.139	1.261
	Ln +1 Section H applications	1.035	0.828
	Ln +1 Multiple section applications	1.923	2.004
Treatment	Ln +1 Patent applications	4.279	4.157
	Ln +1 Interested parties	5.692	5.560
	Ln +1 Inventors	4.607	4.835
	Ln +1 Applicants	4.277	4.172
	Ln +1 Owners	4.799	4.253
	Ln +1 Total population	7.944	8.138
	Ln +1 Section A applications	1.673	1.833
	Ln +1 Section B applications	1.888	1.988
	Ln +1 Section C applications	1.600	1.599
	Ln +1 Section D applications	0.065	0.086
	Ln +1 Section E applications	2.982	2.669
	Ln +1 Section F applications	1.487	1.413
	Ln +1 Section G applications	2.020	1.829
	Ln +1 Section H applications	1.039	0.898
	Ln +1 Multiple section applications	3.009	3.019

Notes: Calculations based on a balanced panel of N = 1,968 province-monthly observations from January 2001 to June 2021. The sample includes all Canadian provinces except Newfoundland and Labrador, Prince Edward Island, Yukon and Nunavut. Treatment group is Alberta, and control group is all remaining provinces. Post-intervention periods are those after April 2016.

Table B.7: Difference-in-differences specifications for quarterly patent applications

	(1)	(2)	(3)	(4)
Treatment x Post	0.108	44.417*	−0.104	168.295
	(0.095)	(23.110)	(14.215)	(95.018)
Party type	Total	Inventors	Applicants	Owners
N	656	656	656	656
Adj. R^2	0.974	0.959	0.957	0.875
Adj. within R^2	0.137	0.148	0.160	0.421
RMSE	0.210	66.427	35.043	130.592

Notes: All specifications include controls in Specification (3) of Table 3, not shown for brevity and fixed effects for provinces and quarters. Clustered standard errors at the province and quarter level shown in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table C.8: DD specifications for monthly patent applications

	(1)	(2)	(3)
Treatment x Post	−0.058	0.088	0.077
	(0.042)	(0.070)	(0.083)
Explained variable		ln(Patents + 1)	
Controls	None	Economic	Economic + Additional
N	1968	1968	1968
Adj. R^2	0.942	0.952	0.952
Adj. within R^2	0.000	0.168	0.177
RMSE	0.314	0.285	0.283

