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Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

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JEL Classification: E31, E50, Q54, Q43

Keywords: Co2 taxes, Carbon Pricing, inflation, monetary policy, climate change

Maximilian Konradt - maximilian.konradt@graduateinstitute.ch
Graduate Institute, Geneva

Beatrice Weder di Mauro - bwederdimauro@cepr.org
INSEAD, CEPR, Graduate Institute, Geneva and CEPR

Carbon Taxation and Greenflation: Evidence from Europe and Canada [*]

Maximilian Konradt[§]   Beatrice Weder di Mauro[¶]

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Abstract

This paper studies the effects of carbon pricing on inflation dynamics. We construct a sample of carbon taxes implemented in Europe and Canada over three decades and estimate for the first time the response of inflation and price components to carbon pricing. We find that past carbon taxes changed relative prices but did not significantly increase inflation. This is consistent with previous findings of carbon taxes impacting emissions but not aggregate output. Based on the cross-section of taxes in Europe, we provide suggestive evidence that the response of inflation was especially muted in countries with revenue recycling schemes and monetary policy regimes that can accommodate the carbon tax.

Keywords: Climate policy, carbon taxes, carbon pricing, inflation, monetary policy, climate change.

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[§] The Graduate Institute, Geneva (e-mail: maximilian.konradt@graduateinstitute.ch)

[¶] The Graduate Institute, Geneva, INSEAD Emerging Markets Institute, Singapore and CEPR (e-mail: beatrice.wederdimauro@graduateinstitute.ch)

1 Introduction

Rising inflation has once again become a primary concern for policy makers, markets and the general public in advanced economies. The aftermath of the Covid-19 pandemic was marked by increasing energy prices, which will likely be exacerbated and prolonged by the Russian invasion of Ukraine in 2022. At the same time, countries have committed to de-carbonize their economies, which has given rise to speculation on the economic consequences of the climate transition. Prominently, Larry Fink, CEO of Black Rock made headlines by predicting that policies against climate change would fuel global inflation.[1] The issue is also on top of the agenda for the European Central Bank, which emphasized the question in its strategy review and climate action plan (see ECB 2021) and acknowledged that it could be forced to take "greenflation" into account in monetary policy operations (Schnabel 2022).

The uncertainty surrounding the economic effects of climate mitigation tools such as carbon taxes illustrates that they remain poorly understood. One the one hand, policies that increase the prices of oil and gas do raise the specter of oil price shocks and 1970s-type stagflation, as quintessential supply side shocks that cause both lower output and higher inflation (see e.g. Hooker 2002, Barsky and Kilian 2004). On the other hand, the economic effects of carbon taxes in principle depend on many factors, including the tax rate and coverage, as well as tax incidence and revenue recycling. Most carbon taxes are pre-announced well in advance, such that firms and households can adjust accordingly. Moreover, the lack of a coordinated global effort to price carbon has forced countries to implement taxes nationally, which implies that contrary to oil shocks any effects are concentrated domestically.

Existing model-based studies provide preliminary evidence on the economic effects of carbon taxation. Estimates from computable general equilibrium (CGE) models indeed point to inflationary effects that vary in size (see e.g. McKibbin, Morris, and Wilcoxen 2014). However, CGE models make a number of simplifications in order to remain tractable, that might be too simplistic in the real world. The purpose of this study is to assess the link between carbon pricing and inflation empirically by drawing on past taxes from Europe and Canada.

To the best of our knowledge, the present study is the first to emphasize the effects of carbon pricing on inflation. We explore 18 individual carbon taxes enacted in European countries and Canadian provinces over three decades. Conceptually our study is in the spirit of Metcalf and Stock (2020a) and Metcalf and Stock (2020b), who assess the economic effects of carbon pricing on output and employment. We complement their work by concentrating on the equally important monetary consequences of carbon taxation. Specially, we estimate dynamic impulse responses of headline and core inflation to changes in the carbon tax rate based on the local projections methodology of Jordà (2005), adapted to panel data.

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[1] Bloomberg, June 18, 2021, see https://www.bloomberg.com/news/articles/2021-06-18/the-climate-change-fight-is-adding-to-the-global-inflation-scare.

Our main finding is that carbon taxes are not inflationary, on aggregate. Both for Europe and Canada, we do not find robust evidence that pricing carbon leads to an increase in inflation, when controlling for economy and year fixed effects. For Canada the results even point to slightly deflationary responses associated with putting a price on carbon. This primary finding is not driven by the empirical methodology or our data sources: We find very similar results when we employ panel-VAR or distributed lag models, or use alternative price and carbon tax data.

When comparing the responses of headline and core inflation (excluding energy and food prices) to carbon pricing, we observe that any inflationary pressure is confined to the headline consumer price index (CPI). Throughout the analysis, our dynamic responses for core inflation lie below those for headline inflation. This is consistent with carbon taxes changing relative prices, i.e. increasing the price of energy, but not spilling over to a broad basket of consumption goods and services.

Finally, we exploit differences in the timing of tax enactments, revenue recycling schemes and monetary policy regimes by drawing on the rich cross-section of carbon taxes in Europe. Our results point to later carbon taxes, which do not tend to feature revenue recycling schemes, being associated with more inflationary effects. Moreover, we estimate that price responses are relatively muted in countries with monetary policy authorities that can react to carbon price shocks, i.e. those not part of the Euro area. In fact, the only sub-sample for which we find robust inflationary evidence is Euro area economies that do not recycle tax proceeds.

Although we do not formally test the effect of monetary policy and revenue recycling as amplifying forces, our results serve as suggestive evidence that is consistent with prior research. First, McKibbin, Konradt, and Weder di Mauro (2021) emphasize the importance of monetary policy in accommodating carbon tax shocks. Second, Metcalf and Stock (2020a) suggest potential growth enhancing effects associated with revenue recycling. We leave formal tests of these channels to future research.

When seen in conjunction with the prior literature on the limited economic effects of carbon taxes our results imply that worries of drastic adverse economic effects and "greenflation" might be overblown. Nonetheless, we acknowledge that future climate policy needs to be increasingly aggressive in order to reach the ambitious emission goals. Carbon taxes on the order of magnitude of tax rates in Scandinavia or Switzerland (exceeding 100 USD per ton of CO2), with universal coverage potentially have much broader economic effects than those documented in this paper.[2]

Related Literature. Our paper contributes to a growing empirical literature studying the effects of climate change policies, with a particular focus on carbon taxes. Economists have long argued that Piguouvian-type carbon taxes are the most efficient way to address climate change. Prior studies have documented that carbon taxes indeed achieve their goal of reducing emissions (e.g. Murray and Rivers 2015, for Canada; Andersson 2019, Martin,

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[2] Although we do our best to capture the role of tax coverage in our analysis by interacting tax rates with tax bases, one might expect potentially different effects if a carbon tax was to apply universally.

De Preux, and Wagner 2014, Lin and Li 2011, Best, Burke, and Jotzo 2020, for Europe). Rafaty, Dolphin, and Pretis (2020) survey this literature.

Literature on the economic effects of climate policies is scarce by comparison and largely based on CGE models (see e.g. McKibbin, Morris, and Wilcoxen 2014, McKibbin et al. 2017, IMF 2020). Although economic activity is at the center of most simulation exercises, inflation is frequently included as an auxiliary variable. Across studies, the simulations of a plausible carbon tax implementation predict an inflationary effects (e.g. McKibbin, Morris, and Wilcoxen 2014, for the United States; Andersen and Mainguy 2010 and Holland and Whyte 2021 for Europe; Rahman 2011, for Australia). Akin to the empirical literature on output effects, our study suggests that empirical estimates of the responses of inflation to carbon pricing lies below those implied by model-based studies.

Our paper is most closely related to the empirical literature on the topic, which has focused on the effects on growth and unemployment. Metcalf and Stock (2020a) and Metcalf and Stock (2020b) study the economic effects of carbon taxes based on a sample of 15 European countries since 1990. The authors find no empirical support for a negative effect on GDP or employment associated with pricing carbon. Based on the identical sample, we complement these results with the previously unexplored monetary effects of carbon taxation.

In addition to national carbon taxes, European countries also tax emissions under the umbrella of the EU Emissions Trading System (ETS). Känzig (2021) documents a negative effect on output and an increase in inflation associated with ETS carbon price changes. Given the difference in institutional design and coverage, as well as the little overlap between national carbon taxes and the EU ETS, these results could plausibly be complementary to each other.[3] Indeed, Moessner (2022) shows that when studied jointly, only changes in the ETS price lead to an inflationary response. Since our empirical analysis on Europe features only countries that are also part of ETS, the effects we document may be seen as complementing those associated with the ETS.

Most of the early literature on the economic effects of carbon pricing is based on the Canadian province British Columbia. For instance, Metcalf (2019) and Bernard, Kichian, and Islam (2018) find no evidence of negative aggregate effects on GDP or employment. Yamazaki (2017) confirms the findings for aggregate employment, but finds a small, negative response of wages in British Columbia related to the carbon tax. This study corroborates the finding of limited economic effects in British Columbia by emphasizing the lack of an inflationary price response.

Our main finding that carbon taxes change relative prices but do not lead to aggregate inflation is consistent with the idea of inflation having both a flexible (energy) and a persistent component (core CPI), in the spirit of Aoki (2001). Recent micro evidence

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[3] The ETS applies only to energy-intensive firms in the energy, power and aviation sector whereas national carbon taxes cover the remaining emitters, mostly in the transport and industry sector. One explanation for the diverging responses of inflation could be related differences in pass-through. For instance, research has shown that power companies have a high pass-through (Fabra and Reguant 2014), whereas less energy-intensive firms might only pass on a fraction of the tax to consumers.

showing that the effects of oil price shocks is confined to a subset of consumer prices (see Gao, Kim, and Saba 2014) is supportive of this view.

The remainder of the paper is organized as follows: The next section introduces our two samples of carbon taxes, in Europe and Canada. Section 3 presents the auxiliary data and outlines the empirical strategy. In Section 4, we turn to the empirical analysis on the effects of carbon pricing on inflation in Europe and Canada. We complement the baseline analysis by exploring the cross-section of European carbon taxes in Section 5. Finally, Section 6 concludes and discusses the results.

2 Carbon taxes in Europe and Canada

Despite their recent resurgence in the public debate, carbon taxes have been employed as tools to reduce emissions since the early 1990s. In Europe, the Scandinavian countries were the first countries to put a price on carbon. Even to date, Sweden and Norway continue to have one of the highest tax rates globally. At about the same time a set of Eastern European countries led by Poland also introduced carbon taxes, albeit at a much lower level.

From 2000 a second wave of countries in Europe began to price carbon, among them Switzerland, Ireland and Iceland. Of the countries considered in this study, the United Kingdom and a set of Southern European countries comprise a third wave of carbon tax economies. Although we do not include them here due to data limitations, Germany and the Netherlands also introduced measures to price carbon in 2021.

In total, our sample for Europe encompasses 15 carbon taxes and provides the basis for our empirical analysis. All countries we consider are also taxing emissions in the energy and power sector under the jurisdiction of the EU ETS.[4] Fortunately there is little overlap between our carbon taxes and other carbon pricing initiatives, based on data by the World Bank's Carbon Pricing Dashboard. Moreover, any changes in prices associated with the EU ETS are common to all countries in our sample and absorbed when including year fixed effects.

In addition to the European taxes implemented nationally, we enrich our analysis by exploring taxes at the provincial level in Canada. We focus especially on British Columbia (BC), but also consider taxes in Alberta and Quebec. The BC carbon tax in 2008 remains one of the most studied carbon taxes to date and stands out as a unique policy experiment due to its almost universal coverage, spanning 70% of total carbon emissions. Quebec and Alberta soon followed with carbon pricing systems of their own.[5] In the year 2019 Canada

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[4] The ETS is a ”cap and trade” system, which has been introduced in 2005. Due to design problems such as free allocations and oversupply, prices of ETS fell below 5 euro and remained at that level for several years. Only in 2018, after the EU fixed some of the related issues, has the price of the ETS started to rise steadily. Switzerland had a parallel cap and trade system in place since 2008, but joined the ETS in 2020. For more details, see https://ec.europa.eu/clima/policies/ets_en.

