A Simple Framework to Analyze Data Requirements for Policy Evaluation

Christian Michel* and André Stenzel†

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Abstract

This note formalizes a framework to analyze whether for given data a theoretical economic model can lead to unambiguous predictions regarding economic outcomes of interest. Instead of structurally estimating demand and supply, we focus on whether the set of model paramaters consistent with observed data uniquely determines the considered outcome. The framework can be applied to a large variety of economic models, and is of particular relevance for policy introductions when consumers potentially exhibit non-standard preferences. We discuss several applications to competition and consumer policy.

JEL Classification: D18, D21, L13

1 Introduction

In this note we introduce a simple framework which formalizes sufficient conditions for the combination of an underlying model and available data to assess an outcome of interest, such as how consumer welfare is affected by a change in the regulatory framework. The note should be understood as the theoretical framework underpinning the analysis in Michel and Stenzel (2018), where we implicitly apply the formal framework in the context of *cooling off laws* when consumers potentially exhibit a projection bias.

*Universitat Pompeu Fabra, and Barcelona GSE. E-mail: christian.michel@upf.edu.

†University of Mannheim, and MaCCI. E-Mail: andre.stenzel@uni-mannheim.de

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The main conceptual idea is as follows. We look for the set of theoretical model parameters consistent with the data that lead to unambiguous predictions regarding the considered outcome. If this is the case for any possible realization (a subset of possible realizations) of the data, we denote the data in light of the model as being *fully informative* (*partially informative*) of the outcome of interest. We believe the application of our framework to be of particular relevance when consumers may experience non-standard preferences. In these cases, a full-fledged structural estimation of demand and supply, which we consider to be an ideal approach, is oftentimes not feasible for lack of identification given the available data.

To exemplify an illustrative application of our framework, consider a canonical competitive market with downward-sloping time-invarying demand and upward-sloping potentially time-varying supply. Given that demand is time-invariant, simply observing the market price (or quantity) in each period is sufficient to assess the sign change in consumer welfare across periods. Under the assumption that the model describes the considered market, if the price has gone up (quantity has gone down), supply must have changed in such a fashion that consumer welfare has been negatively affected.

We relate the framework to the existing literature using three distinct examples which are intrinsically relevant for policymakers.

2 Framework

We first define the notion of an economic model and its outcomes.

Definition 1 (Model & Outcomes) *A model $\mathcal{M}$ characterizes the relationship between a set of parameters and a set of outcomes. Denote a generic parameter as ω^i with range Ω^i, and a generic outcome as $\psi^i \in \Psi^i$. $\mathcal{M}$ is the correspondence $\mathcal{M} : \Omega \rightrightarrows \Psi$ mapping parameters into outcomes, where $\Omega = \prod \Omega^i$ and $\Psi = \prod \Psi^i$.*

A model describes an economic process. Definition 1 allows for both static and dynamic models. The number of periods is implicitly contained, and incorporates that the assumptions governing the economic process may change over time. This reflects e.g. changes in the regulatory framework, or entry/exit of agents over time. An outcome can be related to a given period (e.g. market price), or to multiple periods (e.g. change in market price between periods). $\mathcal{M}$ is a correspondence to account for potential multiplicity of equilibria.

Definition 2 (Dataset) *A dataset δ_ψ consists of observations of a set of outcomes $\psi = \{\psi^1, \ldots, \psi^D\}$ of the model. We denote by δ_{ψ^i} an observation of outcome ψ^i. $\delta_\psi =$*

$\{\{\delta_{\psi^i}\}_{i=1}^D\}$ consists of observations about D outcomes ψ^i, $i \in \{1, \ldots, D\}$. The range of possible datasets δ_ψ is denoted Δ_ψ.

A dataset is a collection of observations corresponding to outcomes of the model. The range of possible datasets Δ_ψ depends on the application and $\Delta_\Psi \neq rn(\Psi)$ is in principle possible. The range of possible data can be larger than the range of outcomes predicted by the model. For example, the model may always predict a weakly positive sign change in consumer welfare between periods ($rn(\Delta CW) = \{\cdot, +\}$), but market data could potentially reveal that it is negative $\Delta_{\Delta CW} = \{-, \cdot, +\}$. In this case, if negative consumer welfare is observed in the dataset, the data imply that the specified model does not capture the economic interaction properly. This directly relates to the notions of *rationalizability* and *falsification.*

Definition 3 (Rationalizability & Falsification) *The set of parameters $\Sigma(\delta_\psi)$ rationalizable by the dataset $\delta_\psi = \{\{\delta_{\psi^i}\}_{i=1}^D\}$ is such that the outcomes predicted by the model match the dataset. Formally,*

$$\Sigma(\delta_\psi) = \{\omega \in \Omega : \forall i \in \{1, \ldots, D\} : \psi^i(\omega) = \delta_{\psi^i}\}. \tag{1}$$

If $\Sigma(\delta_\psi) = \varnothing$, the data δ_ψ have falsified the model.

