Additional Reduced-Form Specifications with Trends for "Pass-Through of Emissions Costs in Electricity Markets"

by Natalia Fabra and Mar Reguant

In this document, we explore additional specifications for the reduced-form specification of the pass-through regressions in the paper "Pass-through of Emissions Costs in Electricity Markets." We present additional versions of Table 3.2 in the main paper, considering additional controls.

As a reminder, the main specification is as follows:

$$p_{th} = \rho \tau_t e_{th} + X_{th}\beta_0 + X_{th}^D \beta_1 + X_{th}^S \beta_2 + \omega_{th} + \epsilon_{th}, \tag{1}$$

where ρ identifies the equilibrium cost pass-through. The emissions rate of the unit that sets the price at a given hour is captured by e_{th}, and τ_t represents the price of emissions permits. Therefore, $\tau_t e_{th}$ is the marginal emissions costs that firms face at a given hour h and day t. The controls X_{th}, X_{th}^D, and X_{th}^S stand for exogenous common, demand and supply controls, respectively, and ω_{th} is a vector of fixed effects.

The most complete specification includes month of sample, day of the week and hour fixed effects to control for potential trends and fluctuations. We also allow the hourly fixed effects to be different for every month, due to seasonal changes in sunlight and weather that affect electricity demand. We allow temperature and maximum temperature to also have a differential effect by month. As common controls, we include fossil-fuel prices (coal, gas and oil), which are allowed to have different effects depending on the hour of the day. On the demand side, we also include a humidity control. On the supply side, we include wind speed due to the presence of significant wind power generation in Spain.

In the main paper, all specifications include month-of-sample fixed effects to control for potential macroeconomic factors that are moving over time and could be correlated with both the emissions price τ_t and other unobservable demand shifters. However, there could remain some within-month macroeconomic trends which could potentially bias our results.

As a robustness check, one could include month-of-sample time trends. Unfortunately, we find that including month-of-sample time trends takes away all the relevant variation in emissions prices. There is no a-priori reason for the evolution of emissions prices to be roughly linear within a month, but the data reveal this to be the case. Figure 1 shows how a linear trend at the month-of-sample captures almost all relevant variation in emissions prices. This is particularly notable in June and July of 2005, despite the strong variation suffered by emissions prices. It is important to note that these trends do not appear to be "macroeconomic", in the sense that there are frequent ups and downs in emissions prices that would seem unlikely for lower frequency fundamental macroeconomic changes.

Given that including macroeconomic trends seems a very important and sensitive robustness check, we have explored whether we can be more flexible than in our baseline specification, without going to the extreme of including month-of-sample time trends. For this purpose, we consider two additional specifications: time trends at the bi-monthly level, and time trends at the quarterly level. Our results remain almost unchanged when we include these controls, as there remains some substantial variation in emissions prices after controlling for these trends. Such variation is most likely uncorrelated to fundamental trends (see Figures 2 and 3).

Results from these three different specifications are presented in Table 1, together with the most complete specification in the paper. As one can see, the relationship between electricity

