Resisting and Accommodating Thomas Sargent

Putting Rational Expectations Economics through the Mangle of Practice

ESTHER-MIRJAM SENT

During the 1960s the field of economics experienced the so-called rational expectations revolution. The central tenet of rational expectations is that individuals should not make systematic mistakes: that is, that economic agents are not stupid; they learn from their mistakes and they draw intelligent inferences about the future from what is happening around them. While the adaptive expectations hypothesis had the disturbing implication that it allowed individuals to make systematic forecasting errors period after period, the rational expectations hypothesis asserted that people learn from their mistakes: people with rational expectations did still commit errors, but not the same ones each time. Individuals could differ from one another in their expectations and still be rational if they were using different information. But when all of these individual expectations were added together, errors tended to cancel out, thereby producing an aggregate view of the future that reflected all of the available information.

Many stories can be identified in the work of historians and philosophers of economics who have endeavored to explain the rise of rational expectations economics (Sent 1998b, 2–12). These stories are neither mutually exclusive nor mutually exhaustive. An additional complication involves the fact that there are multiple definitions of rational expectations. However, historians and philosophers of economics have each tended to focus only on one story about the rise of rational expectations economics and on one interpretation of the rational expectations hypothesis. In this chapter I show, instead,

that it is possible for many interpretations to be held comfortably by one and the same person. It does so by picturing economics as a field of emergent human and disciplinary agency engaged by means of a dialectic of resistance and accommodation. The novel point that the analysis makes consists of showing that facts and knowledge in rational expectations economics represent assemblages of human and disciplinary performances that emerge in time, and also pass in time. Specifically, I consider Thomas Sargent, who has been instrumental in the development of the field largely due to his efforts to connect economic theories and the econometric tests of those theories. Instead of relying on how others perceive Sargent's achievements, I start from his own conceptualization of his contributions.

Drawing on Andrew Pickering's dialectic of resistance and accommodation (Pickering 1992, 1995; Pickering and Stephanides 1992), in this chapter I narrate multiple stories about the rise of rational expectations economics in following the course of Sargent's career. In the process, a variety of interpretations held by one person can be observed. The dialectic of resistance and accommodation allows me to describe a process in the making from the perspective of Sargent. That is, facts and knowledge in rational expectations economics are temporally emergent—they come to light in time through practice. As my analysis will show, facts and knowledge in rational expectations economics do not represent truth as such, but rather are tenuous assemblages of human and disciplinary agency that can fall apart as disciplinary winds change and new currents of thought come into fashion.

The starting point of my analysis is Sargent's definition of good economics. In the fashion of Pickering's mangle, we witness how as a result of disciplinary agency Sargent's different free moves kept getting obstructed by his encounters with resistances, which resulted in forced moves of evolving interpretations of rational expectations and kept getting obstructed by his encounters with resistances due to disciplinary agency. The free moves reflected the tentative choices Sargent made, carrying with them no guarantee of success.[1] The forced moves served to elaborate the choices through disciplinary agency.[2] Resistances that emerged when the extension of culture was not successful were accommodated by Sargent through changing his interests, changing his free moves, or ignoring the forced moves.[3] Following the emerging dance of agency through time, we observe Sargent exerting

his human agency by tinkering with different sets of free moves rather than adjusting his definition of good economics.

In this chapter I show that Sargent witnessed the emergence of a variety of interpretations of rational expectations during the dance of agency, in which the partners are alternately the human agent and the disciplinary agent. I further illustrate that these phases are connected through Sargent's continuous efforts to establish symmetry among agents, economists, and econometricians by means of a variety of free moves. According to Sargent, "The idea of rational expectations is . . . said to embody the idea that economists and the agents they are modeling should be placed on an equal footing: the agents in the model should be able to forecast and profit-maximize and utility-maximize as well as the economist—or should we say econometrician—who constructed the model" (1993, 21). In other words, Sargent saw no reason for the superiority of one category of individuals over another group of people.[4]

As I show in the following sections, Sargent gave the rough notion of symmetry a more precise formulation by embedding it in different sets of free moves. Each of the sections contains a brief case study of how Sargent's search for symmetry evoked different forced moves in the form of distinct interpretations of rational expectations, and how he was repeatedly obstructed by his encounters with resistances (see also Sent 1998b). These resistances that emerged due to disciplinary agency then evoked accommodations. In the next section I discuss how Sargent came to the idea of rational expectations as an econometric concept. In the second section I analyze Sargent's attempts to interpret rational expectations as both an econometric and a theoretic construct. In the third section I evaluate his efforts to incorporate general equilibrium theory into the symmetry structure. In the fourth section I discuss Sargent's eventual interpretation of rational expectations as the final outcome in a learning process.