[5] Alberta introduced a carbon tax in 2017, which was abolished in 2019. Quebec introduced a cap-and-trade system including a price floor in 2013. We use the minimum price of the cap-and-trade system analogous to a carbon tax, as it puts an effective lower bound on the price of emissions.

enacted a national carbon tax that is complementary to the existing provincial taxes.

Canadian provinces provide a neat setting to assess the economic impact of carbon taxes since they do not have autonomous monetary policy, which potentially reacts to higher energy prices. The mandate of the Bank of Canada (BOC) is to stabilize prices at the national level rather than for individual provinces.[6]

Table 1 summarizes our sample of carbon taxes. We observe considerable heterogeneity, both in terms of initial and current tax rates (expressed in 2018 US dollars per ton of CO2 emissions), as well as in the tax base (expressed as the share of total greenhouse gas (GHG) emissions in the economy covered by a tax).[7] Carbon taxes range from a negligible 0.08 USD in Poland to more than 100 USD per ton of CO2e emissions in Switzerland and Sweden. In the large European countries, the tax tends to cover around one third of total GHG emissions, on average. The Canadian carbon taxes (bottom rows) are characterized by a relatively larger coverage compared to their European counterparts, with tax rates of 25 USD per ton of CO2e emissions, on average.

Economists often advocate for Pigouvian taxes to be redistributed to the population (on a per capita basis), since the purpose of the tax is to change consumption behavior and internalize externalities by correcting relative prices, not to increase government revenues. Moreover, the political economy of introducing a Pigouvian tax also incentivizes governments to redistribute revenues back to households (and voters). A number of economies have followed this path by introducing carbon taxes in conjunction with redistribution schemes for the tax revenues.

For instance, carbon tax proceeds in Switzerland are used to finance a energy efficiency program and a technology fund. Moreover, two-thirds of the revenues are redistributed to households on a per capita basis (as a rebate on the compulsory health insurance) and to firms, in proportion to their payroll (Hintermann and Zarkovic 2020). The provincial carbon tax in British Columbia even features a progressive redistribution scheme, where low-income households receive lump-sum payments, in addition to income tax and corporate income tax decreases.

Table C3 of Appendix C gives an overview of different designs and redistribution schemes for our carbon tax sample. For the purposes of this study we broadly distinguish between economies that recycle revenues and those that do not. We acknowledge that the taxes in our sample differ along several other dimensions and this classification might not do justice to fully tease out these institutional differences. For additional background on the carbon taxes we refer the reader to Metcalf and Stock (2020a) (for Europe) and Yamazaki (2017) (for British Columbia).

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[6] We checked minutes of monetary policy announcements around the year of the carbon tax implementation in BC. We could not find any evidence of the carbon tax implementation, or potentially increasing energy prices in BC factoring into monetary policy decisions in Canada.

[7] The tax base is both dependent on the number of sectors that are included in the tax, as well as the range of fossil fuels that are covered. For instance, most taxes with a large base (e.g. Ireland) span all fossil fuels, whereas those with a small base (e.g. Spain) tend to only apply to a minority of fossil fuels. For more details, see the Carbon Pricing Dashboard of the World Bank.

Table 1: Carbon taxes in Europe and Canada

Economy	Enacted	Initial rate (USD)	2018 rate (USD)	Coverage
Finland	January 1990	3.35	76.87	0.36
Poland	January 1990	0.11	0.08	0.04
Norway	January 1991	71.87	64.29	0.62
Sweden	January 1991	75.99	139.11	0.40
Denmark	May 1992	11.94	21.45	0.24
Slovenia	January 1996	11.94	21.45	0.24
Estonia	January 2000	0.33	2.25	0.03
Latvia	January 2004	0.56	5.06	0.15
Switzerland	January 2008	13.90	100.90	0.33
Ireland	January 2010	23.26	25.00	0.49
Iceland	January 2010	9.80	35.71	0.29
United Kingdom	April 2013	8.09	25.46	0.23
Spain	January 2014	29.25	24.80	0.03
France	April 2014	10.24	55.30	0.35
Portugal	January 2015	5.80	8.49	0.29
British Columbia	July 2008	5.83	33.75	0.70
Quebec	January 2013	11.59	14.73	0.85
Alberta	January 2017	20.48	30.00	0.48

Notes: This table summarizes the carbon taxes used for the empirical analysis, for European countries and Canadian provinces. All rates are expressed in 2018 USD per ton of carbon dioxide (CO2) equivalent (e) emissions, using the U.S. GDP deflator to convert nominal USD rates from the Carbon Pricing Dashboard of the World Bank. Coverage denotes the share of total GHG emissions covered by the tax in 2019. For the United Kingdom, and Quebec, we use the price floor of the respective cap-and-trade systems as the carbon tax rate. Source: https://carbonpricingdashboard.worldbank.org/, accessed 15.02.2021.

3 Data and Empirical Approach

This section first describes the data we use in the empirical analysis, based on the taxes listed in Table 1. Second, we outline the steps we take in the empirical analysis for identifying the effect of carbon taxation on inflation: We begin with event studies (synthetic control analysis) based on monthly data to serve as preliminary evidence. Next, we introduce our baseline local projections including a set of fixed effects to credibly identify the response of inflation to carbon pricing.

3.1 Data

Our study builds on a sample of carbon tax rates (in 2018 USD) and emission shares, retrieved from the World Bank's Carbon Pricing Dashboard (see Table 1). Throughout we interact carbon tax rates with tax bases (following Metcalf and Stock (2020b)) to account for proportionally greater economic effects of broader taxes. For robustness, we also explore emissions-weighted carbon prices by Dolphin, Pollitt, and Newbery(2020), summarized in Tables A5 and A6 of Appendix A).

Our primary focus is on the response of headline and core inflation (excluding energy and food). We obtain CPI data at monthly frequency for 32 OECD countries, spanning the period 1985–2019. The data are disaggregated for food, energy and core CPI, which allows us to explore differences across the major consumption categories of the CPI basket. We extract similar monthly data for Canadian province since 2000 from Statistics Canada.

For estimating local projection we use annual data spanning the same period, which we gather from the OECD (for Europe). In total, our sample comprises of 26 European countries with available data, all part of the EU ETS. We enrich the sample by adding data on annual GDP growth per capita (retrieved from the OECD) and monetary policy rates, from the Bank for International Settlements. More details on the European sample, including descriptive statistics on headline and core inflation are presented in Appendix C, Table C1.

We construct an analogous panel for Canadian provinces of annual CPI data (and its components), which we complement with information on gross provincial product per capita, covering the 10 Canadian provinces since 2000. We also add monetary policy rates from the Bank of Canada, which are common among provinces but vary over time. All Canadian data are extracted from Statistics Canada. We summarize the headline and core inflation figures in Table C2 of Appendix C.

3.2 Empirical approaches

Our core empirical analysis builds on the local projections (Jordà 2005) adapted to panel data, which allows us to identify the dynamic response of inflation to carbon taxation. We show that the results are not driven by the empirical approach, or our sources for tax data in Appendix A. Before the local projections we begin with the event studies (based on the synthetic control method) to understand how the introduction of a carbon tax correlates with movements in prices, without controlling for any confounding factors.

The synthetic control method (SCM) proposed by Abadie and Gardeazabal (2003) and Abadie, Diamond, and Hainmueller (2010) enables us to construct a data-driven counterfactual economy that is identical to the economy implementing a carbon tax, except for the tax itself. For instance, to assess the response of CPI to the carbon tax in BC, the algorithm would construct a counterfactual (as a weighted average) consisting of the remaining 9 provinces. By minimizing the difference in CPI leading up to the tax enactment, the algorithm chooses a more accurate counterfactual compared to classic event studies. Identification relies on the assumption that both economies (actual and counterfactual) would evolve in the same way in the absence of the carbon tax.[8]

For estimation we select a 10-year event window around the enactment date and use the period leading up to the tax for the selection of the counterfactual economy. Since our data are at monthly frequency, this exercise amounts to minimizing the difference in CPI

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[8] The SCM has been used extensively to evaluate the economic effects at the country level due to changes in government (e.g. Born et al. 2019, Funke, Schularick, and Trebesch 2021); national tax policies (e.g. Andersson 2019, Grogger 2017); and financial policies (e.g. Billmeier and Nannicini 2013, Chamon, Garcia, and Souza 2017).

based on 60 individual observations. We exclude economies from the donor pool (set of potential economies to construct the counterfactual) that themselves introduced a carbon tax during the event window.

More formally, for each carbon tax enacted in economies E we denote Y_e the vector of CPI in the carbon tax economy and X_e the CPI matrix for the potential counterfactual economies C, in the donor pool. The individual weights w_c^e are contained in the weighting vector W_e. The optimal vector W_e^* minimizes the following mean squared error:

$$(Y_e - X_e W_e)' V_e (Y_e - X_e W_e), \;\; e = 1, ..., E \tag{1}$$

subject to $\sum_{c=1}^{C} w_c = 1$, and $w_c \geq 0 \;\forall\; e,\, c$. The matrix V_e is positive-semidefinite and symmetric (see Abadie, Diamond, and Hainmueller (2010) for more details).

Since our sample encompasses multiple carbon taxes, we seek to assess the average response of CPI to carbon tax enactments. We therefore adapt the approach of Acemoglu et al. (2016), to take averages of CPI across all carbon tax economies, and their synthetic counterfactuals, respectively. Finally, we compute the gap between the average carbon tax economy and the average counterfactual, to illustrate the effect of the carbon tax. We repeat this procedure separately for headline CPI, core CPI, energy and food, as well as for European and Canadian carbon taxes.

Importantly, our use of event studies only serves to provide preliminary evidence. First, while it captures the response to the initial implementation, it fails to account for any subsequent changes in the tax rate. Second, the decision to enact a carbon tax is potentially endogenous to the prevailing economic environment. A specific worry might be that governments are inclined to introduce and raise carbon taxes in a pro-cyclical fashion.[9]

We argue that concerns of endogeneity are less pressing when trying to assess the response of inflation compared to aggregate economic activity, since it is governed by monetary policy of independent central banks, whereas tax policies fall under the jurisdiction of fiscal authorities. Nonetheless, to ensure the effect is properly identified and to control for potential confounding factors we use the local projections (LP) method by Jordà (2005) for our main analysis.

Specifically, we estimate a sequence of panel (OLS) regressions,

$$\Delta CPI_{i,t+h} = \alpha_i + \Theta_h \tau_{i,t} + \beta(L)\tau_{i,t-1} + \delta(L)\Delta CPI_{i,t-1} + \mu(L)\Delta X_{i,t-1} + \gamma_t + \epsilon_{i,t} \tag{2}$$

where τ_{it} is the real carbon tax rate in economy i in year t. Θ_h is the effect of an unexpected change in the carbon tax at year t on annual inflation in h years. To control for persistence of the tax rate and inflation, we use the 4 latest lags of each variable in the regression. $\Delta X_{i,t-1}$ is a varying set of covariates, including GDP growth and changes in the domestic monetary policy rates that enter with 4 lags each. Unobserved heterogeneity specific to an

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[9] For instance, British Columbia deferred the scheduled 2020 increase of its carbon tax until 2021 as a response to the COVID-19 pandemic. See https://www2.gov.bc.ca/gov/content/taxes/tax-changes/covid-19-tax-changes.

economy or year is absorbed by a set of fixed effects, α_i and γ_t.