For a given dataset δ_ψ which corresponds to a set of outcomes ψ of the model, $\Sigma(\delta_\psi)$ is the set of parameter constellations such that the model's predictions correspond to the data. If the data allows to point-identify the fundamental parameters, $\Sigma(\delta_\psi)$ is a singleton.

Definition 4 (Full & Partial Informativeness) *Let I be an economic indicator of interest. Data Δ_ψ about a set ψ of outcomes of the model $\mathcal{M}$ are fully informative about I if the behavior of the outcome of interest is uniquely determined for any parameter constellation which rationalizes the data, provided that the set of parameters consistent with the data is non-empty. Formally, full informativeness requires*

$$\forall \delta \in \Delta_\psi : \quad \Sigma(\delta) \neq \varnothing \implies \forall \omega_1, \omega_2 \in \Sigma(\delta) : I(\omega_1) = I(\omega_2) \tag{2}$$

If the behavior of the economic indicator is uniquely determined for at least one dataset $\delta \in \Delta_\psi$ where the set of parameters consistent with δ is nonempty, we obtain partial *informativeness. Formally, partial informativeness requires*

$$\exists \delta \in \Delta_\psi : \quad \Sigma(\delta) \neq \varnothing \wedge \forall \omega_1, \omega_2 \in \Sigma(\delta) : I(\omega_1) = I(\omega_2). \tag{3}$$

For *full informativeness*, we require that whenever there exist parameter constellations consistent with the data – for any dataset in the range of possible datasets about the ψ outcomes – the behavior of the outcome of interest within the set of consistent parameters is uniquely determined.[1] We also define the weaker notion of *partial informativeness*. Partial informativeness requires that for at least some possible values of the dataset, the outcome of interest exhibits a unique behavior within the set of consistent parameters. By considering models explicitly featuring a policy intervention, we can use these definitions to assess whether a policy is *revelatory*.

Definition 5 (Revelatory Policies) *A model $\mathcal{M}_\mathcal{P}$ incoporates a policy intervention $\mathcal{P}$ if it can be decomposed into models $\mathcal{M}_{pre}$ and $\mathcal{M}_{post}$ such that $\mathcal{M}_{pre}$ and $\mathcal{M}_{post}$ describe the same economic relation before and after the policy intervention. Let ψ denote a set of outcomes of $\mathcal{M}_\mathcal{P}$ for which data Δ_ψ are available, and let I denote an economic outcome.*

We say that the policy $\mathcal{P}$ is fully (partially) revelatory of I in light of $\mathcal{M}_\mathcal{P}$ using Δ_ψ if and only if Δ_ψ is fully (partially) informative of I in light of $\mathcal{M}_\mathcal{P}$.

Ideally, I is an indicator which allows an evaluation of the policy itself. A natural application is to compare the data requirements to assess such an indicator across different policies, i.e. policies $\mathcal{P}^1$ and $\mathcal{P}^2$ where the pre intervention models $\mathcal{M}^1_{pre}$ and $\mathcal{M}^2_{pre}$ are identical and only the post intervention models $\mathcal{M}^1_{post}$ and $\mathcal{M}^2_{post}$ differ. In Michel and Stenzel (2018), we consider the data requirements to assess the directional impact of two distinct cooling off policies on consumer welfare when consumers potentially exhibit non-standard preferences in the form of a projection bias.

3 Applications

To illustrate the usefulness of the above framework, we briefly demonstrate its applicability in three distinct settings.

[1] Note that if point-identification of all model parameters is feasible, full informativeness always obtains in the absence of multiplicity of equilibria.

