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### Essays on optimal experimentation

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# Introduction

*One of the functions of theoretical economics is to provide fully articulated, artificial economic systems that can serve as laboratories in which policies that would be prohibitively expensive to experiment with in actual economies can be tested out at much lower cost. (...) Our task as I see it (...) is to write a FORTRAN program that will accept specific economic policy rules as "input" and will generate as "output" statistics describing the operating characteristics of time series we care about, which are predicted to result from these policies.*

Robert E. Lucas (1980)

In December 2011, Thomas J. Sargent and Christopher A. Sims were awarded the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel. They received the prize "for their empirical research on cause and effect in the macroeconomy". Hereby, the Economics Prize Committee rewarded Sargent and Sims for giving us the tools to overcome one of the major limitations that macroeconomics has to face (also expressed in the above quote by Robert E. Lucas): the fact that it can be very costly to learn how the economy works by conducting controlled experiments. If a chemist wants to know what happens when one combines substance A with substance B, he can simply do so at a relatively low cost (provided that the combination of A and B is not explosive). However, when an economist wants to know what happens when, say, a decentralized way of allocating resources is exchanged for a centralized one, the costs of actually bringing this idea in practice can be huge (recall the communist "experiment").

Because it is so difficult to capture the actual macroeconomy in a controlled environment, economists build their own laboratories in the form of macroeconomic models which they employ to investigate what happens after a certain

policy change. If the underlying theory is any good, the model outcome should have a positive correlation with what would happen if the policy change were to be implemented in reality.

However, since simplifying assumptions are a defining characteristic of any economic model, all theories have their limitations. Consequently, it takes a good model (if any) to beat information obtained through actual experiments. This thesis therefore visits the borders of the Lucas-Sargent-Sims program by considering cases in which experimentation is actually possible and/or present (be it deliberate or accidental). In particular, the first three chapters (which have a more theoretical focus) analyze how deliberate experimentation should be carried out in various settings, while the last two chapters develop empirical methods via which one can exploit an accidental natural setting that is helpful in analyzing the effects of monetary policy shocks.

First of all, experimentation is possible and present when it comes to implementing economic reforms. In such a setup, experimentation can be both deliberate as well accidental. China for example consciously installed special economic zones to investigate how these regions would react to market forces, while experimentation in many Central and Eastern European countries was of a more accidental nature: in those countries some reforms were started prior to others due to political hurdles, as a result of which both policy makers and the public had the possibility to learn from the outcomes of the early reforms. Chapter 1 of this thesis (which is joint work with Sweder van Wijnbergen) analyzes this learning process for voters who are uncertain on whether they will benefit or suffer from a certain reform proposal. In it, we provide an explanation for the puzzling observation that many reforms that start off successfully (in a sense that the reformed firms/sectors turn out to benefit from the reform), often lose majority support along the way. We argue that this may be due to the fact that the process of revealing reform outcomes is an example of sampling without replacement: when it is revealed that individual  $X$  is a winner, other individuals who remain uncertain on their identity realize that this implies that there is one winning place less left where they can end up in. Consequently, they become more pessimistic on the probability that they will turn out to be a reform winner. In Chapter 1, we show that this may lead to a situation in which the median voter becomes so pessimistic that he ends his support to the reforming government, which may explain why

successful reformers are often kicked out of office. In addition, the chapter also deals with the optimal speed of reforms and provides an explanation for why the gradual reform strategy has worked well for China, while this is much less so for Latin American and Central and Eastern European countries.

Chapter 2 goes one step further by actually modeling the process of conscious experimentation. In particular, it applies the "optimal experimentation"-concept to the global warming debate. Although there is little doubt left among climatologists that global warming is anthropogenic, many policy makers still claim to be uncertain on the causes of climate change. Starting from that premise, Chapter 2 shows that these skeptical decision makers obtain an experimentation motive. In particular, it gives them an incentive to *reduce* greenhouse gas emissions. The reason is that such a more aggressive policy eases their learning process on whether global warming is anthropogenic or not, which is valuable to know. Although an increase in emissions would also facilitate learning, that option suffers from the fact that emitting greenhouse gases is irreversible. Since this implies that even climate skeptics should reduce emissions, the policy implications of the different positions in the global warming debate turn out to coincide - thereby diminishing the importance of this debate from a policy perspective.

Chapter 3 analyzes the process of optimal experimentation at the microeconomic level. In that chapter, I consider a price-setting seller who is uncertain on the time-varying slope of his demand curve. This seller does however realize that he can learn the value of this slope parameter from self-generated observations (by regressing the quantity he sells every period on his relative price). Since the estimation of a regression equation is facilitated by the presence of somewhat more extreme observations, it becomes optimal for this seller to experiment with his price. It turns out that the optimal pricing strategy prescribes the alternation of periods in which a high price is quoted, with occasional mark-downs of a rather fixed size. Consequently, the model is able to replicate the discrete pricing pattern that is observed around sales, which has proved to be a major challenge to most price setting models. Simultaneously, the model's learning dynamics are able to reconcile individual price flexibility with an aggregate price level that moves more gradually in response to shocks.

When it comes to analyzing the effects of monetary policy shocks, similar issues play a role: since monetary authorities typically *respond to* economic devel-

opments, true monetary shocks (changes in the policy instrument that are orthogonal to economic circumstances) are hard to find. Consequently, cause and effect are difficult to disentangle. One could therefore argue that monetary authorities should consciously perturb the economy in a random way, to facilitate their learning process on how the economy works. Others have however characterized such a form of policy experimentation as immoral, since it subjects the public to an experiment from which they cannot escape.

As I argue in Chapter 4 of this thesis, the existence of dollarized countries forms a useful natural experiment that can help us in analyzing the effects of true US monetary shocks. The reason is that dollarized countries import US monetary policy just as genuine US states do, but the Fed only responds to developments in US variables when designing its policy. Consequently, changes in the US monetary policy instrument are much more likely to be orthogonal to economic circumstances in the dollarized countries, than to those in the US - thereby decreasing the need for traditional ways of shock identification.

Chapter 5 (which is joint work with Alessandro Gobbi) exploits the same setting, but tries to identify US monetary shocks through sign restrictions. Here, the presence of the dollarized countries brings two advantages. First, the fact that the dollarized economies are not perfectly integrated with the US economy, reduces the risk of the procedure confounding two different shock-types: due to the imperfect integration, non-monetary US shocks are unlikely to affect variables in all countries considered simultaneously (only monetary US shocks do that). Second, the use of dollarized countries enables one to place the restrictions on variables *in the dollarized countries only*. Consequently, the researcher can stay agnostic with respect to all US variables - including the US price level. The latter is a key variable on which there is no consensus yet as to how it responds to a monetary policy shock (*cf.* the "price puzzle"-debate).

The approach taken in both Chapters 4 and 5 leads to the conclusion that prices tend to fall after a monetary contraction (so there is no "price puzzle"), while output does not show a clear response. Based on these results, monetary neutrality thus cannot be rejected.