Importantly, this methodology allows for feedback from historical inflation and economic conditions to the carbon tax rate. For our dynamic effect Θ_h to be identified we rely on the assumption that only those components of the tax that are not predicted by historical carbon taxes and economic conditions, are exogenous. One example of such an exogenous shock could be a green party in government abruptly deciding to increase the carbon tax rate.

All dynamic impulse responses are estimated from annual data, spanning the period 2000–2018 for Canada, and 1985–2018 for Europe, respectively. We restrict our sample of European countries to 26 with available data and who are all part of the EU ETS (listed in Table C1 of Appendix A). To distinguish between broad price changes and changes confined to energy prices we separately estimate impulse responses for headline and core inflation.

Following Metcalf and Stock (2020b), we weight all carbon tax rates by their 2019 emissions coverage, postulating a greater pass-through of tax rates to the economy in case of high tax bases.[10] Standard errors are heteroscedasticity robust (see Plagborg-Møller and Wolf 2021) and clustered on country or province, respectively.

Our counterfactual exercise consists of a one-time permanent increase in the carbon tax by 40 USD that applies to 30% of an economy's GHG emissions, broadly corresponding to our sample averages. Intuitively, a 40 USD tax rate would translate to roughly 10 cent per liter of gasoline or diesel.[11] We compute dynamic impulse responses in the five years after the tax increase, based on the estimated LP coefficients. Throughout, we distinguish between the contemporaneous (in year 0), short-term (in years 1–2) and medium-term (year 3–5) average effects of the carbon tax.

We subject our main results to a battery of robustness checks: We repeat the baseline analysis for both samples using panel-VAR models (Tables A1 and A2 of Appendix A) and distributed lag models for panel data (Tables A3 and A4, Appendix A). Results based on alternative carbon tax data are presented in Tables A5 and A6 of Appendix A. Finally, for the European sample we also check whether the results are sensitive to the source of inflation data (see Appendix A, Table A7).

4 Results

We begin our analysis with suggestive evidence based on the synthetic control method, for both Europe and Canada to illustrate that at first glance, implementing a carbon tax does not seem to go along with a bout of inflation. Second, we proceed with the main empirical analysis based on local projections and our core result that past carbon taxes have not been

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[10] We use tax coverage figures for the year 2019 only, since they are fairly stable over time, based on figures by the World Bank's Carbon Pricing Dashboard. See https://carbonpricingdashboard.worldbank.org/map_data.

[11] The IPCC (Eggleston et al. 2006) calculates with 8.89×10^{-3} to 10.18×10^{-3} tCO2e emissions per gallon of gasoline and diesel, respectively. One gallon corresponds to 3.785 liters.

inflationary. Third, we explore the cross-section of carbon taxes implemented in Europe to document that carbon taxes with revenue recycling schemes implemented in countries with autonomous central banks are the primary drivers of our non-inflationary results.

4.1 Preliminary finding: inflation does not increase after carbon taxes are enacted

We start with the results for Europe, based on the synthetic control analysis. Panel A of Figure 1 illustrates the path of headline CPI of the average European economy with a carbon tax (solid line) against the average of the constructed counterfactual economies (dashed line) in the five years around the tax implementation.[12] Reassuringly, CPI moves in lockstep until the tax implementation, which illustrates that the selected counterfactuals that are accurate representations of the actual economies. In the period after the tax is implemented, we see divergence: whereas CPI in the average counterfactual economy continues to grow at a linear path, inflation is much more muted in the average carbon tax economy: Five years after the tax enactment, headline CPI in the average carbon tax economy lies 10 percentage points below the counterfactual economy.

The results for Canadian provinces (Panel B of Figure 1) confirm this finding: Again, the paths of the carbon tax economy and the counterfactual are almost identical prior to the tax enactment, on average. The initial period after the tax is marked by stronger increase in CPI in the counterfactual, compared to the carbon tax economy. Put differently, headline inflation is higher in the provinces without a carbon tax, compared to the average province that implemented a carbon tax. Five years removed the gap is about 4 percentage points, broadly in line with the European results.

Underlying the aggregate response of the headline CPI index is important heterogeneity, which we explore next. For the CPI categories “Energy”, “Food” and “Core CPI”, we estimate similar responses and plot the difference of the average carbon tax economy and the average counterfactual economy (i.e. subtracting the solid and the dashed lines in Figure 1) in Figure 2. Starting with the European sample (Panel A) we first note that compared to headline CPI the counterfactual economies are less precisely estimated, illustrated by deviations from zero in the years before the tax enactment. This is most pronounced for the volatile food and energy components. Comparing the various categories, energy (blue line) increases initially (in the tax economy *relative* to the counterfactual economy) after the tax implementation, but then falls after the third year. Core CPI (red line) declines persistently, by about 5 percentage points after five years. Similarly, food prices (green line) tend to fall in the years after the tax implementation.

The average counterfactual is more accurately estimated for the sample of Canadian provinces (Panel B). We see little deviation prior to the tax implementation, afterwards we

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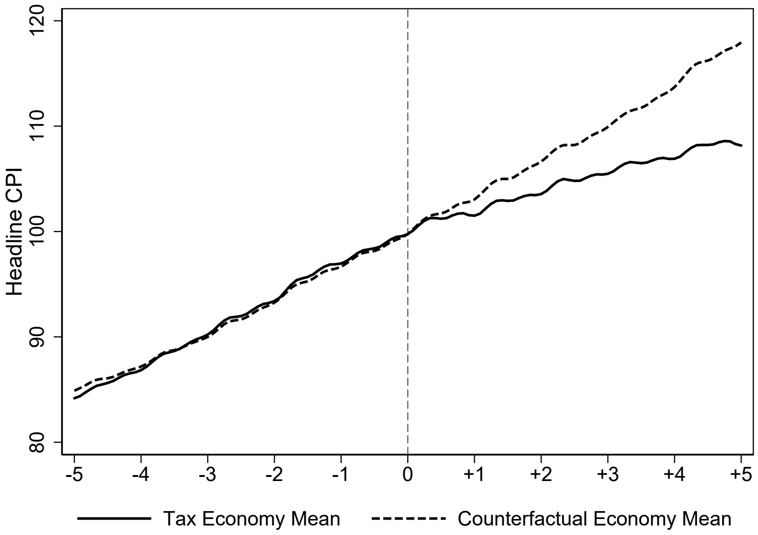
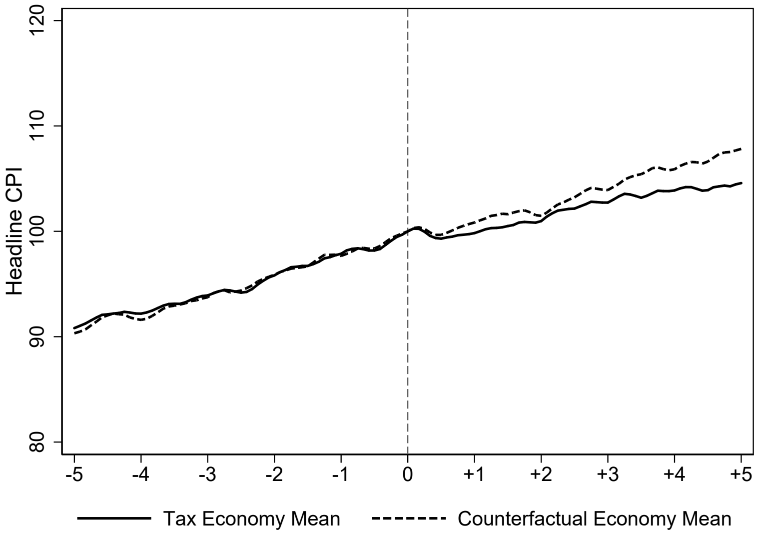
[12] We normalize the CPI to 100 in the month of the tax implementation to highlight the patterns after the tax. Similar graphs for a sample of individual countries are reported in Figures B1 and B2 of Appendix B. Table B1 of Appendix B lists the weights the algorithm selects for the construction of each counterfactual economy.

Figure 1: Headline CPI Synthetic Control

A. Europe



B. Canada

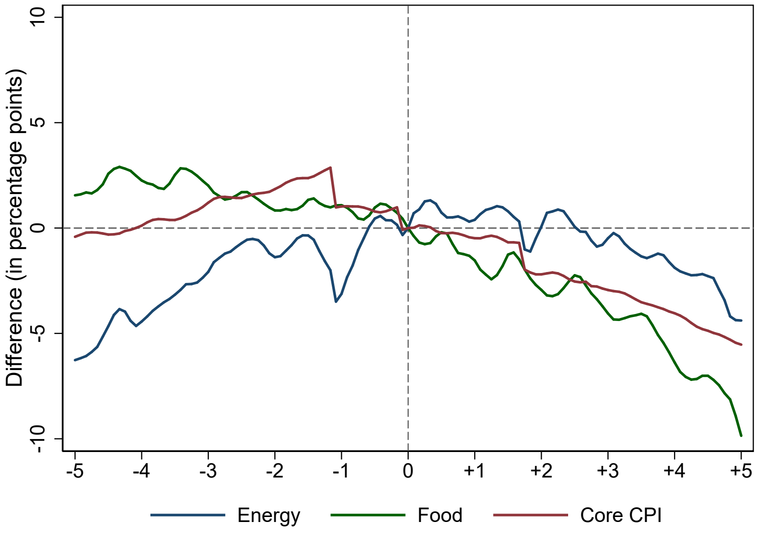


Notes: Figure shows the path of headline CPI for the average European (Panel A) and Canadian (Panel B) carbon tax economies, in the 10 years around the tax implementation date (normalized to 100 in the month of the tax enactment) relative to the average counterfactual economies (dashed lines). More details on the construction of the counterfactual economies in Table B1 and Figures B1 and B2 of Appendix B.

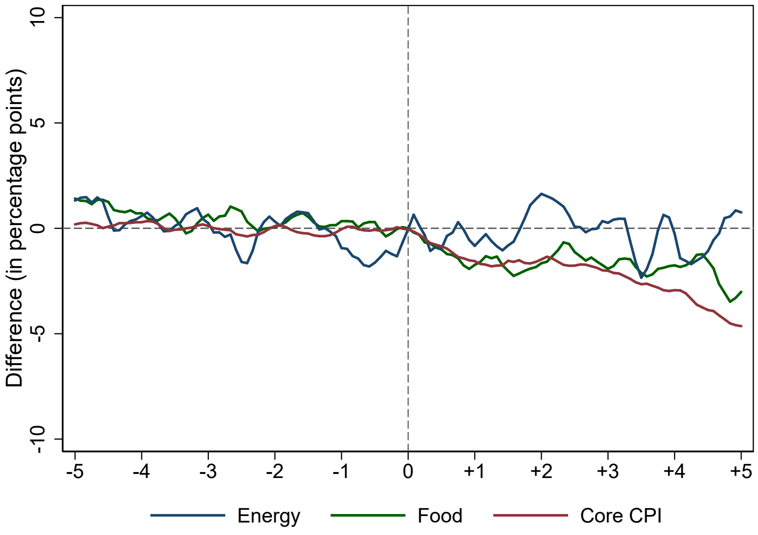
find similar results as in Europe: Energy prices tend to increase slightly in the carbon tax economies, before they oscillate around zero. Conversely, food prices experience a modest fall, and core CPI declines persistently, by roughly 4.5 percentage points after five years.

Figure 2: CPI categories Synthetic Control

A. Europe



B. Canada



Notes: Figure shows the gap in CPI categories between the average tax economies and the average counterfactual economies for Europe (Panel A) and Canada (Panel B) in the 10 years around the tax implementation date (normalized to 0 in the month of the tax enactment). More details on the construction of the counterfactual economies in Table B1 and Figures B1 and B2 of Appendix B.

