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RESEARCH BRIEF

The Use of Regression Statistics to Analyze Imperfect Pricing Policies

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Taxes can completely solve a variety of market failures, but actual policies often face administrative or political constraints that force them to deviate from the theoretical ideal. This paper presents a method that uses a minimum of market information and simple regression statistics to quantify the efficiency costs of such constraints. We demonstrate that, under certain intuitive conditions, standard output from a regression of true externalities on policy variables, including the R2 and the sum of squared residuals, has an immediate welfare interpretation. We demonstrate the usefulness of our approach in four diverse empirical applications.

Public policies often seek to address important market failures. Prominent examples are externality-correcting policies, which range from taxes on cigarettes, alcohol, or sugary beverages to mandatory immunizations to the regulation of pollution. In ideal settings, a Pigouvian tax can completely correct a market failure when the marginal damage is known and when no other market failures are present. Yet, relatively few policies closely follow this prescription. Often it is administratively impossible, technologically too costly, or politically infeasible to price actions according to the externalities that they generate.

Consequently, externality-correcting policies are generally imperfect. We more formally describe how such imperfection emerges in the following way: a given externality is dependent on a set of variables, but the corrective policy is able to control only a subset of those variables or their imperfect proxies.

For example, the external damages from sulfur dioxide depend on the amount of pollution emitted, the weather, and the location of emissions relative to population centers. But sulfur dioxide regulations are based only on emissions quantities. In transportation, congestion externalities are highly concentrated in certain times of day but most toll prices are uniform or vary only slightly with traffic conditions. In health, the externalities associated with second-hand smoke depend on many factors, including proximity to other people, whether the smoking is indoors or outdoors, etc. But cigarette taxes are uniform.

In this paper, we develop a model that characterizes the welfare costs of second-best policies. We show that, under certain conditions, familiar statistics from simple regressions of the true externality on the variables upon which policy is based have direct welfare interpretations. Specifically, the R2 summarizes the fraction of the welfare gain from the perfect (Pigouvian) policy that is achievable by the second-best policy. We also show that the deadweight loss scales with the sum of squared residuals. We demonstrate the usefulness of the method through four empirical applications.

The first application considers random mismeasurement. Energy efficiency is measured according to laboratory test procedures which differ from in-use averages, thereby creating mismeasurement in externalities across regulated products. We take advantage of a change in the fuel-economy test procedure for automobiles in the United States to quantify the efficiency cost of basing fuel economy regulation on the older, noisier test ratings. We conclude that the vast majority (95%) of the welfare gain from an optimally designed fuel-economy policy that used the new ratings can be achieved by a policy that uses the old rating system.

Our second application regards real-time electricity pricing. Unlike our other three applications, this does not concern an externality. Instead, here we explore the welfare implications arising from the fact that the marginal cost of generating electricity varies hour by hour while electricity tariffs do not vary to reflect these costs. We apply our method to characterize the welfare gain of tariffs that vary along some time or date dimensions, but fall short of the theoretical ideal of real-time pricing. We find that realistic time-varying tariffs recover only a modest fraction of the gains achieved by real-time pricing.

Our third application concerns the regulation of energy-consuming durable goods. Policies that regulate such goods are typically based on their energy efficiency. However, the lifetime externality created by such goods depends on both their energy efficiency and their lifetime utilization. Differences in lifetime utilization between goods of the same energy efficiency suggest that such policies will fall short of the Pigouvian ideal.

We use a novel data set that indicates the lifetime miles traveled for a large sample of automobiles. Our data confirms that average lifetime miles traveled by individual vehicles of a particular model vary substantially across different models. This implies that vehicle models with the same fuel-economy rating in fact have very different levels of expected lifetime carbon dioxide emissions. We conclude that actual fuel-economy policies, which treat such vehicles identically, recover only about one-quarter to one-third of the welfare gain compared to a policy that considers both fuel economy and vehicle longevity.

A fourth application considers spatial differentiation. The externality of a given amount of energy use can differ depending on location but policies often cannot differentiate geographically. Here, we consider the heterogenous externalities associated with the use of electric appliances. In this case, differences in emissions across space occur due to the fact that the emissions rate from the marginal power plant differs across regions of the country. We demonstrate that an alternative regression statistic, the within-R2 from a regression with spatial fixed effects, has the desired welfare interpretation. We conclude, for this particular case, that the welfare costs of failing to spatially differentiate are small.

In conclusion, this paper shows how familiar regression statistics can provide insights about the welfare implications of second-best policies that aim to fix market failures but are constrained to be imperfect.

References

Jacobsen M. R., C. R. Knittel, J. M. Sallee, and A. A. van Benthem, 2018, “The Use of Regression Statistics to Analyze Imperfect Pricing Policies.” MIT CEEPR Working Paper 2018-002.

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