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Persistent Unemployment and Policy Uncertainty: Numerical Evidence from a New Approach

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In the recovery from the United States' 2009 recession, unemployment has proven resistant to both aggressive fiscal policy and expansionary monetary policy. A possible explanation is the policy cost uncertainty hypothesis. This holds that managers of private firms have been rationally avoiding hiring workers in the years after 2010 because of the risk of higher future costs imposed by government policies. However, such a hypothesis cannot be directly tested in standard models of firm behavior. Thus, to formally test the policy cost uncertainty hypothesis, we use a novel "value functional" or "recursive" model of firm behavior, in which managers maximize the value of the business rather than its profits. Using this approach, we demonstrate that policy cost uncertainty affects the hiring decisions of firms, that the response to policy uncertainty is higher in some industries than others, and that the scale of the firm also affects its sensitivity to policy risk. This approach has potentially broad application within business economics, particularly in evaluating investment and hiring decisions; real options; and other aspects of uncertainty, fixed costs, and managerial flexibility.

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The causes of persistent unemployment are a matter of longstanding debate in the economics profession, with tremendous implications for the health and wealth of nations. For over two centuries, classical, neoclassical, Keynesian, monetarist, and real business cycle theorists have introduced competing theories on the topic. Political changes often coincided with intellectual ferment, and emerging theories sometimes coincided with changing political regimes. Indeed, one can almost mark the history of economics in the modern era by recalling the emergence of the Federal Reserve System a century ago, the Great Depression of the 1930s, the stagflation of the 1970s, the "Reaganomics" of the 1980s, and the "irrational exuberance" of the 1990s.

The Great Recession of the late 2000s challenged economic orthodoxy once again. In the United States, it triggered dramatic federal intervention in the economy, which gained the support of both political parties and much of the intellectual elite, even as it earned scorn from others. However, such intervention failed to arrest persistent high unemployment in the initial years of the recovery, even as inflation and interest rates remained historically low and government expenditures surged. Furthermore, unlike in the Great Depression, trade policies did not change dramatically. Even tax policy —as indicated by federal income tax rates applied to current income—changed little, at least until 2013.

Thus, the question must be posed again: what are the primary causes of persistent unemployment, and shall we look beyond expansionary fiscal and monetary policy to address them?

1. Alternative Explanations of Persistent Unemployment

Sluggish employment in a weak recovery

The pace of employment growth in the four years since the end of the Great Recession was much slower than in the recoveries that the United States enjoyed after most recent recessions. Furthermore, the pattern of weak employment growth persisted in both the first

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two years, and the second two years, after the trough of the recession:

- During the four previous recoveries, the average change in overall nonfarm payrolls during the seven quarters after the trough of the downturn was a rise of 1.8 percent. In contrast, overall employment rose during the analogous time period after the recent recession by only 0.2 percent.[1] Civilian unemployment rates remained over 10 percent in several states through the spring of 2011 —fully a year and a half after the recession was declared to be over.
- In the succeeding two years, the civilian unemployment rate dropped back under 8 percent for the country as a whole, with a handful of U.S. states and territories (including the quite-different states of California, Mississippi, Nevada, and North Carolina, as well as Puerto Rico) still experiencing rates above 9 percent in the first quarter of 2013.[2] This extended duration was "an unprecedented combination" according to the Federal Reserve Bank of Cleveland, noting that the unemployment rate peaked (above 9 percent) in the Great Recession more than 20 months after the beginning of the recession, and remained near that level for another 20 months.[3]

Examining the same phenomenon using an arguably more robust measure, the employment-to-population ratio, paints an even more depressing picture. Peaking above 64 percent in 2000, this ratio dropped to under 60 percent during the Great Recession, and remained around 59 percent through the first half of 2013. These levels had not been experienced since the early 1980s.

Possible causes of persistent unemployment

Let us briefly consider the possible macroeconomic causes of such sluggish employment. We have separated these into two categories associated with the dominant schools of economic thought for the past half-century, plus the category that we wish to consider in the remainder of this paper:

Monetary, trade, or fiscal policies. The economics profession focused on this trio of topics for much of the twentieth century, particularly after the searing experience of the Great Depression and the emergence of the macroeconomic theories originated by John Maynard Keynes. Keynes, and later Milton Friedman and others, criticized the response of the United States federal government to the Great Depression.