To summarize, the preliminary evidence on the response of aggregate consumer prices and its components does not point to rapid inflation after carbon taxes are implemented. On the contrary: if anything, the simple counterfactual exercises suggest deflationary effects associated with the introduction of carbon pricing. However, as we note above, event studies do not control for potential confounding factors, such as diverging economic conditions in the tax and counterfactual economies that are unrelated to the tax itself. To better address these identification issues we next turn to our core empirical analysis building on local projections.

4.2 Main result: little evidence of an inflationary response to carbon pricing

We proceed in a similar fashion for presenting the main results, starting with the European sample before providing evidence from Canada. Throughout, we separately report results for headline and core CPI inflation, as well as different sub-samples. For instance, we exclude small European taxes to ensure they do not drive our results. For Canada, we separately analyse the BC carbon tax, which has received much attention in the academic literature.

The dynamic impulse responses for European countries to a one time permanent introduction of a 40 USD carbon tax applied to 30 percent of emissions are summarized in Table 2. We begin with headline CPI inflation (Panel A), distinguishing between the immediate response (in year 0 after the tax), the short-term effect (average in years 1 and 2) and the medium-term effect through years 3 to 5. For the complete sample of 15 carbon taxes, we start with a model including country fixed effects in the first row. The estimated responses are small in magnitude and imprecisely estimated: On impact, the tax leads to a slight increase in inflation by 0.17%. Over the short- to medium-term the response becomes negative, between 0.30% and 0.41% on average, with both coefficients barely exceeding their standard errors.

Next, we add GDP per capita growth and the change in the domestic monetary policy rate (entering with 4 lags each) in the model, to control for changes in the macro-financial environment around the tax increase. The estimated responses (in row 2) barely change and remain quantitatively small and imprecisely estimated. The third row presents results from our baseline specification, including country and year fixed effects. The dynamic responses are positive, albeit small and not precisely estimated: We find an initial increase of 0.42%, that phases out to 0.14% in the first two years after the tax, and averages 0.25% from years 3 to 5. Only the estimate in year zero exceeds its standard error.

For illustration we plot the cumulative impulse response (under a parallel path assumption) for the complete European sample, including country and year fixed effects, in Figure 3 (Panel A). Shaded gray bounds denote confidence bands of one and two standard deviations, respectively. In the five years after the tax implementation, the dynamic response lies within one standard error of zero. This confirms our preliminary finding on the absence of a robust inflationary effect after carbon tax enactments in Europe.

The results remain of similar magnitude and statistical precision when excluding taxes below 20 USD, reassuring us that the responses are not driven by small European taxes. If anything the estimated dynamic effects are quantitatively smaller compared to the complete sample, suggesting that carbon taxes are associated with less upward price pressure in the

Table 2: Local Projections, European sample

Sample	Controls	Impact in year 0	Impact in year 1–2	Impact in year 3–5
Panel A. Headline Inflation				
EU+	Country FE	0.17	−0.41	−0.30
		(0.33)	(0.34)	(0.25)
EU+	Ec. Controls	−0.07	−0.08	−0.39
		(0.37)	(0.24)	(0.19)
EU+	Country+Time FE	0.42	0.14	0.25
		(0.33)	(0.31)	(0.30)
CT20	Country FE	0.12	−0.53	−0.45
		(0.32)	(0.30)	(0.25)
CT20	Ec. Controls	−0.05	−0.24	−0.36
		(0.34)	(0.19)	(0.15)
CT20	Country+Time FE	0.41	0.09	−0.01
		(0.34)	(0.30)	(0.30)
Panel B. Core Inflation				
EU+	Country FE	0.22	−0.34	−0.26
		(0.36)	(0.28)	(0.25)
EU+	Ec. Controls	−0.03	−0.20	−0.19
		(0.30)	(0.22)	(0.23)
EU+	Country+Time FE	0.21	−0.09	0.09
		(0.40)	(0.33)	(0.29)
CT20	Country FE	0.16	−0.48	−0.37
		(0.36)	(0.25)	(0.20)
CT20	Ec. Controls	0.01	−0.25	−0.17
		(0.30)	(0.18)	(0.18)
CT20	Country+Time FE	0.30	−0.03	−0.04
		(0.38)	(0.28)	(0.22)

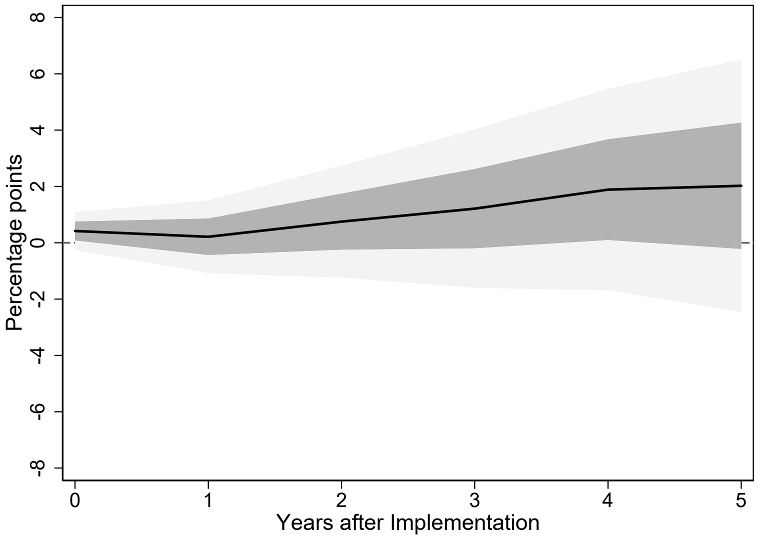
Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. “EU+” uses the whole sample of European countries, “CT20” excludes taxes below 20 USD. “Ec. Controls” includes GDP growth (per capita) and the domestic central bank policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on country.

European economies that implemented larger carbon taxes.

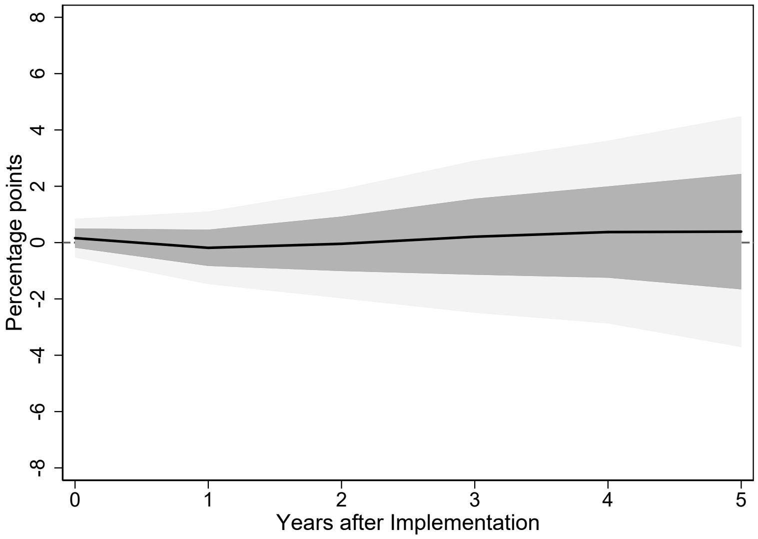
In the previous section we documented diverging responses of headline and core CPI to carbon taxes, as a result of increasing energy prices. To formally test for this, we repeat our analysis with core CPI inflation as a dependent variable in Panel B of Table 2. Mirroring the results for headline inflation, the estimated responses are close to zero and seldom exceed their standard errors. For the “EU+” sample, we find a small positive response on impact, that phases out over the five years after the tax enactment, when including

Figure 3: Cumulative Impulse Response, European sample

A. Headline Inflation



B. Core Inflation



Notes: Figure shows the cumulative dynamic impulse responses of headline (Panel A) and core inflation (Panel B) for the "EU+" sample to a 40 USD carbon tax with 30% emission coverage. All impulse responses are computed from a model that includes country and time fixed effects. Shaded gray bounds denote one (light gray) and two (dark gray) standard deviations around the estimated response.

country and year fixed effects (third row). The dynamic responses excluding taxes below 20 USD look identical.

Once more, we graphically illustrate the cumulative dynamic effect of core CPI inflation for the baseline sample, including country and year fixed effects in Panel B of Figure 3. In the five years after the tax, the response of inflation is very close to zero and imprecisely estimated. Compared with headline inflation (Panel A), core inflation shows a more muted dynamic response. This is consistent with our preliminary evidence that carbon taxes primarily affect energy prices, but do not spill over to other prices (see also Känzig (2021)).

Next, we replicate the empirical analysis for the sample of Canadian provincial carbon taxes. The findings are consistent with the European evidence on the lack of an inflationary effect, and if anything, point to deflationary responses. Panel A of Table 3 uses headline CPI inflation as the dependent variable. In the specification using the full sample and including provincial and year fixed effects (row 3), we estimate a small negative initial, followed by a positive short-term response. In years 3–5 the effect turns negative again, and is precisely estimated. When we exclude Quebec and Alberta the dynamic effects become larger in magnitude: Initially headline inflation increases by 1.96 percentage points, in the following five years the response drops to –0.75% per year, on average.

Figure 4 (Panel A) shows the cumulative impulse response of headline CPI inflation for the full sample and including province and year fixed effects. We note immediately that the dynamic response is more precisely estimated compared to the European sample, although the error bands (shaded gray) exclude zero only in year five. For Canadian provinces, the estimate response of headline inflation to the carbon tax is –1.5% (after 5 years), which is consistent with the preliminary evidence from on the event studies.[13]

Similarly, the impulse responses for core inflation are broadly consistent with the European-based estimates (Panel B). We find negative initial and medium-term responses when using all Canadian provinces and including year fixed effects (row 3), with the latter effect precisely significant. When using only BC, we estimate a positive contemporaneous effect that turns negative over the short- to medium-term. Most of the point estimates for core inflation lie below their counterparts for headline inflation.

Panel B of Figure 4 highlights this difference graphically (based on the full sample including province and time fixed effects): We find evidence of a deflationary response in years 1, 4 and 5 after the tax implementation. Compared to headline inflation, the dynamic response path is shifted downwards, but still very close to zero when looking at error bands. Albeit at a lower level, the responses corroborate the evidence from Europe on the lack of an inflationary effect of historical carbon taxes.

In summary, both the European countries and the Canadian provinces provide little evidence of a broad inflationary effect associated with the introduction of a carbon tax. Whereas the results point to modest and imprecisely estimated effects in Europe, we even find slightly deflationary responses in Canadian provinces. Moreover, we show that any inflationary responses are confined to headline CPI and less prevalent in core CPI inflation, consistent with relative price changes. These findings are robust to alternative empirical methodologies and data sources (see Appendix C).

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[13] One explanation for the negative price response in British Columbia is related to the very progressive redistribution scheme. When the high-income households bear the burden of the tax and cut back on consumption as a result, it could put downward pressure on prices of other CPI categories, such as services (consistent with the dynamics displayed in Panel B of Figure 2).