Tax salience Chetty *et al.* (2009) consider the responsiveness of demand for alcoholic beverages to changes in sales tax. They provide a model with the key feature that sales tax is not salient to all consumers as it is not incorporated into the posted price in US stores. The fraction of consumers θ for whom sales tax is not salient is then obtained by comparing the tax elasticity of demand $\epsilon_{x,1+t^s}$ with the price elasticity of demand $\epsilon_{x,p}$: $\theta = \frac{\epsilon_{x,1+t^s}}{\epsilon_{x,p}}$, where the elasticities depend on model fundamentals. Chetty *et al.* (2009) empirically estimate θ by comparing responses to changes in excise taxes (which are incorporated into the price and hence allow estimation of the price elasticity) and changes in sales taxes.

In the context of our framework, we can think of the model as determining the relation between fundamentals, including θ, and a variety of outcomes including the elasticities. Let the data Δ_ψ consist of the empirical analogue to the elasticities. They are then fully informative of the parameter of interest θ: By considering $\frac{\epsilon_{x,1+t^s}}{\epsilon_{x,p}}$, the model is either falsified ($\theta > 1$, if consumers react more strongly to changes in sales than excise taxes), or there is a unique θ consistent with the data, namely $\theta = \frac{\epsilon_{x,1+t^s}}{\epsilon_{x,p}}$.

Add-on Pricing Heidhues and Koszegi (2018) discuss approaches to assess the potential importance of *hidden prices* when regulators have access to price and demand data. They consider a setting where firms offer both a base product (price f) and an associated add-on product (price a, per-unit cost c), and where consumers potentially misperceive their add-on demand. They derive the optimal markup for the add-on product which a firm charges given that it is aware of the potential misperception as

$$\frac{a-c}{a} = \left(-\frac{1}{\text{elasticity of add-on demand}}\right) \cdot \left(1 - \frac{\text{marginal consumer's perceived add-on demand}}{\text{marginal consumer's add-on demand}} \cdot \frac{\text{marginal consumer's add-on demand}}{\text{average add-on demand}}\right).$$

If consumers do not misperceive the add-on demand, the sign of the markup is directly related to whether the marginal consumer's add-on demand exceeds the average add-on demand. They argue that in the credit-card industry, marginal consumers, who are poorer, have a higher demand for credit than inframarginal consumers. If consumers exhibited no misperception, this would hence induce a negative markup for the add-on product which in this context are interest rates. As this is not the case, this simple argument rejects the notion that consumers do not misperceive the add-on demand.

In the context of our framework, if the data reveals that (i) the markup for the add-on product is positive and (ii) that the marginal consumer's add-on demand exceeds the average consumer's demand, there is no parameter constellation consistent with the model that does not feature misperception. If only the model without misperceptions is considered, it would be falsified (see Definition 3).

Cooling-off Laws In Michel and Stenzel (2018), we show that a policy introduction itself can be used to assess economically relevant indicators such as the efficacy of the policy, or market fundamentals such as whether consumers exhibit non-standard preferences. We provide a framework in which consumers potentially suffer from a projection bias which lets them mispredict future state-dependent consumption utilities, biasing them towards the utility enjoyed in their current state. Absent policy interventions, purchase decisions take place one period prior to consumption so that the projection bias is relevant. We consider theoretically the introduction of two distinct cooling off policies, a mandatory cooling off period, and a return policy.

Exploiting the assumption that firms strategically respond to policy interventions by allowing them to change their pricing strategy, we show that the policies differ in what can ex-post be assessed using reasonable market-level data, i.e. overall quantities, prices, and whether the cooling-off policy resulted in returns or stepping back, respectively. If a mandatory cooling off period is adopted, the change in quantities always allows to assess whether consumer welfare was positively or negatively affected by the policy intervention: the policy is fully revelatory of the sign change in consumer welfare using data on the change in quantities. To the contrary, this is not the case when a return policy is adopted, where the policy is fully revelatory only under much stronger data requirements including the overall market size.

4 Conclusion

We believe that because of the large number of theoretical models with a behavioral economics foundation that deal with the introduction of policies, a systematic analysis of the necessary data requirements for policy evaluation is particularly useful. The developed framework can of course also be used for models in which the rationality of consumers can safely be posited. Notably, an unambiguous assessment does not require point-identification of all underlying parameters, which implies that the feasibility of such an assessment is not equivalent to the ability to make counterfactual policy predictions. However, we believe that the main advantages of the framework lie in its simplicity and broad applicability without extensive technical knowledge. We thus see it as an easy first step when considering a policy evaluation (in a behavioral context) that should already be incorporated during the policy design phase. Ideally, a policy should be designed in such a fashion that it can be evaluated ex-post using data which can reasonably be gathered.

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