However, the response of the federal government to the recent recession was quite different from that during the Great Depression. U.S. policymakers aggressively loosened monetary policy, contrary to the effective contraction of the Great Depression. In addition, the nation began stimulative fiscal policies in the last year of President Bush's second term of office, and expanded that stimulus during the initial years of President Obama's first term. Furthermore, and again unlike the Great Depression, the United States did not retreat into protectionism.

Commodity prices; real estate; technology changes. The "real business cycle" school of thought that emerged in the later years of the twentieth century provides a competing set of possible causes of persistent unemployment. In particular, real business cycle theory suggests that consumers and business owners respond to trade disruptions, cycles in commodity prices, and technology shifts, as well as to changes in government policy that affect prices.

In the case of the Great Recession and its recovery, there was no shock to the system on the order of magnitude of the oil embargo in the 1970s. It is similarly difficult to blame a real estate bubble that evaporated years ago. Finally, production technology has evolved slowly during this time period. Although the real estate bubble and technological change undoubtedly had some effect on the real economy, they cannot explain persistent unemployment four years and more after the beginning of the recovery.

One aspect of real business cycle theory worth considering is the presumption that consumers and businesses exhibit "rational" expectations, of the kind first proposed by John Muth [1961] and greatly developed by Robert Lucas and others. One classic implication of rational expectations—that an increase in inflationary expectations would be caused by stimulative monetary policy—has not evidenced itself: indeed interest rates have been at historic lows. As will be shown further, the model presented here involves a different kind of expectation about the future than that proposed by Muth.

[1]Change in total nonfarm payrolls between June 2009 (that is, the end of the second quarter), and March 2011, seasonally adjusted data (Bureau of Labour Statistics May 2011).

[2]State and federal unemployment rates obtained from the U.S. Bureau of Labor Statistics.

[3]This analysis, by Tasci [2011], is notable for recognizing the signs of sluggish recovery in the first year of the 2011–13 period for which we evaluate the effects of policy cost uncertainty. See the discussion of the model in Section 2.

The policy cost uncertainty hypothesis. Recently, a new hypothesis for the cause of persistent unemployment has gained attention: that uncertainty about government policies that could impose significant additional taxes and costs is responsible for a reluctance of private-sector firms to hire workers.[4] In particular, the hypothesis focuses on burdens on employers to fund health care and comply with related laws, pay higher assessments to fund extended unemployment benefits, as well as pay higher income taxes on earnings from business operations and from related investments. Reports from a variety of businesses and areas within the country, and from multiple sources, provide evidence that business hiring and investment plans were negatively affected by policy cost uncertainty during this time period [Federal Reserve Board 2012 and 2013; National Federation of Independent Businesses 2011 and 2013]. Of course, economists tend to place much less emphasis on what people *say* they are doing than on what they actually do, but these reports—together with persistent unemployment in the economy—provide a strong motivation for this test of the policy cost hypothesis.

This characterization of policy cost uncertainty represents, of course, an incomplete assessment. However, it focuses our attention on the possibility that standard macroeconomic theory has been inadequate to the task of modeling the hiring decisions of private employers and that this inadequacy has been exposed by the slow recovery to the Great Recession.

Defining policy cost uncertainty

We define policy cost uncertainty as: A nonzero likelihood, as perceived by employers, of a significant increase in government policy-imposed costs on businesses, including payroll taxes, health insurance costs and compliance burdens, and income taxes.

Note that this definition focuses on the *likelihood* of certain events occurring, rather than the *realization* of possible events. The likelihood of an increase in taxes and costs is expressed as a probability *between* zero and one.[5] How businesses react to the likelihood that their costs and taxes will change is indeed a question of business decisions under uncertainty.

Such a measure is distinct from other indicators of "uncertainty." In particular, it is distinct from statistics on the variation in a random variable, such as the standard deviation, and from the "uncertainty index" proposed by Baker, Bloom, and Davis [2012].[6] However, the assumption here of a significant likelihood of policy cost increases in the 2011–13 era is consistent with the level of the uncertainty index during that time.[7]

Finally, the forward-looking expectations in this model are not the same as "rational expectations," and the likelihood of a policy cost increase is not the same as the best estimate of future costs. We discuss this topic further in the final section of the article.