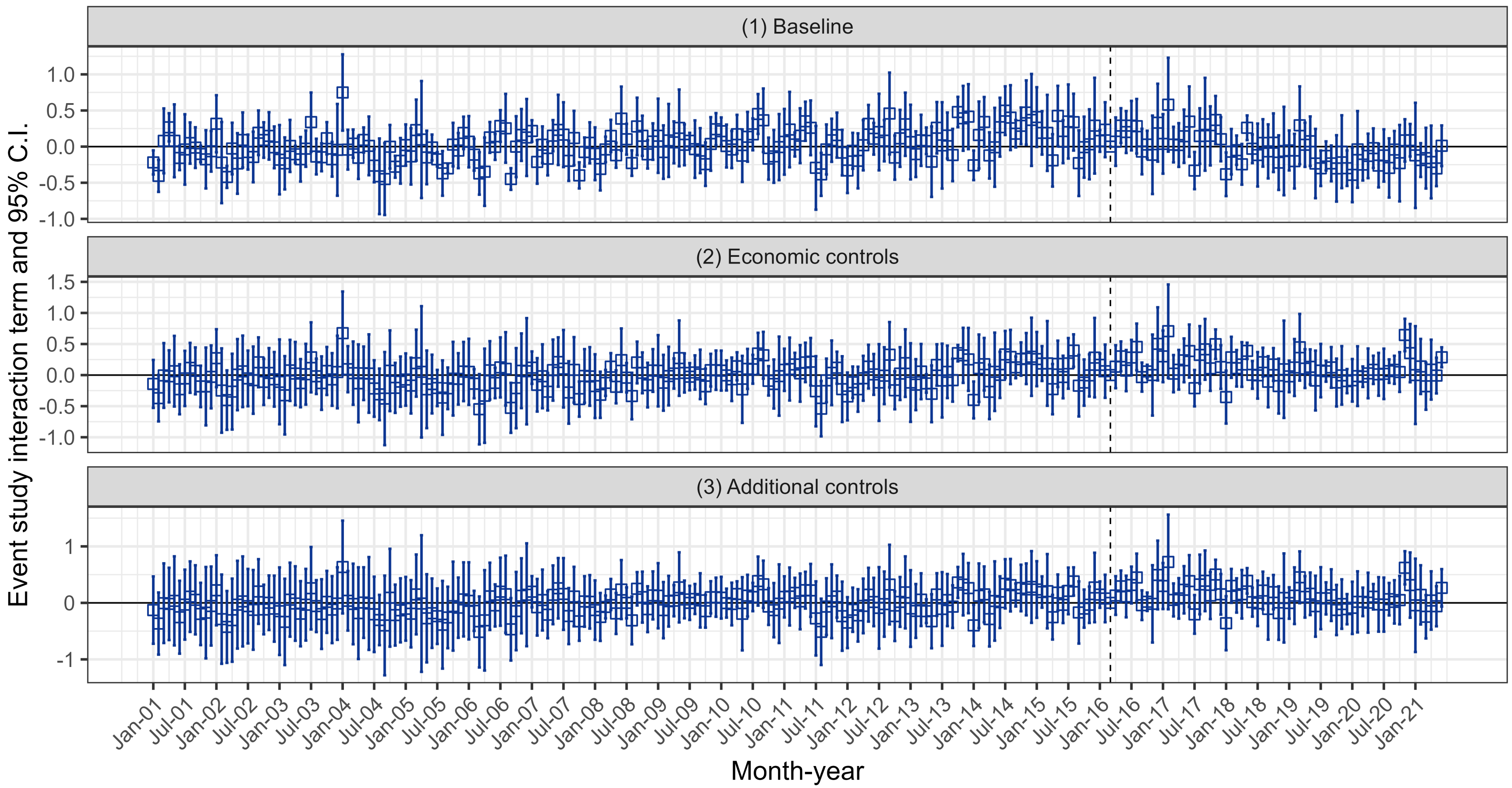
Notes: Clustered standard errors at the province and monthly level shown in parentheses. Specifications include fixed effects for provinces and months and the controls for their quarterly counterpart in Table 3. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table C.9: Difference-in-differences results for monthly patent applications by IPC section

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment x Post	0.319***	0.346**	0.000	0.099*	−0.452***	0.229**	−0.151	0.193
	(0.071)	(0.124)	(0.125)	(0.048)	(0.060)	(0.096)	(0.101)	(0.108)
Patent section (IPC)	A	B	C	D	E	F	G	H
N	1968	1968	1968	1968	1968	1968	1968	1968
Adj. R^2	0.823	0.853	0.767	0.163	0.849	0.774	0.877	0.860
Adj. within R^2	0.049	0.038	0.051	0.016	0.054	0.014	0.044	0.057
RMSE	0.414	0.396	0.395	0.248	0.380	0.405	0.375	0.393

