The Causal Impact of Electricity Prices on German Manufacturing: A Spatial Analysis

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Extended abstract

Our study aims to improve the understanding of how plants in the manufacturing sector react to electricity price developments. Little is known about the causal impact of electricity prices on firm performance as electricity prices are typically endogenous. We use an identification strategy based on exogenous variation in firms' electricity costs. By exploiting variation in electricity network charges at spatial discontinuities and over time as an instrumental variable, we investigate the impact of price changes on electricity use and competitiveness of German manufacturing plants. The analysis is based on official plant-level census data by the German Statistical Offices.

The empirical literature on causal effects of energy taxes or other price based instruments on energy use and firm performance on the firm or plant level is relatively scarce. Martin et al. (2014) find that a moderate energy tax encourages electricity conservation and reduction of energy intensity in the UK manufacturing sector. Previous work using German data has found no evidence of an effect of the German electricity tax on economic performance of manufacturing plants and firms (Flues and Lutz, 2015). In contrast, electricity use of manufacturing plants is responsive to price changes due to the German renewable energy surcharge. No evidence of an effect on gross output, exports or employment has been identified however (Gerster, 2015). For the US, Jessoe and Rapson (2015) find no reaction of firms to changing marginal prices in time-of-use pricing schemes.

Our study uses variation in electricity network charges to identify changes in electricity prices. Electricity network charges are an important driver of electricity retail prices in Germany. In 2012, a plant with an electricity use of 50 MWh faced a retail price of 186.2 EUR/MWh on average. The retail price was composed of 30 percent electricity network

charges, 20 percent renewable energy surcharge, and 19 percent other fees and taxes on average. Retailers and utilities only received a share of 31 percent.

Electricity network charges are individually imposed and annually adjusted by the distribution system operators (DSOs) under strict surveillance by the regulator. In contrast to other electricity markets, e.g. in the US, German electricity network charges are not congestion charges. The charges are fixed for one year in advance and their main determinants are maintenance and investments for the restructuring of the electricity grid. The restructuring is driven by the accelerated decentralization of the German energy system to accommodate the expansion of distributed electricity supply mainly driven by renewable energy sources. There is substantial variation at spatial discontinuities and over time as can be seen in figure 1. In 2012 the electricity network charges varied across DSO areas from 40 to 100 EUR/MWh. All remaining tariffs, taxes, and charges are either determined on federal level or can be precisely controlled for.

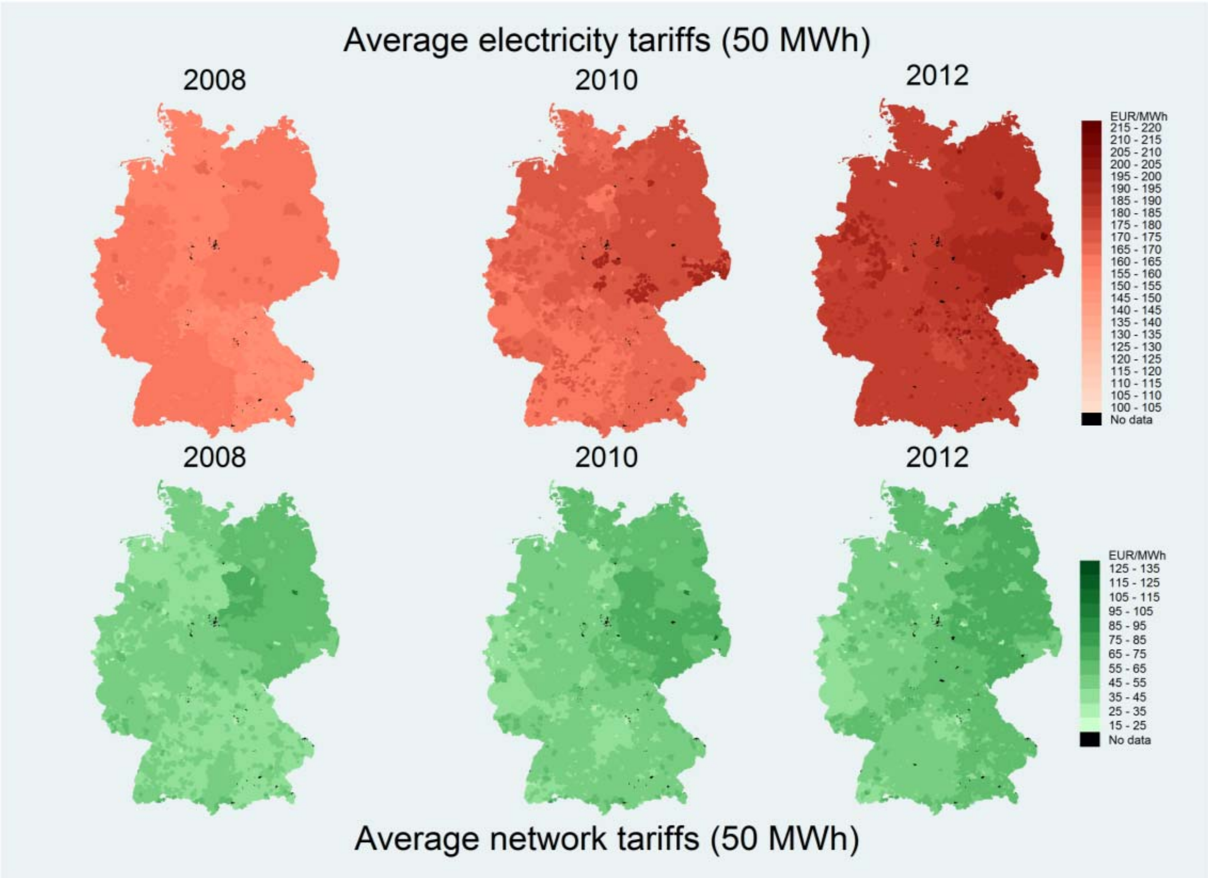

Figure 1: Spatial and temporal variation in electricity tariffs and network charges.