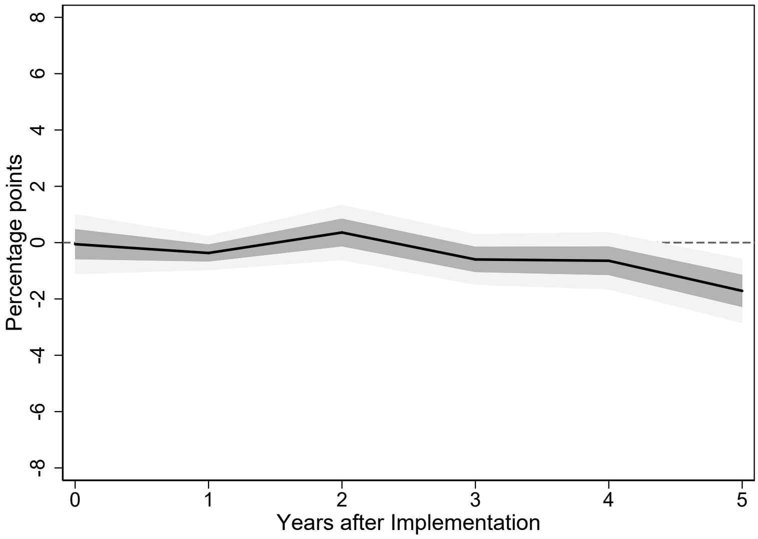
Table 3: Local Projections, Canadian sample

		Impact in year		
Sample	Controls	0	1–2	3–5
Panel A. Headline Inflation				
All	Prov. FE	−0.30	−0.16	−0.88
		(0.49)	(0.31)	(0.33)
All	Ec. Controls	0.28	−0.19	−0.81
		(0.48)	(0.32)	(0.36)
All	Prov.+Time FE	−0.06	0.24	−0.68
		(0.53)	(0.22)	(0.26)
Only BC	Prov. FE	0.96	−0.34	−1.08
		(1.53)	(0.79)	(0.40)
Only BC	Ec. Controls	0.81	−0.46	−1.08
		(1.14)	(0.52)	(0.27)
Only BC	Prov.+Time FE	1.96	−0.75	−0.77
		(1.20)	(0.73)	(0.38)
Panel B. Core Inflation				
All	Prov. FE	−0.52	−0.30	−0.64
		(0.43)	(0.27)	(0.32)
All	Ec. Controls	−0.02	−0.41	−0.42
		(0.40)	(0.34)	(0.23)
All	Prov.+Time FE	−0.37	0.01	−0.55
		(0.55)	(0.19)	(0.17)
Only BC	Prov. FE	1.10	−1.19	−0.64
		(1.04)	(0.38)	(0.20)
Only BC	Ec. Controls	1.10	−1.38	−0.29
		(0.98)	(0.30)	(0.18)
Only BC	Prov.+Time FE	1.80	−0.97	−0.34
		(1.05)	(0.42)	(0.28)

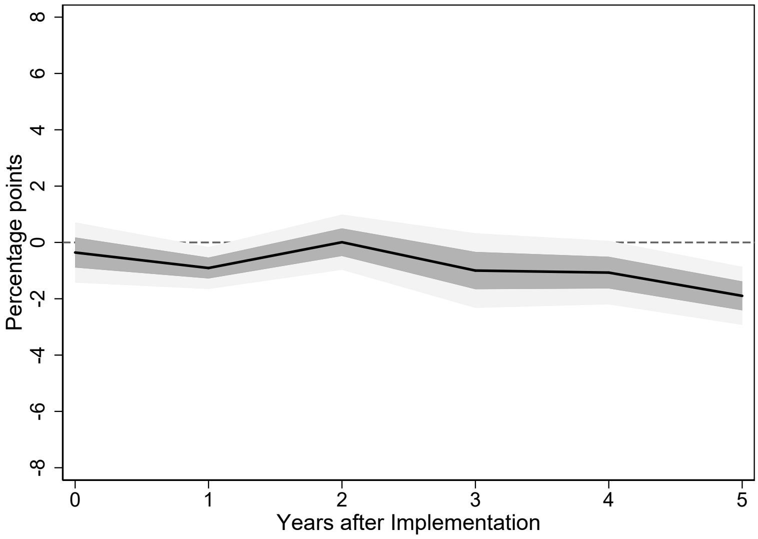
Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. “All” uses the whole sample of Canadian tax provinces, “Only BC” excludes taxes in Quebec and Alberta. “Ec. Controls” includes GDP growth (per capita) and the BOC central bank policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on province.

Figure 4: Cumulative Impulse Response, Canadian sample

A. Headline Inflation



B. Core Inflation



Notes: Figure shows the cumulative dynamic impulse responses of headline (Panel A) and core inflation (Panel B) for the full Canadian sample to a 40 USD carbon tax with 30% emission coverage. All impulse responses are computed from a model that includes province and time fixed effects. Shaded gray bounds denote one (light gray) and two (dark gray) standard deviations around the estimated response.

5 The cross-section of European carbon taxes

In this section we build on the baseline empirical analysis by asking whether the effects we estimate vary for different sub-samples of European carbon tax countries. First, we explore heterogeneity in terms of implementation date, distinguishing between three waves of carbon taxes in Europe. This serves to understand whether the results are sensitive to the timing of implementation, for instance due to the prevailing macro-financial environment. Second, we shed light on the role of revenue recycling, by broadly classifying the countries in our sample into (non-)recycling countries. Lastly, we evaluate whether the response of inflation to pricing carbon is potentially endogenous to the monetary policy regime, by grouping countries with and without autonomous monetary policy. We find support for both monetary policy and revenue recycling affecting the response of inflation to putting a price on carbon.

5.1 Three waves of carbon taxes

Our data encompass carbon taxes implemented over a 25 year span, between 1990 and 2015. To test whether the response of inflation is dependent on the time of the tax implementation, we sort our tax countries into three groups ("waves"): The first includes all taxes that came into effect before 2000, consisting of the Scandinavian countries, Poland and Slovenia. Taxes enacted between 2000 and 2010 build the second group. The final group comprises of taxes introduced after 2010 (UK, Spain, France and Portugal). To assess the response for each wave, we separately estimate the model by excluding those taxes not belonging to a particular wave, e.g. excluding all taxes beyond the year 2000 to capture the first wave effect.

The dynamic impulse responses to the 40 USD carbon tax with 30% coverage are displayed in Table 4. We start with the effect on headline inflation (Panel A) for the first wave ("W1") of tax countries. Consistent with the overall results, we find a small and imprecisely estimated response, when including country and time fixed effects (row 3). In none instance do the point estimates exceed their standard errors. The results barely change when using core CPI inflation (Panel B), if anything they become smaller (or more negative).

The dynamic effects are more sizeable for the second wave of carbon taxes ("W2"): The response of headline inflation is 1% on average in each period after the tax enactment, albeit with very large standard errors. The estimates well exceed those for the first wave and the whole sample. We focus on core inflation in Panel B and find broadly similar responses: Initially, the effect is positive and quantitatively large with greater statistical precision, but decreases in magnitude over the next five years.

For taxes enacted after 2010 ("W3") we find a positive dynamic response on impact, when including country and year fixed effects. Afterwards, the coefficients remain positive, albeit at a smaller level and less precisely estimated. Turning to core inflation (Panel B), the dynamic responses are very close to zero over the estimation period, and even turn negative in the medium-term.

Overall, the evidence from three waves of carbon taxes points to more inflationary effects for the more recent tax implementations: Whereas early taxes induce little price pressure, the effect becomes larger for taxes implemented since 2000. Nonetheless, we find that any inflationary pressure that may arise shows up predominantly in headline, but not core inflation. In a vacuum this pattern is hard to rationalize, given that the first wave of carbon taxes was characterized by higher tax rates and coverage, compared to the latter ones. We therefore explore other differences in tax design and monetary conditions that might explain the varying responses of inflation to carbon pricing across the three waves.

5.2 Revenue recycling

Some countries introduced carbon taxes in conjunction with revenue recycling mechanisms, where tax proceeds are used to offset existing distortionary taxes, or for lump-sum payments to households. Revenue recycling potentially affects the response of inflation to carbon pricing, if some groups are compensated more than others. We classify countries following the definition of Metcalf and Stock (2020a).[14] and re-estimate the local projections for each group separately.

We present the results in Table 5. Starting with the revenue recycling countries ("RR1"), we find responses of headline inflation that are small and fail to exceed their standard errors, when including country and year fixed effects. The estimated effects are larger in magnitude for the sample of non-revenue recycling countries ("RR0"). On impact, the coefficient is small and imprecisely estimated, but increases over time until 1.19% in the final three years, on average.

Turning to core inflation, we estimate responses that are in line with the previous findings. When estimated on the sample of revenue recycling countries all dynamic effects are around zero, on average. For the countries that do not recycle tax proceeds the local projections yield responses that are initially positive but decay over the five years after the tax enactment. None of the estimates exceed their standard errors.

Based on these results, it does seem like the response of inflation is more muted for economies that introduced carbon taxes in conjunction with recycling mechanisms. Although we do not test this relationship further, it is broadly in line with suggestive evidence by Metcalf and Stock (2020a), emphasizing the potential growth enhancing effects of revenue recycling. The fact that early carbon tax adopters overwhelmingly recycle tax revenues can rationalize the diverging results for the three waves considered above.

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[14] We note that this simple classification might not do justice in accounting for often complex differences in tax design. For instance, France vowed to use revenues to lower the tax burden on low-income households and pensioners (see Marten and Van Dender 2019), but is classified as a non-revenue recycling country in Metcalf and Stock 2020a.

Table 4: Local Projections, Three European waves

Sample	Controls	Impact in year 0	Impact in year 1–2	Impact in year 3–5
Panel A. Headline Inflation				
W1	Country FE	0.22	−0.42	−0.14
		(0.38)	(0.38)	(0.33)
W1	Ec. Controls	−0.04	0.00	−0.38
		(0.46)	(0.27)	(0.20)
W1	Country+Time FE	0.32	−0.03	0.25
		(0.38)	(0.36)	(0.34)
W2	Country FE	0.97	0.56	−1.86
		(1.32)	(1.40)	(0.74)
W2	Ec. Controls	1.10	0.46	−0.37
		(1.13)	(1.28)	(1.10)
W2	Country+Time FE	1.65	1.37	1.05
		(1.09)	(1.13)	(0.69)
W3	Country FE	−1.34	−1.30	1.05
		(0.97)	(0.80)	(1.35)
W3	Ec. Controls	−0.95	−0.11	0.29
		(1.60)	(0.71)	(1.07)
W3	Country+Time FE	2.15	0.33	1.32
		(1.15)	(0.49)	(1.11)
Panel B. Core Inflation				
W1	Country FE	0.25	−0.29	−0.14
		(0.42)	(0.34)	(0.30)
W1	Ec. Controls	−0.09	−0.14	−0.15
		(0.33)	(0.26)	(0.23)
W1	Country+Time FE	0.10	−0.27	0.10
		(0.43)	(0.38)	(0.32)
W2	Country FE	1.01	0.13	−1.10
		(1.36)	(1.26)	(0.97)
W2	Ec. Controls	1.72	0.43	−0.29
		(1.09)	(1.10)	(1.21)
W2	Country+Time FE	2.15	1.68	0.31
		(1.41)	(1.17)	(0.95)
W3	Country FE	−0.51	−0.30	0.07
		(0.65)	(0.43)	(0.91)
W3	Ec. Controls	−0.52	0.10	−0.27
		(0.85)	(0.49)	(0.76)
W3	Country+Time FE	−0.08	0.03	−0.43
		(0.95)	(0.52)	(1.22)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. “W1” excludes carbon taxes implemented after the year 2000, “W2” uses only carbon taxes implemented between 2000 and 2010. Any carbon taxes enacted prior to 2010 are dropped for the final wave (“W3”). “Ec. Controls” includes GDP growth (per capita) and the domestic central bank policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on country.