Figure 1: Constant and Linear Trend for Emissions Prices by Month-of-Sample

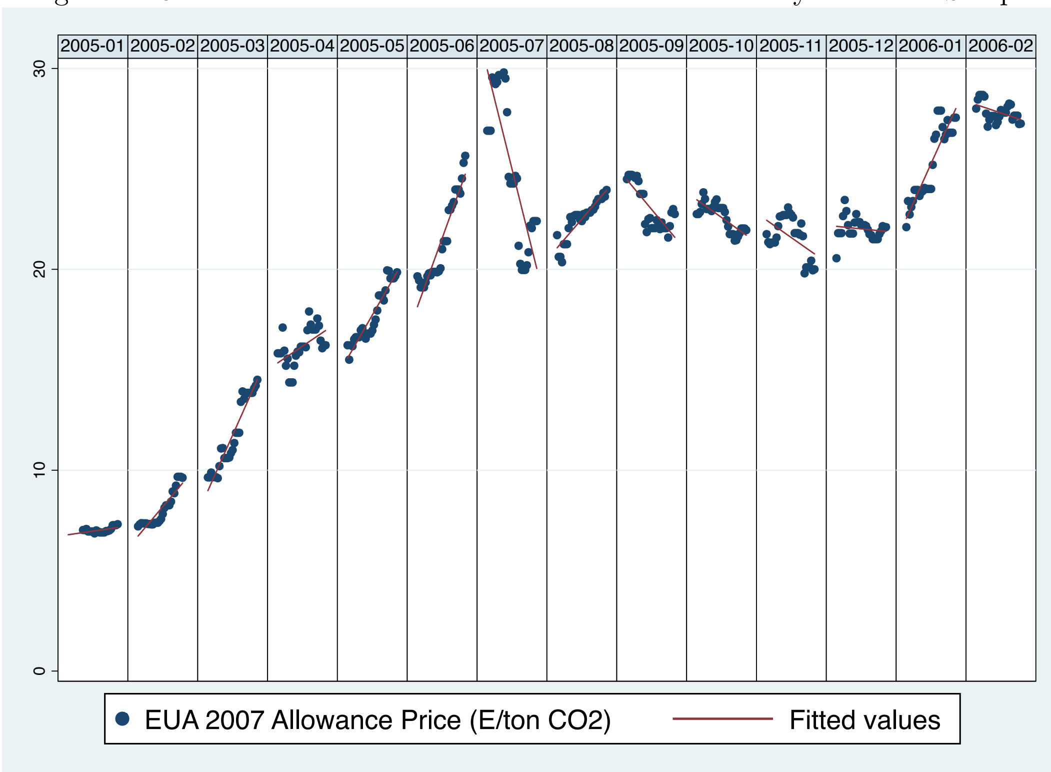


Figure 2: Constant and Linear Trend for Emissions Prices Bimonthly

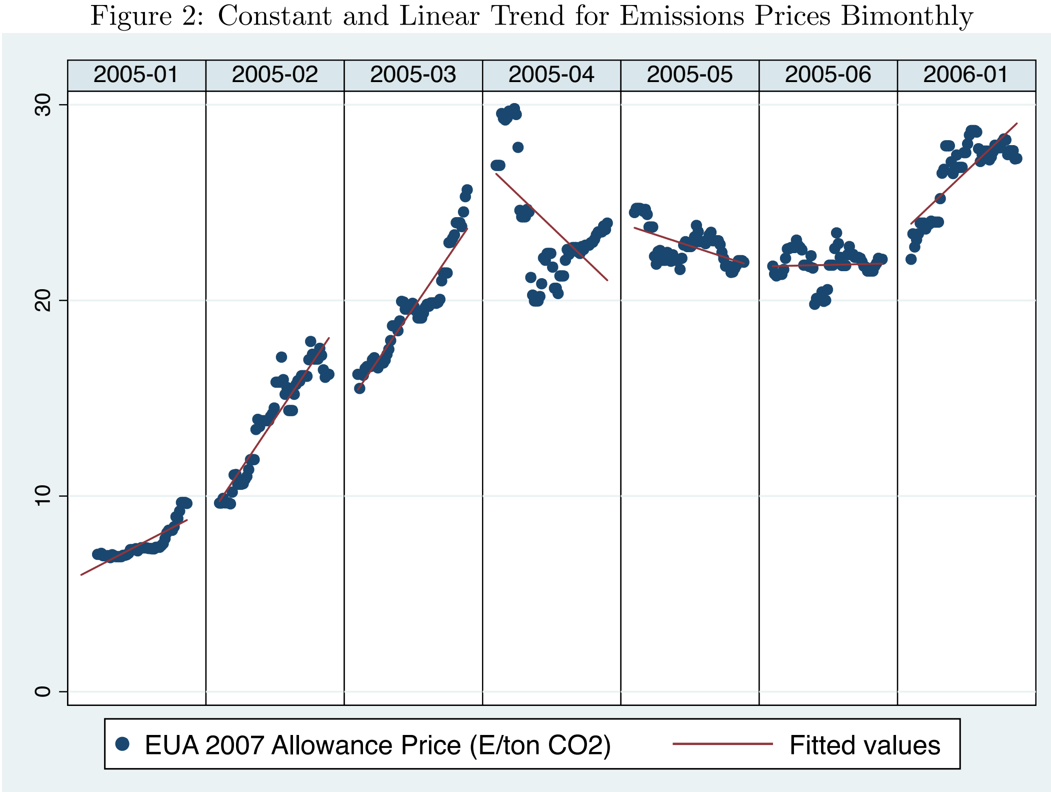
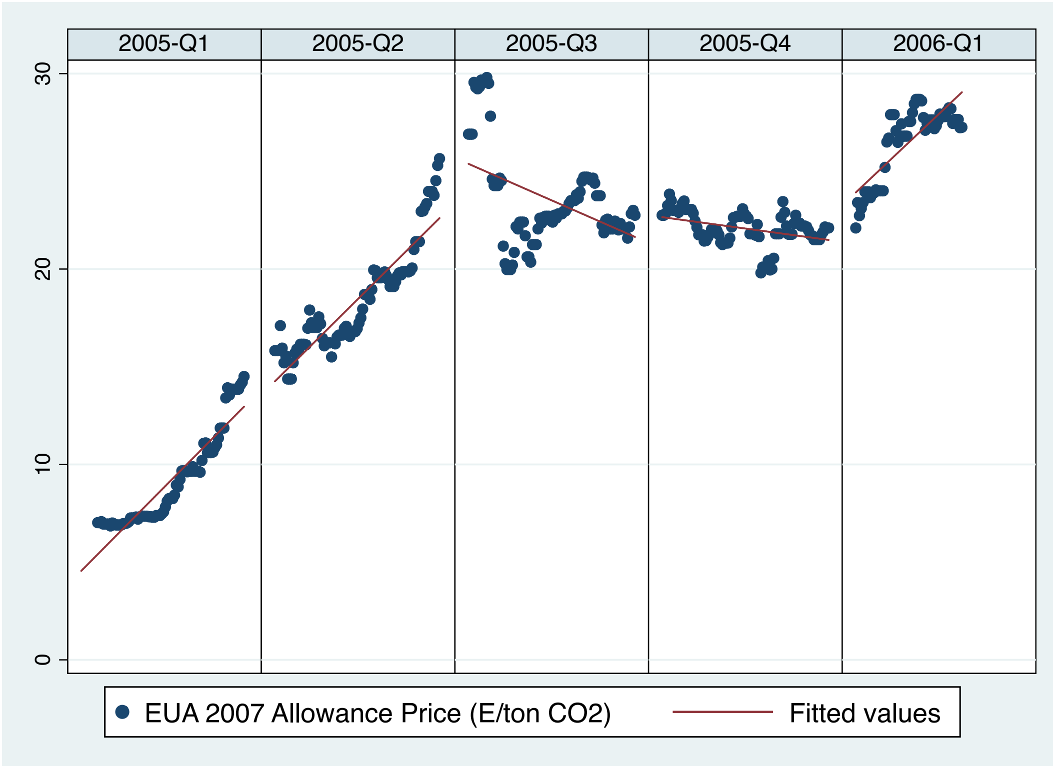