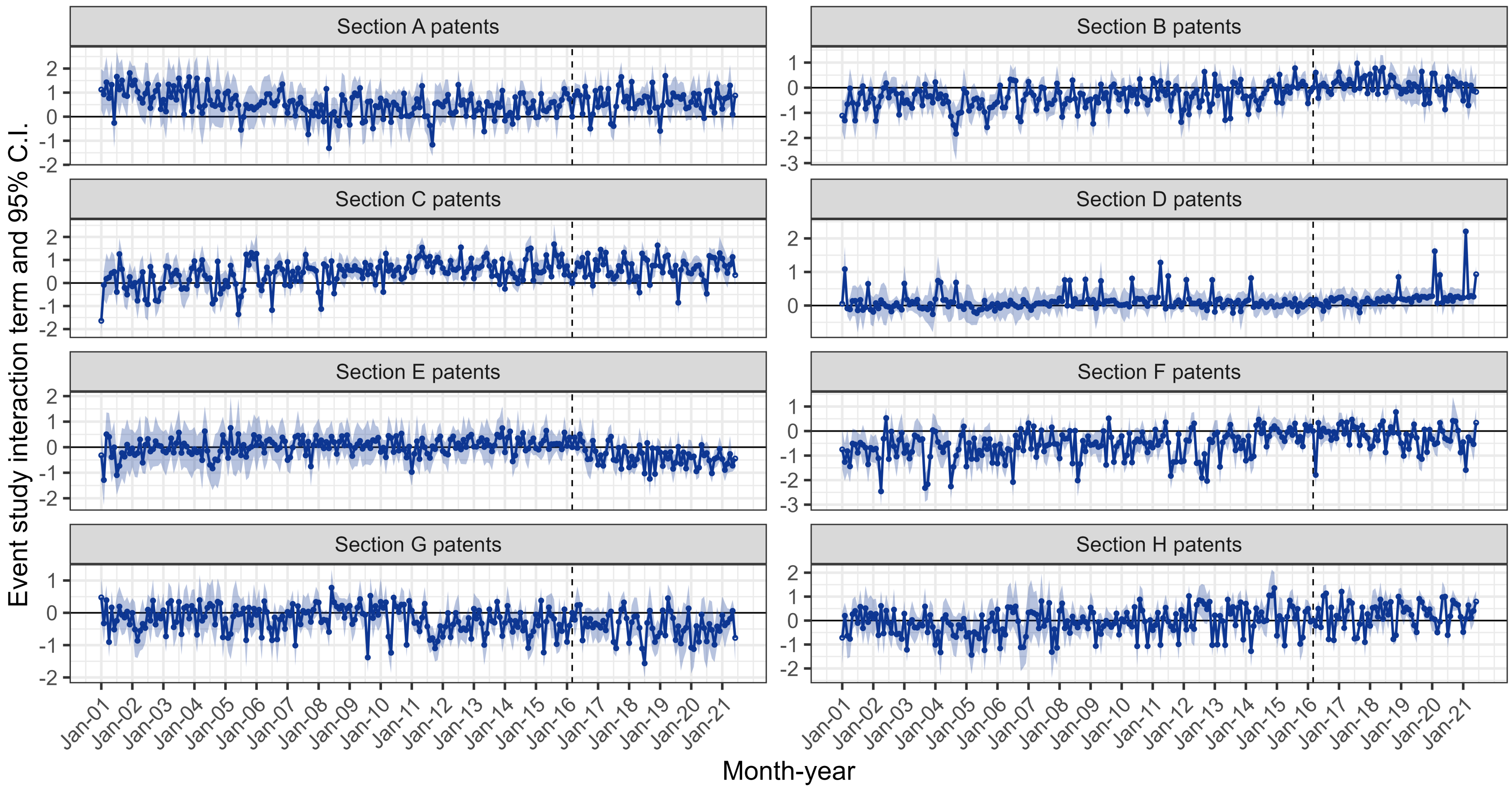
Notes: Sections of the IPC are A: Human Necessities, B: Performing Operations; Transporting, C: Chemistry; Metallurgy, D: Textiles; Paper, E: Fixed Constructions, F: Mechanical Engineering; G: Physics, H: Electricity. Patents with multiple sections are not included. All specifications include controls in Specification (3) of Table C.8, not shown for brevity and fixed effects for provinces and monthy. Clustered standard errors at the province and month level shown in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Figure 5: Event study plot for monthly patent applications



Notes: The figure shows the estimated coefficients of the interaction term between period and treatment binary variables in Equation 2 for each month. The points represent the point estimate, while the error bars represent the 95% confidence cluster-robust interval. The vertical line represents the start of the AITC intervention (first expense eligibility date) in April 2016, with the reference level being the month before the intervention. Baseline, economic, and additional controls specifications include the controls seen in specifications (1) through (3) in Table C.8.

Figure 6: Event study plot for monthly patent applications by IPC section



Notes: The figure shows the estimated coefficients of the interaction term between period and treatment binary variables in Equation 2 for each month, separating by IPC section. The lines represent point estimates, while the shaded areas represent the 95% confidence cluster-robust intervals. The vertical line represents the start of the AITC intervention (first expense eligibility date) in April 2016, with the reference level being the quarter before the intervention. Controls are the same as those in Specification (3) in Table 3.