Table 5: Local Projections, Revenue recycling

Sample	Controls	Impact in year 0	1–2	3–5
Panel A. Headline Inflation				
RR1	Country FE	0.21	−0.45	−0.28
		(0.38)	(0.32)	(0.25)
RR1	Ec. Controls	0.04	−0.15	−0.39
		(0.39)	(0.23)	(0.19)
RR1	Country+Time FE	0.27	−0.09	0.14
		(0.38)	(0.32)	(0.26)
RR0	Country FE	−0.59	0.47	−0.83
		(1.68)	(1.59)	(0.90)
RR0	Ec. Controls	−0.12	0.69	0.14
		(1.52)	(1.02)	(1.28)
RR0	Country+Time FE	0.32	0.84	1.19
		(1.34)	(1.03)	(0.59)
Panel B. Core Inflation				
RR1	Country FE	0.22	−0.33	−0.18
		(0.38)	(0.30)	(0.28)
RR1	Ec. Controls	−0.09	−0.22	−0.20
		(0.28)	(0.21)	(0.20)
RR1	Country+Time FE	0.01	−0.32	0.10
		(0.40)	(0.34)	(0.29)
RR0	Country FE	0.80	−0.22	−0.61
		(1.67)	(1.10)	(1.22)
RR0	Ec. Controls	1.04	0.15	0.60
		(1.40)	(1.03)	(1.43)
RR0	Country+Time FE	1.59	0.61	0.51
		(1.74)	(1.05)	(1.23)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. “RR1” includes only those carbon tax countries that recycle revenues, based on the classification by Metcalf and Stock (2020). This includes Denmark, Finland, Norway, Portugal, Sweden and Switzerland. “RR0” excludes all carbon taxes of countries that recycle tax proceeds. “Ec. Controls” includes GDP growth (per capita) and the domestic central bank policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on country.

5.3 The role of monetary policy

Finally, we test whether the effect of carbon taxation on inflation depends on a country's autonomy over monetary policy. This channel is emphasized by McKibbin, Konradt, and Weder di Mauro (2021), who show that the economic consequences of climate policies are not independent of monetary policy. Unfortunately we do not have a direct way of testing for interaction effects, but Europe provides a neat setting to distinguish between countries with own central banks that can potentially react to any price pressure associated with carbon taxes, and those countries that fall under the umbrella of the ECB, which does not take individual country dynamics into account.

When using only those countries with independent monetary policy ("MP1") the dynamic responses point to a small initial response of headline inflation, including country and year fixed effects (Table 6, Panel A). The estimates enter negative territory in the five years after the tax. Conversely, we find positive and precisely estimated positive effects for the sample including the Euro area countries ("MP0"). On average, the dynamic response exceeds 1% and is roughly double its standard errors.

We find smaller, more negative responses when using the core CPI inflation measure (Panel B). For countries with independent monetary policy the responses are negative but imprecisely estimated. The results based on the countries without independent monetary policy also lie below the headline inflation estimates, but are still positive and precisely estimated compared to results reported above.

Three waves of carbon taxes in Europe provide us with suggestive evidence on the heterogeneity of responses of inflation to pricing carbon: Based on the local projections, we find that early carbon taxes, enacted in countries with independent monetary policy and revenue recycling schemes are associated with little price pressure. Conversely, later carbon taxes implemented in Euro zone countries that do not feature a revenue recycling mechanism have induced an inflationary response.

6 Conclusion

Against the backdrop of the current debate on the economic effects of climate mitigation policies by market participants and central banks, this paper empirically assesses the response of inflation to carbon pricing. Does putting a tax on carbon in fact lead to "greenflation"?

Our findings, drawing on 18 carbon taxes from Europe and Canada, cast doubt on the view that carbon pricing leads to inflation. Controlling for country and year fixed effects, as well as economic controls, we find no evidence of an inflationary response, on average. This result holds both for European countries and Canadian provinces, and survives a battery of robustness checks.

Moreover, we document that any inflationary effects associated with putting a price on carbon are confined to headline CPI indices, but do not spill over to core CPI measures.

Table 6: Local Projections, Monetary policy

		Impact in year		
Sample	Controls	0	1–2	3–5
Panel A. Headline Inflation				
MP1	Country FE	−0.08	−0.70	−0.41
		(0.33)	(0.35)	(0.25)
MP1	Ec. Controls	−0.33	−0.29	−0.49
		(0.36)	(0.22)	(0.19)
MP1	Country+Time FE	0.16	−0.29	−0.09
		(0.41)	(0.36)	(0.29)
MP0	Country FE	1.18	1.18	0.36
		(0.56)	(0.78)	(0.69)
MP0	Ec. Controls	1.15	1.03	0.71
		(0.52)	(0.56)	(0.60)
MP0	Country+Time FE	1.03	1.72	1.77
		(0.39)	(0.54)	(0.53)
Panel B. Core Inflation				
MP1	Country FE	0.00	−0.55	−0.35
		(0.39)	(0.34)	(0.29)
MP1	Ec. Controls	−0.30	−0.32	−0.31
		(0.28)	(0.23)	(0.20)
MP1	Country+Time FE	−0.10	−0.51	−0.11
		(0.42)	(0.36)	(0.30)
MP0	Country FE	0.97	0.45	0.08
		(0.57)	(0.53)	(0.40)
MP0	Ec. Controls	0.95	0.55	0.66
		(0.62)	(0.55)	(0.60)
MP0	Country+Time FE	1.00	1.08	0.92
		(0.73)	(0.65)	(0.50)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. "MP0" includes only the sample of carbon taxes in countries without autonomous monetary policy, i.e. Euro area members and Denmark (the krone is pegged to the Euro). "MP1" instead uses the set of countries with autonomous monetary policy. "Ec. Controls" includes GDP growth (per capita) and the domestic central bank policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on country.

This is consistent with the idea that carbon taxes change relative prices, increasing the cost of energy, but do not lead to a broad increase in prices.

Drawing our attention to a subset of European carbon taxes allows us to exploit differences in tax design and implementation. We find that the response of inflation to a similarly sized carbon tax shock is more muted in countries that adopted carbon taxes early, recycle tax revenues and have monetary autonomy to react to changing prices. Further research will be needed to draw the broader implications for optimal monetary policy reactions in response to carbon price shocks.

In summary, our results broadly support the notion on the limited economic effects of historical carbon taxes, despite their success in reducing emissions. Indeed, when seen in conjunction with the previous literature on carbon pricing, taxing carbon appears an efficient tool in reducing emissions with limited economic consequences. Nonetheless, we recognize that much more aggressive carbon taxation may become necessary to reach the emission reduction targets and it is plausible that a broad and steep increase in carbon taxes may induce more economic consequences compared to their historical counterparts.

Since our analysis is at the aggregate level we are not well equipped to investigate potential channels of how carbon pricing affects inflation dynamics. At the firm-level, understanding tax incidence seems paramount: (how) do firms pass on carbon taxes to consumers?[15] Moreover, households could form expectations of more ambitious climate policy and accommodate higher energy prices already prior to the tax enactment (see e.g. Coibion and Gorodnichenko 2015). Household expenditure behavior might also shed light on whether the tax induces them to switch from more expensive energy-intensive goods and services to cheaper, less energy-intensive alternatives (e.g. Bems and Di Giovanni 2016).

Of course, in most countries carbon taxes are only one part of a comprehensive toolkit to combat climate change. Focusing solely on carbon taxes might blur the picture when trying to understand the economic effects of climate policy more broadly. A study encompassing shadow prices from other instruments complementary to the carbon taxes could be a promising avenue for future research.

Finally, the distributional consequences of carbon taxes also have to be seen in synthesis with their effects on prices. As prior studies suggest (see e.g. Känzig 2021) carbon taxes tend to burden low income households most in the absence of a progressive redistribution mechanism. To the extent that low income households consumption baskets include relatively more energy-intensive goods and services whose prices tend to increase, our findings offer an explanation for this distributional pattern.

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[15] We provide indicative evidence in McKibbin, Konradt, and Weder di Mauro (2021) that producer prices increase more than consumer prices after carbon tax enactment, for Euro area countries.

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Appendix A Robustness checks

In this appendix we provide additional results building on the baseline empirical analysis. In sections A.1 and A.2 we test whether our main results are sensitive to the empirical methodology by using panel-VARs and distributed lag models, respectively. Moreover, we re-estimate the local projections with emission-weighted carbon tax rates by Dolphin, Pollitt, and Newbery (2020) in section A.3. Finally, we use alternative inflation measures based on new data by Ha, Kose, and Ohnsorge (2021) in section A.4.

A.1 Panel-VAR models

In this section, we repeat our study on the effects of carbon taxation on inflation by substituting a structural vector autoregressive (VAR) model, adapted to panel data for the local projections. Although we do not expect this to substantially affect the results (see e.g. Plagborg-Møller and Wolf 2021) it serves as an additional check on our findings. Formally, we estimate a similar model as before separately for headline and core CPI inflation as a dependent variable:

$$\Delta CPI_{i,t+h} = \alpha_i + \Theta_h \tau_{i,t} + \beta(L)\tau_{i,t-1} + \delta(L)\Delta CPI_{i,t-1} + \gamma_t + \epsilon_{i,t}$$

where τ_{it} is the real carbon tax rate in economy i in year t. Θ_h is the effect of an unexpected change in the carbon tax at year t on annual CPI in h years. To control for persistence of the tax rate and CPI, we include the 4 latest lags of each variable in the regression. Unobserved heterogeneity specific to each economy or year is absorbed by a set of fixed effects, α_i and γ_t. The identifying assumption is identical to the local projections. For comparability we consider a similar carbon tax scenario as before, i.e. a 40 USD carbon tax applied on 30% of GHG emissions.

The estimated responses for the whole European sample of carbon tax countries are summarized in Table A1. Panel A reports the responses of headline inflation and points to very similar estimates compared to the local projections-based results. The dynamic responses are small and imprecisely estimated, in neither case do they exceed their standard errors. For core inflation (Panel B), we find similar estimates that are both small in magnitude and imprecisely estimated. If anything, the VAR-based results for the European sample imply more muted responses of inflation to carbon pricing, compared to the local projections.

Results based on Canadian provinces are presented in Table A2. Again, we estimate responses that enter with a negative sign, but are estimated with low precision for headline CPI inflation (Panel A). For core inflation the results are slightly larger in magnitude, but remain negative and imprecisely estimated. Overall, these dynamic responses are remarkably consistent with the local projections-based results in Table 3.

Table A1: Panel-VARs, European countries

		Impact in year		
Sample	Controls	0	1–2	3–5
Panel A. Headline Inflation				
EU+	Country+Time FE	0.11	−0.09	−0.70
		(0.83)	(0.70)	(0.77)
Panel B. Core Inflation				
EU+	Country+Time FE	0.22	−0.22	−0.38
		(0.57)	(0.50)	(0.53)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. Estimates are based on the panel-VAR model for the whole sample of European tax countries and include country and year fixed effects. Standard errors are heteroscedasticity robust and clustered on country.

Table A2: Panel-VARs, Canadian provinces

		Impact in year		
Sample	Controls	0	1–2	3–5
Panel A. Headline Inflation				
All	Prov.+Time FE	−0.28	−0.10	−0.56
		(0.86)	(0.97)	(1.21)
Panel B. Core Inflation				
All	Prov.+Time FE	−0.75	0.00	−0.73
		(0.68)	(0.78)	(0.96)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. Estimates are based on the panel-VAR model for the whole sample of Canadian tax provinces and include province and year fixed effects. Standard errors are heteroscedasticity robust and clustered on province.

A.2 Distributed lag models

As an additional robustness exercise, we employ distributed lag models to assess the effect of carbon taxation on inflation. Compared to local projections and panel-VARs, distributed lag models require a stronger identification assumption of no feedback from changes in economic conditions and inflation to the carbon tax rate.

Formally, we estimate the following equation with inflation (headline and core, respectively) as a dependent variable:

$$\Delta CPI_{i,t} = \beta(L)\tau_{i,t} + \delta_i + \gamma_t + \epsilon_{i,t}$$

where τ_{it} is the real carbon tax rate in economy i in year t. β captures the dynamic effect of a change in the carbon tax rate in the carbon tax at year t on inflation. All variables enter the regression with four lags. Unobserved heterogeneity specific to each economy or year is absorbed by a set of fixed effects, δ_i and γ_t. Again, we compute responses to a counterfactual carbon tax scenario as before.