Phase One: Accommodating Randomness

In what follows I use Pickering's insights to address Sargent's interpretation of rational expectations economics in the late 1960s and early 1970s. During this period, the concept of adaptive expectations was under severe attack in economics for fitting econometric models that forecast better than economic agents. Moreover, theories developed by neoclassical economists were de-

terministic while models employed by econometricians were random.[5] This conflict was an obstacle in Sargent's efforts to exert his human agency by searching for symmetry. Some economists sought to meet these objections by using the rational expectations hypothesis (Begg 1982).

Inspired by these changes in his environment, Sargent attempted to reestablish symmetry by making free moves toward the perspective of time-series econometrics, in particular distributed lags and the term structure of interest rates (Sargent 1968, 1969).[6] Through his analysis of distributed lags for interest rates Sargent became aware of the role of expectations, because orthodox neoclassical theory stated that they influence the relationship between spot and forward rates, nominal and real rates, and short-term and long-term rates. Furthermore, the free move to expectations, or more specifically rational expectations, provided Sargent with an answer to how symmetry might be achieved, as they allowed him to introduce probabilistic ideas into economic theory as well. He considered rational expectations a more elegant way to resolve the separation between the randomness of distributed lags in econometrics and the determinism of neoclassical models. Since Sargent initially started from the viewpoint of econometrics, an econometrically motivated interpretation of the concept of rational expectations emerged as a forced move, which involved treating the econometrician and the agents in the model in a symmetric fashion. His scientific culture, in turn, further directed his plans and intentions toward serious resistances, which are obstacles in his attempt to satisfy his interests.

Since he focused on interest rates, Sargent also encountered the importance of Lévy stable distributions with infinite variance and the associated problem of constructing statistical estimators as a forced move.[7] With his student Robert Blattberg at Carnegie Mellon University, Sargent established that with Lévy stable distributions almost every technique of modern econometrics is useless and would have to be discarded (Blattberg and Sargent 1971). As a result, almost all references to stable Lévy distributions in economic variates disappeared by the mid-1970s, and many of the earlier enthusiasts recanted with regard to Lévy stable distributions (Mirowski 1989b, 1990). The threat of Lévy stable distributions was averted by ignoring them, without a direct critique of the earlier findings of infinite variance. Randomness, therefore, was tamed by assuming that variances are finite.

Sargent was especially troubled by these resistances thrown up by disciplinary agency, for he sought to exert his human agency by establishing symmetry between techniques used by economic agents and the models developed by econometricians. In particular, the emergence of an econometrically motivated interpretation of rational expectations as a forced move required the availability of statistical estimators. Whereas Lèvy stable distributions previously only threatened neoclassical econometrics, they could now also compromise economic theory based on rational expectations. When stable laws enter the stage, econometricians and agents would run into resistances with the construction of statistical estimators. Rather than relinquishing the econometrically motivated interpretation of rational expectations through distributed lags, Sargent's dance of resistance and accommodation led him to somewhat silently give up Lèvy stable distributions with infinite variance.

In this first phase of his quest for symmetry among agents, economists, and econometricians, therefore, Sargent encountered the resistance that Lévy stable distributions lack an algorithm for estimating the parameters. This obstructed his human agency in its attempts to connect the randomness in the models used by econometricians and agents with the determinism in the models developed by economists. Therefore, relinquishing Lévy stable distributions and their forced moves served Sargent well in his attempts to establish symmetry among agents, economists, and econometricians. Yet this act led him to tame disciplinary agency by adopting the "unrealistic" assumption that data previously shown to have exhibited infinite variance now followed a distribution with finite variance. Hence, this phase illustrates the first instance of the mangle of practice at work.