We merge comprehensive data on electricity tariffs, network charges, and the corresponding DSOs with administrative data from the German production census. The census data contains general characteristics, performance measures, and energy use data on plant and firm level. This rich and reliable data source offers us the opportunity to empirically investigate the effect of the variation in electricity network charges and hence electricity prices on plants in the manufacturing sector. In Germany there is no official electricity price data available. Instead we use a dataset which contains all offered electricity tariffs by retailers to construct a price for the individual plant. We use the different electricity prices for electricity use up to 100 MWh at the municipal level and merge these to each plant conditional on its electricity use and location.

We estimate the model

$$\ln E_{it} = \ln P_{E,it} + \ln L_{it} + \ln T_{it} + X_{it} + u_{it}$$

Where E is electricity consumption, P is the price faced by the plant i in year t, L is the number of employees, T measures turnover and X is a dummy for exporters. To account for the endogeneity and potential measurement error of electricity prices we use an instrumental variables approach based on the exogenous network charges:

$$\ln P_{E,it} = \ln NC_{it} + \ln L_{it} + \ln T_{it} + X_{it} + v_{it}$$

We estimate the model using both pooled OLS and panel estimation with plant fixed effects. The preliminary results are shown in Table 1 and 2.

Table 1: Results, pooled OLS and IV models

Dependent variable: ln(electricity procurement)	**Pooled OLS**	**Pooled OLS** Reduced form	**Pooled IV** Str. eq.	First stage
ln(average elec. price)	-2.852***		-4.756***	
	(0.116)		(0.362)	
ln(average netw. tariff)		-0.506***		0.105***
		(0.062)		(0.009)
ln(employees)	0.118***	0.131***	0.109***	-0.005***
	(0.014)	(0.015)	(0.013)	(0.001)
ln(turnover)	0.059***	0.053***	0.055***	-0.00004
	(0.009)	(0.011)	(0.009)	(0.0007)
export dummy	0.117***	0.114***	0.113***	-0.0007
	(0.014)	(0.015)	(0.013)	(0.001)
Constant	17.019***	4.450***	26.865***	4.723***
	(0.606)	(0.287)	(1.872)	(0.036)
R^2	0.16	0.06	0.11	0.04
Observations	40,690	40,844	40,690	40,690

* p<0.10, ** p<0.05, *** p<0.01. Standard errors are clustered at the plant level.

Preliminary results for the years 2007-2012 show the expected positive relationship between the exogenous network charges and the electricity price faced by the plants. Further there is a negative relationship between network charges and electricity consumption. Our instrument is highly significant in the first stage regression. The results of the IV estimation indicate that a 1 % increase in the electricity price would result in an almost 5 % reduction in electricity use. The identification here comes from cross sectional variation as well as variation over time. In the panel estimation using plant fixed effects only variation over time in the network charges is used for identification.

For the panel IV model with plant fixed effects we find an even stronger impact of electricity charges on electricity consumption. However, the first stage regression is somewhat weaker and the inflation of the standard error on the instrumented electricity price suggests that our instrument is weak in the panel setting. In other words the variation over time in network charges is not strong enough to identify the plant's response to an electricity price increase indicating that identification in the pooled OLS IV model is mainly based on cross sectional, i.e. geographical, variation.

Table 2: Results, Panel models

Dependent variable:	**Panel FE**	Panel FE	**Panel FE IV**	
ln(electricity procurement)		Reduced form	Str. eq.	First stage
ln(average elec. price)	-0.429***		-11.273***	
	(0.073)		(1.637)	
ln(average netw. tariff)		-0.466***		-0.041***
		(0.067)		(0.006)
ln(employees)	0.179***	0.189***	-0.079	-0.024***
	(0.017)	(0.173)	(0.025)	(0.003)
ln(turnover)	0.091***	0.083***	0.265***	0.016***
	(0.009)	(0.009)	(0.034)	(0.002)
export dummy	0.009	0.006	0.078**	0.006**
	(0.010)	(0.010)	(0.031)	(0.003)
Constant	4.008***	3.722***	57.735***	4.793***
	(0.391)	(0.303)	(8.115)	(0.035)
R^2	0.07	0.05	0.14	0.01
Observations	40,690	40,844	40,690	40,690
* p<0.10, ** p<0.05, *** p<0.01. Standard errors are clustered at the plant level.				

The next steps for our analysis are to increase robustness of the identification strategy using cross sectional variation. To control for unobservable characteristics affecting plant performance that vary across space we are currently constructing a spatial regression discontinuity research design: This strategy requires us to limit the sample to similar plants located near each other but with different DSOs and therefore with different network charges. We can then impose network border fixed effects to control for unobservable differences between border areas. The approach is similar to the spatial research designs that have been employed in other contexts by e.g. Black (1999) and Rathelot and Sillard (2008).

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