Table A3 contains the estimated responses, for headline inflation in Panel A. Following the local projections-based result we separately estimate the regression using only country fixed effects, economic controls and country and year fixed effects. Focusing on the latter specification (row 3), we find modest positive effects for the full European sample. However, none of the estimates exceed their standard errors and are well below 1% in magnitude. For core inflation (Panel B) we estimate even smaller estimates that barely surpass zero. These findings are consistent with the evidence from local projections and panel-VAR models and highlight that the empirical methodology does not drive our results.

For the Canadian sample, we find evidence of small deflationary effects (Table A4). Headline inflation shows a modest and precisely estimated negative response in the medium-term. The dynamic effect of core inflation goes in a similar direction, with negative effects in the years 3 to 5.

Table A3: Distributed Lag Models, European countries

		Impact in year		
Sample	Controls	0	1–2	3–5
Panel A. Headline Inflation				
EU+	Country FE	0.13	−0.61	−0.72
		(0.73)	(0.18)	(0.23)
EU+	Ec. Controls	−0.35	−0.43	−0.48
		(0.62)	(0.22)	(0.25)
EU+	Country+Time FE	0.70	0.26	0.19
		(0.76)	(0.43)	(0.39)
Panel B. Core Inflation				
EU+	Country FE	−0.27	−0.70	−0.72
		(0.73)	(0.21)	(0.19)
EU+	Ec. Controls	−0.91	−0.30	−0.43
		(0.55)	(0.20)	(0.17)
EU+	Country+Time FE	0.27	0.03	0.14
		(0.78)	(0.40)	(0.40)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. All estimates are based on a distributed lag model for the whole sample of European carbon tax countries. “Ec. Controls” includes GDP growth (per capita) and the domestic central bank policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on country.

Table A4: Distributed Lag Models, Canadian provinces

		Impact in year		
Sample	Controls	0	1–2	3–5
Panel A. Headline Inflation				
All	Prov. FE	−0.45	−0.07	−0.80
		(0.19)	(0.31)	(0.18)
All	Ec. Controls	−0.45	−0.14	−0.74
		(0.16)	(0.30)	(0.20)
All	Prov.+Time FE	−0.19	0.34	−0.54
		(0.58)	(0.24)	(0.12)
Panel B. Core Inflation				
All	Prov. FE	−0.69	−0.11	−0.55
		(0.27)	(0.24)	(0.20)
All	Ec. Controls	−0.62	−0.17	−0.49
		(0.27)	(0.23)	(0.23)
All	Prov.+Time FE	−0.64	0.11	−0.63
		(0.53)	(0.20)	(0.11)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. Estimates are based on the distributed lag model for the whole sample of Canadian tax provinces. "Ec. Controls" includes GDP growth (per capita) and the BOC policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on country.

A.3 Alternative tax data

In this section we repeat the local projection analysis, but alternating the carbon tax rate. We use emissions-weighted tax rates from Dolphin, Pollitt, and Newbery (2020), that account for differences among sectors, e.g. due to tax exemptions. Compared to the tax rates obtained from the World Bank, this serves to capture additional institutional nuances that we can not control for in our main analysis.

The results for the European sample are presented in Table A5. For headline inflation (Panel A) we find relatively large estimates that in most cases exceed 1%, when including country and year fixed effects. However, only in the latter period does the dynamic effect exceed its standard errors. The responses of core inflation are negative and very close to zero, for all horizons (row 3). None of the estimates are precisely estimated.

We follow the same steps to estimate responses for Canadian provinces, displayed in Table A6. For the specification with year and province fixed effects (row 3), we document quantitatively large and precisely estimated responses. Initially headline inflation (Panel A) falls by 1.62% and continues to decline in the short-term period. However, after year three the response turns positive, resulting in a slightly inflationary cumulative response.

The dynamic effects are more muted (or negative) for core inflation (Panel B): On impact inflation declines by −1.88% and remains at −1.6% over the next two years, on average, when including province and year fixed effects. In the medium-term the response turns positive again, albeit at a lower level. All dynamic effects have low standard errors compared to the previous specifications. Five years removed, we find a slight deflationary effect (for core inflation) following the tax enactment.

Overall, these estimates confirm that our results are not driven by specific tax data we use to compute dynamic responses. Both for Europe and Canada the estimates remain robust when we use alternative data on carbon tax rates.

Table A5: Local projections for European countries, alternative tax data

		Impact in year		
Sample	Controls	0	1–2	3–5
Panel A. Headline Inflation				
EU+	Country FE	−0.27	−0.67	−0.30
		(0.45)	(0.47)	(0.35)
EU+	Ec. Controls	−0.02	−0.07	−0.41
		(0.38)	(0.25)	(0.18)
EU+	Country+Time FE	−0.54	1.68	1.91
		(3.27)	(2.02)	(1.78)
Panel B. Core Inflation				
EU+	Country FE	−0.82	−0.17	−0.73
		(0.77)	(0.55)	(0.34)
EU+	Ec. Controls	−0.79	0.43	−0.63
		(0.69)	(0.63)	(0.28)
EU+	Country+Time FE	−0.09	−0.17	−0.05
		(0.90)	(0.91)	(0.40)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. All estimates are based on local projections using emissions-weighted tax rates for the whole sample of European carbon tax countries. “Ec. Controls” includes GDP growth (per capita) and the domestic central bank policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on country.

Table A6: Local projections for Canadian provinces, alternative tax data

Sample	Controls	Impact in year 0	1–2	3–5
Panel A. Headline Inflation				
All	Prov. FE	−0.09	−2.86	0.84
		(1.20)	(0.70)	(0.36)
All	Ec. Controls	0.74	−0.76	0.68
		(0.91)	(1.12)	(0.51)
All	Prov.+Time FE	−1.62	−1.39	2.31
		(0.60)	(0.57)	(0.50)
Panel B. Core Inflation				
All	Prov. FE	−1.63	−2.03	1.49
		(0.73)	(0.58)	(0.34)
All	Ec. Controls	−0.27	−1.20	0.72
		(0.75)	(0.60)	(0.45)
All	Prov.+Time FE	−1.88	−1.60	1.30
		(1.00)	(0.55)	(0.41)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. All estimates are based on local projections using emissions-weighted tax rates for the whole sample of Canadian provinces. “Ec. Controls” includes GDP growth (per capita) and the BOC policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on province.

A.4 Alternative inflation data

In a recent paper, Ha, Kose, and Ohnsorge (2021) introduce a novel database on inflation, spanning a long period and encompassing a rich set of countries. The authors compile data from several sources in an effort to attain maximum coverage. Although the data show strong co-movement with our data (from the OECD), we re-estimate the baseline local projection model with the alternative inflation data. We focus on the European sample since the data are only available at the national level.

Overall the results (in Table A7) are in line with our baseline estimates. In the specification using country and time fixed effects we find a positive response for headline CPI (Panel A), that is precisely estimated in year zero and in the medium-term. Compared with the baseline results this implies a more inflationary effect when using the alternative inflation data.

Panel B displays the dynamic responses of core inflation to a change in the tax rate. The estimates are both small and do not exceed their standard errors, consistent with our earlier results, when including country and time fixed effects.

Table A7: Local projections for European countries, alternative inflation data

		Impact in year		
Sample	Controls	0	1–2	3–5
Panel A. Headline Inflation				
EU+	Country FE	−0.32	−0.34	0.23
		(0.62)	(0.35)	(0.49)
EU+	Ec. Controls	0.22	−0.14	0.43
		(0.61)	(0.38)	(0.34)
EU+	Country+Time FE	1.00	0.54	1.06
		(0.57)	(0.38)	(0.33)
Panel B. Core Inflation				
EU+	Country FE	−0.21	−0.28	−0.06
		(0.31)	(0.33)	(0.27)
EU+	Ec. Controls	−0.10	−0.11	−0.01
		(0.31)	(0.31)	(0.26)
EU+	Country+Time FE	0.07	0.15	0.19
		(0.31)	(0.28)	(0.26)

Notes: Table shows the dynamic impulse responses of headline (Panel A) and core inflation (Panel B) to a 40 USD carbon tax with 30% emission coverage. All estimates are based on local projections using inflation data by Ha, Kose, and Ohnsorge (2021) for the whole sample of European carbon tax countries. "Ec. Controls" includes GDP growth (per capita) and the domestic central bank policy rate, each entering with four lags. Standard errors are heteroscedasticity robust and clustered on country.

Appendix B Synthetic Control Method

This appendix expands on the synthetic control method used in section 4.1 of the empirical analysis. Section B.1 lists the main donor economies for the construction of the counterfactual, for each carbon tax economy. Section B.2 provides additional evidence for individual economies underlying the average results we show in Figures 1 and 2.

B.1 Donor economies

Each counterfactual economy is constructed in a data-driven way based on a pool of potential donor economies. For each carbon tax economy underlying the results presented in section 4.1 we list the main donor economies in Table B1, sorted by weight with which they enter the counterfactual.

Table B1: Synthetic controls, donor economies

Tax economy	Donor economies
Finland	United Kingdom, Germany, Canada
Norway	France, Iceland
Sweden	France, United Kingdom, South Korea
Denmark	France, Iceland
Switzerland	Japan, Norway, Belgium
Ireland	Japan, Latvia, Portugal
Iceland	Turkey, Latvia
United Kingdom	Estonia, South Korea, Netherlands
Spain	Slovenia, Austria, Greece
France	Italy, Sweden, Czech Republic
Portugal	Sweden, Lithuania, Hungary
British Columbia	Manitoba, Ontario, Prince Edward Island
Quebec	Nova Scotia, Manitoba, New Brunswick

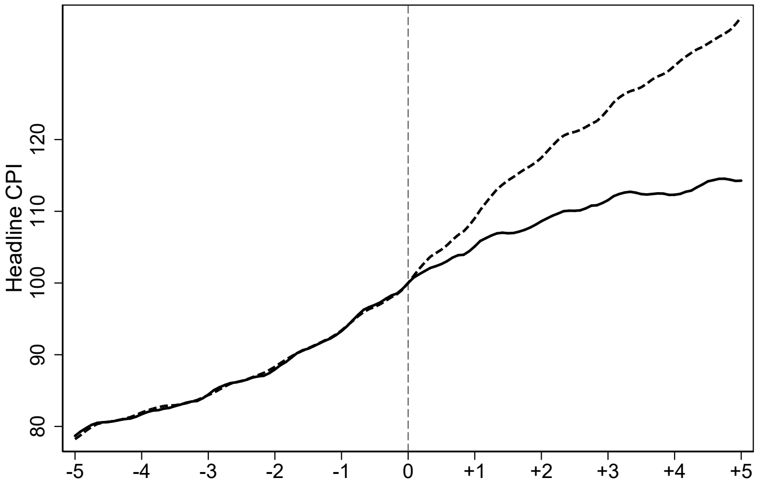
Notes: Table lists the main donor economies (by weight) for the construction of a synthetic control for Figure 1. The donor pool consists of 32 OECD countries (for Europe) and the 10 provinces (for Canada), respectively and is restricted to economies that did not introduce a carbon tax in 10 year period around a carbon tax implementation.