Phase Two: Accommodating Prediction

While econometricians were the first promoters of rational expectations, their initial focus on lag distributions changed to vector autoregressions during the late 1970s and early 1980s.[8] While the desire to establish symmetry among agents, economists, and econometricians continued to guide Sargent's human agency, the change in his disciplinary surroundings led him to advocate a different connection. That is, while he continued to start from the perspective of econometrics during this phase of his work, he now tried to establish symmetry by making a free move toward vector autoregressions.

The vector autoregressive model was designed especially to forecast. Indeed, the model was not based on economic theories at all;[9] instead, its main applications were in engineering. Christopher Sims, one of the pioneers of vector autoregressions in economics, believed that theoretical restrictions in statistical inference should be kept to a minimum (Sims 1980). Whereas large national econometric models were successful in the 1950s and 1960s, their performance hit rock bottom in the 1970s. The models did not successfully predict and could not explain the simultaneous high inflation and unemployment rates. Vector autoregressions, on the other hand, seemed capable of producing forecasts that were, compared to the standard variety, more accurate, more frequent, and cheaper. It was a straightforward, powerful, statistical forecasting technique that could be applied to any set of historical data.

Inspired by these developments, Sargent exerted his human agency by concentrating on restricting vector autoregressions as a free move on the econometric side of symmetry. As before, Sargent ended up with an econometrically motivated interpretation of rational expectations as a forced move. Rather than handling distributed lags, symmetry between agents and econometricians now required that agents with rational expectations fit vector autoregressions. The inclusion of economists in Sargent's symmetry pictures further mandated using the acquired econometric information to construct a theoretical model. However, a major disciplinary resistance in the form of observational equivalence (Sargent 1976) emerged and hindered Sargent in fully exerting his human agency. That is, contradictory theoretical models both could generate the very same vector autoregressive relations. To incorporate economic theory in his symmetry structure, Sargent felt he needed to overcome this resistance of observational equivalence by an accommodation that established a stronger connection between vector autoregressions and economic theory.[10]

With the aid of his colleague Lars Hansen, Sargent responded to the problem of observational equivalence by showing that vector autoregressive models were not necessarily atheoretical (Hansen and Sargent 1981a, 1981b, 1990, 1991b). In particular, Hansen and Sargent argued that their goal "has been to create a class of models that makes contact with good dynamic economic theory and with good dynamic econometric theory" (1991b, 1). In response, they made a different set of free moves. Having grounded "good dynamic econometric theory" in the engineering tools of vector autoregressions, Hansen and Sargent searched for "good dynamic economic theory" in the engineering

theory of recursive dynamics and linear optimal control.[11] The combination of vector autoregressions—recursive dynamics or linear optimal control—and rational expectations helped Sargent to establish symmetry in this phase. Yet, disciplinary agency called forth new resistances because this combination was technically not very successful, difficult to implement, and based on controversial assumptions. As in the previous phase, the consequences of Sargent's free moves led him to adopt "unrealistic" representations.[12]

In addition, Sargent became aware of the fact that his analysis relied on outdated engineering techniques that required much stability.[13] He had largely avoided questions about the way in which economic agents make choices when confronted by a perpetually novel and evolving world. This was the case despite the importance of the questions, because disciplinary agency showed that his tools and formal models were ill tuned for answering such questions. Changes in his environment and the appearance of a few extra resistances were necessary for Sargent to move in this direction. Before I discuss this final phase, I will outline the additional resistances that Sargent encountered.

Phase Three: Accommodating Sameness

This phase is centered on Sargent's eventual forced move to the interpretation of rational expectations as individual rationality and mutual consistency of perceptions. From the early-to-mid 1980s, Sargent focused on the free move of incorporating general equilibrium theory in his framework of rational expectations and vector autoregressions.[14] The general equilibrium framework imposed full theoretical restrictions on the coefficients in the vector autoregression and therefore avoided the problem of observational equivalence encountered earlier. Whereas the previous two phases in Sargent's work started with the conception of agents as little econometricians while economists were added as somewhat of an afterthought, the phase discussed in this section started with the free move of conceiving of agents as little economists while econometricians were added as somewhat of an afterthought.