Figure 3: Constant and Linear Trend for Emissions Prices by Quarter



prices and emissions costs does not hold once we include month-of-sample trends. However, the most likely cause is that such trends are removing all meaningful variation in emissions prices. If we include bi-monthly trends or quarterly trends, the results are very similar to those in our baseline specification. We find these results very reassuring.

Additionally, we consider whether the estimates are as sensitive to the inclusion of monthly trends when we use an extended sample that includes all the trial period. As mentioned in the main text, there were several regulatory changes that make the period after February 2006 not appropriate for the study of pass-through.[1] We include these regressions only to show that, if more variation were present in the emissions price or if we could afford to consider a longer sample, the results would not be so dramatically different when including month-of-sample time trends. In fact, as one can see in Table 2, the results remain stable even after including month-of-sample time trends.

In sum, this additional analysis shows the strengths (and the practical limits) to our identification strategy. Our goal is to exploit variation in emissions prices that was driven by initial uncertainty in emissions prices, rather than fundamental macroeconomic trends. Month-of-sample time trends coincidentally remove all relevant variation in emissions prices. However, these trends do not appear to follow a particular pattern at a lower frequency. For this reason, considering bimonthly and quarterly macroeconomic trends allows us to reconcile the results with what we find in the paper.

[1]For example, the regulation included some provisions that induced electricity prices to cluster at specific price points, which would bias any pass-through estimate.

Table 1: Cost Pass-through Regression with Trends

	(1)	**(2)**	**(3)**	**(4)**
Mg. Emissions Costs - Peak	1.107	-0.010	1.326	1.191
	(0.175)	(0.249)	(0.221)	(0.218)
Mg. Emissions Costs - Off Peak	0.496	-0.606	0.733	0.580
	(0.164)	(0.247)	(0.216)	(0.211)
Month-SampleXTime	N	Y	N	N
Bimonth-SampleXTime	N	N	Y	N
Quarter-SampleXTime	N	N	N	Y

Notes: Sample from January 2004 to February 2006, includes all thermal units in the Spanish electricity market. Only peak hours are included (between 8am and 8pm). All specifications include month of sample, weekday, and hour-month fixed effects, as well as weather and demand controls (temperature-month, maximum temperature-month, humidity), supply controls (wind speed and wind speed squared); and common controls (commodity prices of coal, gas, and oil interacted with hourly fixed effects). The marginal emissions cost is instrumented with the emissions price. Robust standard errors in parentheses. Number of observations: $16,186$.

Table 2: Cost Pass-through Regression with Trends including Royal Decree Period

	(1)	**(2)**	**(3)**	**(4)**
Mg. Emissions Costs - Peak	0.810	0.704	0.949	0.847
	(0.088)	(0.102)	(0.103)	(0.094)
Mg. Emissions Costs - Off Peak	0.606	0.491	0.743	0.640
	(0.084)	(0.099)	(0.102)	(0.091)
Month-SampleXTime	N	Y	N	N
Bimonth-SampleXTime	N	N	Y	N
Quarter-SampleXTime	N	N	N	Y

Notes: Sample from January 2004 to June 2007, includes all thermal units in the Spanish electricity market. Only peak hours are included (between 8am and 8pm). All specifications include month of sample, weekday, and hour-month fixed effects, as well as weather and demand controls (temperature-month, maximum temperature-month, humidity), supply controls (wind speed and wind speed squared); and common controls (commodity prices of coal, gas, and oil interacted with hourly fixed effects). The marginal emissions cost is instrumented with the emissions price. Robust standard errors in parentheses. Number of observations: $26,050$.