B.2 Individual results

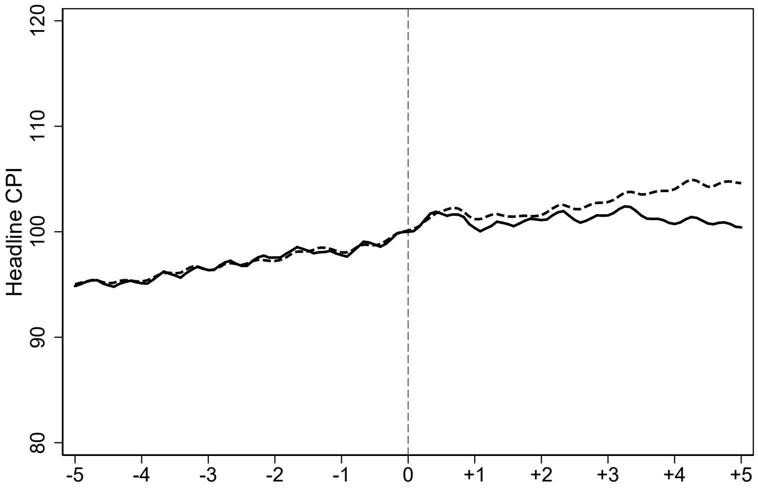
In section 4.1 we base all our results on the average effect of introducing a carbon tax, by computing the mean over all carbon tax economies and their counterfactuals. Underlying the overall average are individual responses of each economy, some of which are highlighted here. Figure B1 presents individual results based on the headline CPI index for Finland (Panel A), Switzerland (Panel B) and France (Panel C), respectively. Similarly, we separately show the responses of British Columbia (Panel A) and Quebec (Panel B) in Figure B2.

Figure B1: Synthetic controls, European countries

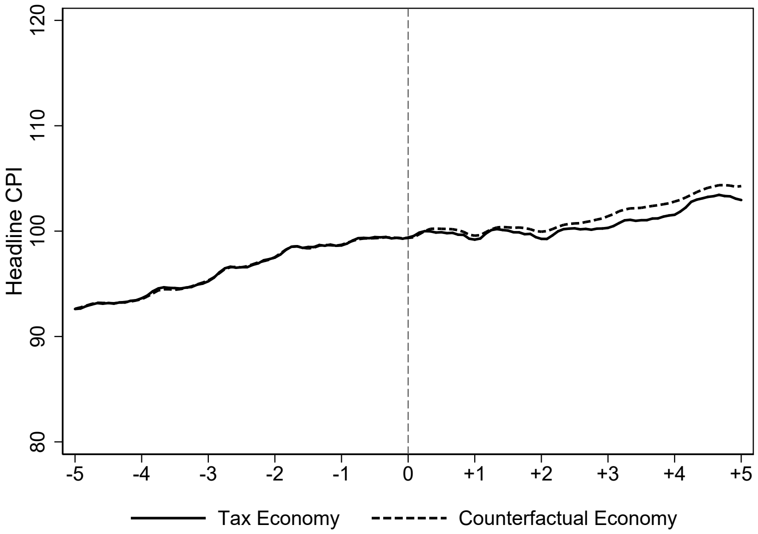
A. Finland



B. Switzerland



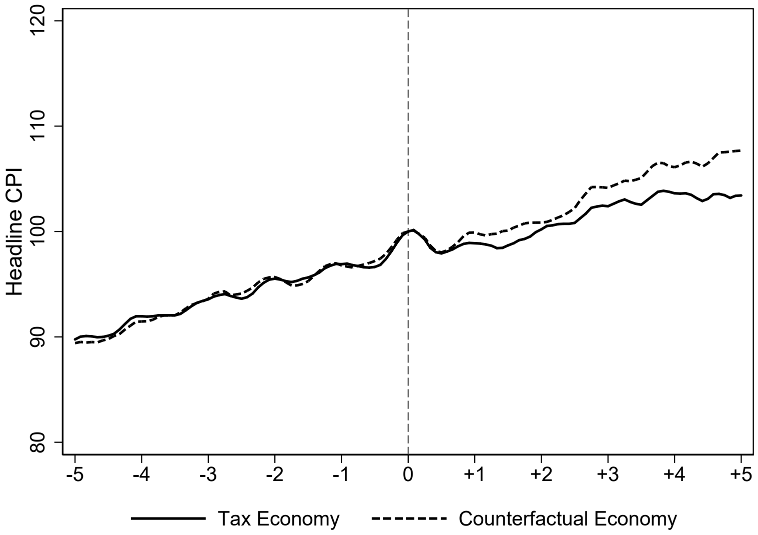
C. France



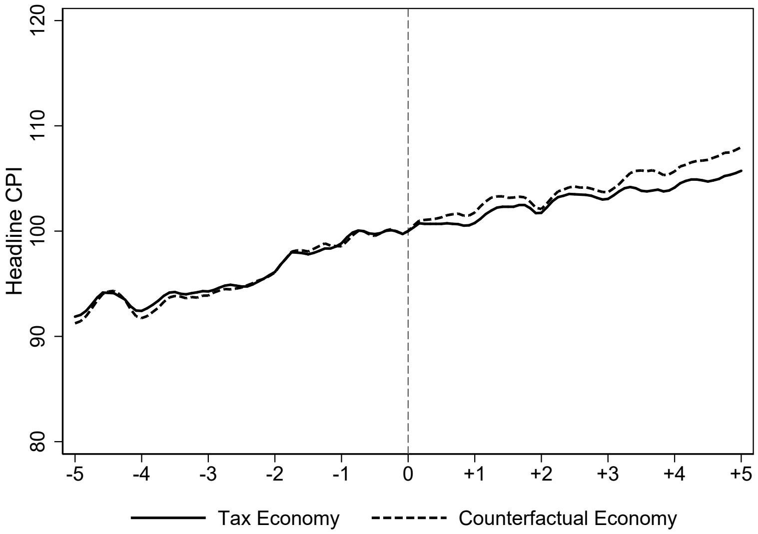
Notes: Figure shows the path of headline CPI for carbon tax countries Finland (Panel A), Switzerland (Panel B) and France (Panel C) compared to the respective counterfactual economies. The donor pool was restricted to OECD countries which did not themselves enacted a carbon tax during the 5 years before and after the tax implementation. More details on the construction of the counterfactual economies in Table B1.

Figure B2: Synthetic controls, Canadian provinces

A. British Columbia



B. Quebec



Notes: Figure shows the path of headline CPI for carbon tax provinces British Columbia (Panel A) and Quebec (Panel B), compared to the respective counterfactual economies. The donor pool was restricted to provinces which did not themselves enacted a carbon tax during the 5 years before and after the tax implementation. More details on the construction of the counterfactual economies in Table B1.

Appendix C Data

In this appendix we provide supplementary summary statistics on the economies that are part of the empirical analysis. Section C.1 further separately summarizes the samples we employ in the empirical analysis, for Europe and Canada. Section C.2 provides additional information on the specific designs for each carbon tax.

C.1 Inflation data

This section presents summary statistics on our dependent variables. Table C1 summarizes the headline and core inflation data for the sample European countries. Table C2 does the same for the 10 Canadian provinces.

Table C1: Descriptive statistics, European countries

	Headline inflation					Core inflation				
Country	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
Austria	34	1	4	2	1	34	1	4	2	1
Belgium	34	0	5	2	1	34	1	6	2	1
Czech Republic	27	0	21	5	5	23	−2	8	2	3
Denmark	34	0	5	2	1	34	1	5	2	1
Estonia	21	0	10	4	3	21	1	10	3	2
Finland	34	0	7	2	2	34	0	8	2	2
France	34	0	6	2	1	34	0	6	2	1
Germany	34	0	5	2	1	34	1	6	2	1
Greece	34	−2	23	7	7	34	−2	24	7	7
Hungary	34	0	35	11	9	28	1	36	10	9
Iceland	34	2	32	7	8	26	1	11	4	3
Ireland	34	−4	6	2	2	34	−4	6	2	2
Italy	34	0	9	3	2	34	0	10	3	2
Latvia	27	−1	952	45	182	23	−3	21	4	5
Lithuania	27	−1	1021	60	208	23	−1	20	3	5
Luxembourg	34	0	4	2	1	34	1	4	2	1
Netherlands	34	−1	4	2	1	34	0	4	2	1
Norway	34	0	9	3	2	34	1	9	3	2
Poland	29	−1	812	39	150	23	0	21	4	6
Portugal	34	−1	19	5	5	34	0	21	6	6
Slovakia	27	−1	23	6	5	23	0	10	4	3
Slovenia	34	−1	1281	83	236	19	0	8	3	3
Spain	34	−1	9	3	2	34	0	10	3	3
Sweden	34	0	10	3	3	34	−1	11	2	3
Switzerland	34	−1	6	1	2	34	−1	6	1	2
United Kingdom	34	0	8	3	2	34	0	10	3	2
		0	166	12	32		0	11	3	3

Notes: Table lists the countries included in the European sample, which we use in the baseline analysis. The sample starts in 1985, or the earliest available year for a given country. Columns 3–6 and 8–11 provide summary statistics (minimum, maximum, mean and standard deviation) for headline and core inflation, respectively.

Table C2: Descriptive statistics, Canadian provinces

	Headline inflation					Core inflation				
Province	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
Alberta	28	−1	8	2	2	28	0	6	2	1
British Columbia	28	0	4	2	1	28	0	4	2	1
Manitoba	28	0	4	2	1	28	0	4	2	1
New Brunswick	28	−1	6	2	1	28	0	6	2	1
Newfoundland and Labrador	28	−1	5	2	1	28	1	6	2	1
Nova Scotia	28	0	5	2	1	28	−1	4	2	1
Ontario	28	0	3	2	1	28	0	4	2	1
Prince Edward Island	28	−1	6	2	2	28	−1	6	2	1
Quebec	28	−2	5	2	1	28	−2	7	2	1
Saskatchewan	28	0	4	2	1	28	0	4	2	1
		0	5	2	1		0	5	2	1

Notes: Table lists the provinces included in the Canadian sample, which we use in the baseline analysis. The sample starts in 1990. Columns 3–6 and 8–11 provide summary statistics (minimum, maximum, mean and standard deviation) for headline and core inflation, respectively.

C.2 Tax design in Europe and Canada

In this section we attempt to distinguish between the specific design of the carbon taxes in our analysis. Table C3 details the main sectors that are subject to a particular carbon tax. Moreover, in case a revenue recycling scheme is in place we supplement information on how revenues used.

Table C3: Tax design, European countries and Canadian provinces

Tax economy	Main sectors taxed	Revenue recycled
Finland (1990)	Transportation (mainly road), Industry, Residential & Commercial, Agriculture	Corporate and income tax cuts
Poland (1990)	/	/
Norway (1991)	Transportation (Road and Off-road), Industry, Residential & Commercial, Agriculture	Corporate tax cut
Sweden (1991)	Transportation (Road), Residential & Commercial, Industry	Corporate and income tax cuts
Denmark (1992)	Transportation (mainly road), Industry, Residential & Commercial, Agriculture	Corporate and income tax cuts
Slovenia (1996)	Transportation (mainly road), Residential & Commercial, Industry	/
Estonia (2000)	Industry	/
Latvia (2004)	Industry	/
Switzerland (2008)	Residential & Commercial, Industry	Climate Investment Fund, Redistribution to households, firms
Ireland (2010)	Transportation (Road), Residential & Commercial, Agriculture, Industry	/
Iceland (2010)	Transportation (Road), Agriculture, Industry	/
United Kingdom (2013)	Electricity	/
Spain (2014)	/	/
France (2014)	Transportation (Road), Residential & Commercial, Industry	Lower tax burden on low-income households and pensioners
Portugal (2015)	Transportation (Road), Residential & Commercial, Agriculture, Industry	Income tax cut
British Columbia (2008)	All sectors, tax mostly accrues to businesses and households	Corporate and income tax cuts, Rebates to low-income households
Quebec (2013)	Industry, Power, Transport and Buildings	/
Alberta (2017)	Households and small industrial emitters	Rebates to low-income households, green infrastructure investments, corporate tax cut

Notes: Table lists for each European country and Canadian province with a carbon tax the main sectors the tax applies to (based on 2019 data) and details on the revenue recycling designs. Sources: Country notes of OECD (2019), Marten and Van Dender (2019) for Europe. Carbon Pricing Dashboard, Winter (2020) for Canada.