Though the pioneer of rational expectations, Robert Lucas, had used general equilibrium theory from the start, it was not until the late 1970s that Sargent moved in this direction. During that time, he spent a year as a visiting professor at the University of Chicago and took two courses from Lucas. Sargent sought to establish symmetry by linking the free moves to vector au-

toregressions employed by econometricians and the general equilibrium theory developed by economists through the concept of rational expectations. Hence, in the interpretation of the concept that emerged as a forced move, agents have expectations that are rational when these depend, in the proper way, on the same things that, according to economic theory, actually determine that variable. A collection of agents works to solve the same optimum problems by using the relevant economic theory, and the solution of each agent is consistent with the solution of other agents. Econometric methods can then be used to estimate the vector autoregressions that result from this economic model. For Sargent, establishing symmetry among agents, economists, and econometricians with this setup was facilitated by the fact that general equilibrium theory involved an a priori bias toward symmetry among agents. As a result, the forced moves that emerged in association with disciplinary agency led Sargent toward symmetry not only among categories of people but also within groups of individuals.

Though Sargent had finally achieved symmetry, my narrative does not have a happy ending here. Instead, Sargent encountered new resistances that emerged from disciplinary agency due to the combination of rational expectations, general equilibrium theory, and vector autoregressions. First, if there is symmetry among the agents, then there is no reason for them to trade with each other, even if they possess different information. Instead of a hive of activity and exchange, Jean Tirole (1982) proved that a sharp no-trade theorem characterizes rational expectations equilibria (Sargent 1993, 113). Second, agents and econometricians have to be different in order to justify the error term. When implemented numerically or econometrically, rational expectations models need to impute more knowledge to the agents within the model who use the equilibrium probability distributions than is possessed by an econometrician who faces estimation and inference problems that the agents in the model have somehow solved (Sargent 1987c, 79). Third, there is a need for asymmetric actors in rational expectations economics for the concept of policy recommendations to make sense. In particular, making recommendations for improving policy implies the assumption that in the historical period the system was not really in a rational expectations equilibrium, having attributed to agents expectations about government policy that did not properly take into account the policy advice (Sargent 1984, 413). A fourth resistance deals with the issue of conceptualizing learning if agents are

thought to be little econometricians. In particular, econometric metaphors of reasoning possess a blind spot for the process of information search and errors made in information collecting, because econometric theories of inference and hypothesis testing are applied after the data has been collected; they do not start until the variables and numbers needed for the formulas are available (Sargent 1993, 23). These resistances, combined with those outlined in the previous section, eventually jointly transformed Sargent's entire program. As I will describe in the following section, Sargent tried to reimpose symmetry among agents, economists, and econometricians by making them all boundedly rational.

In this phase, therefore, forced moves associated with general equilibrium theory led Sargent to embrace symmetry not only among but also within categories of individuals. However, due to resistances that subsequently emerged as a result of disciplinary agency in Sargent's attempt to connect the techniques used by agents, the theories constructed by economists, and the models developed by econometricians, Sargent was unable to maintain symmetry within the setup he had developed. A "realistic" account required heterogeneous agents, an asymmetric government, and difference between agents and econometricians.[15] In an effort to accommodate the emerging characteristics of the dance of human and disciplinary agency, Sargent sought to reestablish symmetry through the use of bounded rationality. This is the final phase in his work to which I now turn.

Phase Four: Accommodating Learning

In what follows I discuss how Sargent eventually changed his attitude toward rational expectations in response to developments in the late 1980s. During this period, Sargent became involved with the Santa Fe Institute, where researchers were exploring themes such as complexity, intractable unpredictability, spontaneous self-organization, adaptation, nonlinear dynamics, computational theory, upheavals at the edge of chaos, inductive strategies, and new developments in computer and cognitive science. The Santa Fe Institute, which was founded by a number of distinguished physicists at the Los Alamos National Laboratories, originally had nothing to do with economics. This changed after the workshop, "Evolutionary Paths of the Global Economy," was held September 8–18, 1987, at the institute campus in Santa Fe

(Anderson, Arrow, and Pines 1988). This successful gathering served as the inspiration for the economics program at the institute, which focuses on the economy as a complex, constantly evolving system in which learning and adaptation play a major role.

One area that received a great deal of attention during the workshop was the specific question of how economic agents take the future into account when making decisions. The axiom of rational expectations seemed patently untrue to the physical scientists, who were acutely aware of the difficulties inherent in predicting the future.[16] The problem in developing a more "realistic" model was that if economic agents were assumed to be able to anticipate the future, but not perfectly, then it is hard to know just how imperfect rationality should be. One suggestion was to develop theoretical economic agents that learned in the way that actual economic agents did, which was in line with Sargent's desire to restore symmetry. Before analyzing Sargent's embracement of the approach based on the Santa Fe program, however, we need to consider prior accommodation efforts by Sargent to deal with the problems outlined in the previous sections.

Sargent was bothered by the asymmetry among agents, economists, and econometricians that emerged from disciplinary agency within the setting of rational expectations, general equilibrium theory, and vector autoregressions. In response to this resistance, he was led in the mid-1980s to revise part of his framework. Instead of starting from rational expectations, Sargent made a free move to agents with adaptive expectations in work mostly coauthored with Albert Marcet, who was a graduate student at the University of Minnesota during Sargent's tenure there and who subsequently followed in Sargent's footsteps by accepting an assistant professor position at Carnegie Mellon University (Marcet and Sargent 1986, 1988, 1989a, 1989b, 1989c, 1992). The models they developed were adaptive in the sense in which that term is used in the control literature (but not in the macroeconomics literature).[17] In particular, the agents were assumed to behave as if they know with certainty that the true law of motion is time invariant. Because the agents operate under the continually falsified assumption that the law of motion is time invariant and known for sure, the models do not incorporate fully optimal behavior or rational expectations.

Because Sargent was unwilling to relinquish rational expectations entirely, he did not see learning as new to economics. Instead, he saw it as a way of

strengthening the standard ideas and dealing with their problems—as a way of understanding how economic agents will grope their way toward neoclassical behavior even when they are not perfectly rational (Sargent 1993, 23). In particular, he tried to reinforce rational expectations by focusing on convergence to this equilibrium (Marcet and Sargent 1992, 140). He also tried to use learning with adaptive expectations to deal with some of the problems associated with rational expectations (Sargent 1993, 25). Finally, incorporating learning could assist in the computation of equilibria (Marcet and Sargent 1992, 161).

This new framework, however, did not fully allow Sargent to satisfy his interests due to the emergence of new resistances in disciplinary agency. That is, the representation resulting from the forced moves was "unrealistic" in the sense that agents were assumed to have already formed a more-or-less correct model of their existing situation, and learning was just a matter of sharpening up the model a bit by adjusting a few knobs. Since Sargent had moved toward picturing economists and econometricians as being far from rational and knowledgeable about the system they analyze, this "unrealistic" picture still left him with a rather weak attempt at exerting his human agency.

Sargent was unhappy with the "unrealistic" interpretation of learning under adaptive expectations that had emerged due to disciplinary agency, and he wanted to find something closer to the way economists and econometricians learn. How could he circumvent the forced moves that resulted in the "unrealistic" representation? In attempting to answer this question, the Santa Fe meeting inspired Sargent to appeal to artificial intelligence. Instead of assuming that agents were perfectly rational, they could be modeled as being artificially intelligent and learning from experience like real economic agents. Rather than modeling the economy as a general equilibrium, societies of interacting artificially intelligent agents could be organized into an economy. Reluctant to abandon his earlier contributions completely, Sargent did not fully embrace the Santa Fe approach. Instead of relinquishing the neoclassical notion of an equilibrium, he focused on convergence to equilibrium (Marimon, McGrattan, and Sargent 1990).

Sargent saw what he called his bounded rationality program as an effort to restore symmetry among agents, economists, and econometricians. Whereas resistances had earlier frustrated his attempts to establish symmetry through the use of rational expectations, he now moved to picturing agents, economists, and econometricians alike as being boundedly rational but converg-

ing to rational expectations. Ironically, however, the move to artificial intelligence came along with forced moves that left Sargent with a new asymmetry that emerged between him and the agents in his models. Specifically, Sargent had to be smarter when he made the agents more bounded in their rationality, because disciplinary agency illustrated that his models became larger and more demanding econometrically. Furthermore, artificial intelligence did not allow Sargent to fully establish symmetry, because the proliferation of free parameters in the bounded rationality program left him with an asymmetry between economists and econometricians: "Bounded rationality is a movement to make model agents behave more like econometricians. Despite the compliment thereby made to their kind, macroeconometricians have shown very little interest in applying models of bounded rationality to data. Within the economics profession, the impulse to build models populated by econometricians has come primarily from theorists with different things on their minds than most econometricians" (1993, 167–68).

This final phase illustrates how Sargent's attempts at exerting his human agency by establishing symmetry continued to be frustrated as a result of the emergence of resistances due to disciplinary agency. Sargent himself acknowledged that neither learning through adaptive expectations nor learning through artificial intelligence established the symmetry he sought. Whereas the disciplinary agency associated with adaptive expectations excluded agents from the symmetry structure, the forced moves associated with artificial intelligence continued to exclude agents from the symmetry structure and further left Sargent with an asymmetry between economists and econometricians. Will Sargent ever be able to establish symmetry among economists, econometricians, and agents? Will he continue to encounter forced moves and resistances that keep him from establishing symmetry? What will emerge from the interaction of human and disciplinary agency? We will have to wait and see.

Conclusion

In this chapter I have shown how Thomas Sargent was faced with the emergence of different interpretations of rational expectations in different periods as a result of the dance of human and disciplinary agency. I have outlined four case studies of Sargent trying to establish symmetry among agents, economists, and econometricians. The first case study was staged in the late 1960s

through early 1970s. The events explored in the second study took place in the late 1970s through early 1980s. The third study was set in the early-to-mid-1980s. The events discussed in the final case study took place in the late 1980s through early 1990s.

Sargent's community in the late 1960s through early 1970s consisted of his student Robert Blattberg, among others. In this setting, Sargent made the free moves to focus on the randomness of lag distributions, the determinism of neoclassical economic theory, connecting economic theory and econometric method through rational expectations, and the term structure of interest rates. As a result of those decisions, Sargent was led to adopt an econometrically motivated interpretation of rational expectations and to acknowledge the importance of Lévy stable distributions following the forced moves. The resistances he ran into were that for Lévy stable distributions there was no general estimation method and the properties of estimators could only be investigated in an indirect way. He accommodated these by giving up Lévy stable distributions despite the evidence in favor of their "realism." Christopher Sims and Lars Hansen were Sargent's collaborators in the late 1970s through early 1980s. Influenced by a change in his economic environment and by Sims, Sargent tried to combine rational expectations with vector autoregressions and to use the acquired statistical information to construct a theoretical model. This proved to be problematic because the resistance of observational equivalence implied that contradictory theoretical models could generate the very same vector autoregressive relations. When Sargent tried to accommodate this resistance by collaborating with Hansen on recursive dynamics and linear optimal control models, new resistances emerged because Sargent's models were technically not very successful and were difficult to implement. Furthermore, disciplinary agency led Sargent to develop models based on "unrealistic" assumptions. In the early-to-mid-1980s, Sargent worked with Robert Lucas, among others. In this environment, he initially adopted free moves toward general equilibrium theory, vector autoregressions, and rational expectations. This move promised to allow him to establish symmetry not only among but also within categories of individuals. However, he found that asymmetry appeared as a consequence of the no-trade theorems, incorporating information gathering, error term justification, and policymaking recommendations. Sargent tried to accommodate these resistances and restore symmetry by adopting adaptive expectations and artificial intelligence.

Albert Marcet and the Santa Fe Institute were part of Sargent's environment in the late 1980s through early 1990s. In these surroundings, Sargent first focused on adaptive rather than rational expectations. This reduced the asymmetry among agents, economists, and econometricians, but disciplinary agency prohibited him from fully establishing symmetry. Sargent tried to incorporate a more "realistic" interpretation of learning by finally adopting a version of artificial intelligence that was limited to convergence. Yet, resistances continued to frustrate Sargent's search for symmetry since he was left with asymmetry between himself and agents and between economists and econometricians.

Sargent entertained different interpretations of rational expectations in different periods. In the late 1960s through early 1970s he used an econometrically motivated interpretation of rational expectations with a focus on distributed lags. In the late 1970s through early 1980s this emphasis changed to vector autoregressions. During both of these phases, Sargent started with the conception of agents as little econometricians while economists were added to the symmetry picture as somewhat of an afterthought. In the early-to-mid-1980s, Sargent focused on how rational expectations in a general equilibrium framework could lead to vector autoregressions. During this phase, he started with the conception of agents as little economists while econometricians were added as somewhat of an afterthought. In the late 1980s through early 1990s, Sargent tried to show convergence to rational expectations through learning by agents, economists, and econometricians alike through the use of adaptive expectations or artificial intelligence. Furthermore, Sargent's choices were partly inspired by his social environment; Blattberg in the late 1960s through early 1970s, Sims and Hansen in the late 1970s through early 1980s, Lucas in the early-to-mid-1980s, and Santa Fe and Marcet in the late 1980s through early 1990s. It was further shown that as a result of each interpretation of rational expectations, Sargent had to deal with different resistances due to disciplinary agency.

Rather than analyzing rational expectations economics in general, I have focused on the account of one of the central players in the rational expectations movement, Thomas Sargent. What were the alternatives available to him? What choices did he make? What were the emerging consequences of those decisions due to disciplinary agency? How did he accommodate undesirable consequences? The framework I used to answer these questions was

inspired by insights from Andrew Pickering. I started out with Sargent's interests, which were situated in and subject to change through scientific practice. I showed how Sargent tried to extend culture to serve his interests and how he used his motivations as a standard for judging whether the extension of culture was successful or not. The free moves reflected the tentative choices that Sargent made, carrying with them no guarantee of success. The forced moves served to elaborate the choices through disciplinary agency. Sargent could accommodate resistances that emerged when the extension of culture was not successful by changing his interests, changing his free moves, or ignoring the forced moves.

In this chapter I have pictured economics as a field of emergent human and disciplinary agency engaged by means of a dialectic of resistance and accommodation. I have used the framework of interests, moves, resistances, and accommodation to illustrate the emergence of continually changing interpretations of rational expectations in Sargent's work and to provide an internal criticism. The insight that Sargent ran into resistances in his attempts to satisfy his interests can be used to resist his analysis. Rather than imposing outside standards, I have shown that Sargent was unable to meet his own standards. This kind of analysis provides an interesting alternative to the many different, simple, and equally (un)compelling stories about the rational expectations revolution that have been circulating among members of the history of economics community up until now. It differs by showing that facts and knowledge in rational expectations economics represent assemblages of human and disciplinary performances that emerge in time and also pass in time. The novel point that the analysis makes concerns the temporal aspects of facts and knowledge in rational expectations economics and how they are highly delicate and subject to change.

An additional attraction of the approach I used in analyzing Sargent's work is that there is a symmetry in the treatment of the "interests" of Sargent and the "interests" of the agents in his model. As Wade Hands notes: "While economists do not normally use the term 'interests,' they do in fact explain economic behavior on the basis of the 'interests' of the agents involved" (1994, 81). In fact, Pickering "has been criticized precisely because [his work] characterizes the behavior of scientists in the way that a neoclassical economist would characterize individual behavior" (84).[18] While Sargent has endowed his agents with neoclassical behavior, here I characterized his

behavior in a neoclassical economic way. The fact that this is precisely the symmetry that Sargent eventually sought to achieve serves to strengthen the arguments for using Pickering's framework.

NOTES

I am grateful to Keith Guzik, André van Hoorn, and Andrew Pickering for their helpful suggestions.

1. Following Pickering (1992, 1995; Pickering and Stephanides 1992), Sargent's initial steps consisted of free moves made in an effort to serve his interests. However, these were tentative and revisable trials that carried no guarantee of success.
2. The consequences of the initial steps are labeled Sargent's forced moves. These revealed how his scientific culture further directed his plans and intentions.
3. Resistances are the obstacles Sargent encountered in his attempt to satisfy his interests. Faced with a failure to satisfy his interests as a result of resistances, Sargent was led to accommodate them by tinkering with the elements of the structure he had built up as a result of his free and forced moves.
4. Since Sargent never explained the justification of symmetry among agents, economists, and econometricians, I can only speculate on this issue: first, Sargent might have defended symmetry as a quality inherent in things; second, he might have argued that symmetry follows from a power of recognition inherent in the mind; third, he might have claimed that symmetry is a matter of metaphor.
5. In economics, the dominant or mainstream approach is known as neoclassical economics. Econometrics is the branch of economics that applies statistical methods to the empirical study of economic theories and relationships.
6. A time series is a sequence of data points, measured typically at successive times, that are spaced apart at uniform time intervals. Time series analysis comprises methods that attempt to understand such time series, often either to understand the underlying theory of the data points (Where did they come from? What generated them?) or to make forecasts (predictions). Time series prediction is the use of a model to predict future events based on known past events: to predict future data points before they are measured.

   For models with one dependent and one explanatory variable, the distributed lag will look like this: $y_t = \alpha + \beta_0 x_t + \beta_1 x_{t-1} + \ldots + e_t$.

The term "structure of interest rates" refers to the phenomenon that interest rates vary with time—where interest rates for longer time periods often are higher than those for shorter time periods.

7. A probability distribution assigns to every interval of the real numbers a probability, so that the probability axioms are satisfied. A Lévy stable distribution is a special type of probability distribution whose characteristics are explained in the text. Variance is the expected value of the square of the deviation of a random variable from its own mean.
8. A process y_t is called a vector ARMA(p,q) process if
$y_t = \Theta_1 y_{t-1} + \ldots + \Theta_p y_{t-p} + \nu_t + A_1 \nu_{t-1} + \ldots + A_q \nu_{t-q}$

where

$$\Theta_n = \begin{bmatrix} \theta_{11,n} & . & . & . & \theta_{1k,n} \\ . & . & & & . \\ . & & . & & . \\ . & & & . & . \\ \theta_{k1,n} & . & . & . & \theta_{kk,n} \end{bmatrix}, n = 1, \ldots, p$$

$$A_n = \begin{bmatrix} \alpha_{11,n} & . & . & . & \alpha_{1k,n} \\ . & . & & & . \\ . & & . & & . \\ . & & & . & . \\ \alpha_{k1,n} & . & . & . & \alpha_{kk,n} \end{bmatrix}, n = 1, \ldots, q$$

and ν_t is k-dimensional vector (or multivariate) white noise defined by $E[\nu_t] = 0$, $E[\nu_t \nu_t'] = \Sigma_\nu$ (positive definite) and ν_t and ν_s are independent for $s \neq t$. The process y_t is called a vector AR(p) process if $q = 0$; that is,
$y_t = \Theta_1 y_{t-1} + \ldots + \Theta_p y_{t-p} + \nu_t$
and y_t is called a vector MA(q) process if $p = 0$; that is,
$y_t = \nu_t + A_1 \nu_{t-1} + \ldots + A_q \nu_{t-q}$.
9. Whereas time-series analysis examines variables over time, structural analysis studies the relationship between different variables at a point in time.
10. I should note that while these problems led Sargent to change his approach, they never bothered Sims because he was indifferent to symmetry.

11. Recursive dynamics computation has been shown to allow the efficient simulation of systems with large degrees of freedom. Optimal control is a mathematical tool that allows users to find optimal paths over time for different variables that describe a dynamic economic system.
12. It is important to stress that Sargent himself acknowledged that it is difficult to take seriously the predictions of his models in this phase.
13. Specifically, they presumed a stationary process, which is a stochastic process in which the probability density function of some random variable X does not change over time or position. As a result, parameters such as the mean and variance also do not change over time or position.
14. General equilibrium theory is a branch of theoretical economics that seeks to explain production, consumption, and prices in a whole economy. It does so by using a bottom-up approach that starts with individual markets and agents. Note also that Sargent did not make use of Walrasian general equilibrium analysis but rather employed representative agent analysis instead.
15. Again it needs to be emphasized that Sargent himself recognized these emerging characteristics of the dance of human and disciplinary agency due to the free moves, forced moves, and resistances.
16. Note that the earlier defense of rational expectations by Sargent and the current criticism of rational expectations by physicists relied on different notions of "realism." Spelling these out, however, is beyond the scope of this chapter.
17. In engineering and mathematics, control theory deals with the behavior of dynamical systems over time. Macroeconomics is the study of the entire economy in terms of the total amount of goods and services produced, total income earned, the level of employment of productive resources, and the general behavior of prices.
18. While Pickering (1995, 7) freely admits intentionality as a central feature of human action and would not disagree that humans make intentional choices on the basis of their beliefs and desires, the weight of his research and argument lies in demonstrating how human behavior is not a derivative of such interests. Instead, his stories of human action (scientific practice) highlight how such action is bound together with material, nonhuman performances. In fact, once we look at the case studies themselves, we find that human intentions, goals, and desires get mangled and emerge in time as a result of these human and nonhuman performances.