Formalizing the hypothesis

Given the observations about the sluggish economy, and the definition of policy cost uncertainty, we formalize the policy cost uncertainty hypothesis as follows:

Given policy cost uncertainty during the 2011–13 time period:

- some employers rationally avoided hiring to avoid possible future policy-imposed costs; and
- this avoidance is responsible for some significant part of the employment gap.

[4]The policy cost uncertainty hypothesis relies on the assumption that, at least in aggregate, other forms of business risk (such as business cycle, interest rate, weather, supply chain, logistics, and technology risks) did not change substantially after 2010. For many individual businesses, this is clearly not the case. However, as noted in the discussion regarding the real business cycle theory, it is hard to identify one of these as causing persistent unemployment across the entire U.S. economy.

[5]Because we capture these probabilities in a transition probability matrix (where each row sums to one) any nonzero, nonunitary entry means there is at least one other probability that is also nonzero and nonunitary. Therefore, ruling out zero probabilities also rules out the "certainty" case where all probabilities are one.

[6]Baker, Bloom, and Davis [2012] construct an index from various indicators of uncertainty about the economy, including news coverage, expiring tax code provisions, and forecaster disagreement. Such an index provides a very useful metric for uncertainty. Recent events offer a distinction between the "likelihood of a policy-caused cost increase" and "uncertainty about policy-caused costs." In our model, a likelihood of a tax increase, as perceived by business managers, would be modeled by a relatively high probability of transitioning from a "baseline cost 2010" state to a "high cost 2014" state. In the Baker, Bloom, and Davis uncertainty index, the same perceived likelihood could be presaged by an expiring tax code provision or an intense debate about tax policy, both of which could increase the uncertainty index; or by a surprise imposition of a cost that arises from an administrative action, which may or may not increase the uncertainty index.

[7]The uncertainty index had a substantially elevated level in 2011–13, when compared with the pre-2010 era, which is consistent with the assumption underlying the policy cost uncertainty hypothesis. Of course, all indices vary over time, and the variation in the policy uncertainty index during the 2011–13 period does not disprove the existence of significant policy cost uncertainty.

Testing the policy cost uncertainty hypothesis

The observation that uncertainty about the future can affect business decisions is hardly novel. However, as described below, standard microeconomic models fail to adequately capture how policy uncertainty affects business decisions. In addition, standard macroeconomic models often omit policy uncertainty entirely, relegate it to a minor factor, or confine it to a variable that affects only part of the economy.

In particular, such models do not describe why firms might rationally *not* expand their operations when a recovering economy offers them the possibility of increased profits by immediately hiring workers. The embedded assumption in these models—that firms always maximize profits—is a time-honored one. Indeed, it is a foundation of the neoclassical economics that has been the beginning point for economic theory for well over a century [Marshall 1920]. Replacing the profit-maximizing principle with an alternate principle is a step that should be taken gingerly.

However, there is now a competing model of firm behavior, which allows us to examine the policy cost uncertainty hypothesis directly. This is the path we take in this paper.

A new approach: The value-maximizing firm

In this analysis, we use a novel "value functional" or "recursive" model of firm behavior. The underlying principle in this model is that managers do not maximize profits in any single period, but instead maximize *value.* They do so by recursively solving a series of two-period optimization problems. The mathematics behind the value functional approach to optimization problems has been developed over approximately the past 50 years. However, only recently has it been explicitly applied to firm behavior, and even more recently has it been possible to numerically model business decisions using data representative of actual operating businesses.

Such an approach shares certain fundamental presumptions with standard neoclassical, classical, Keynesian, and real business cycle models. These include the presumption that business managers are aware of multiple possible economic conditions that could prevail in any period, and that they take actions when conditions change.

However, the business manager in the value functional approach is also presumed to have some knowledge about the *probabilities* that the state could change in the future, as well as knowledge of what changes in business operations the manager could exercise if such a change occurs. This knowledge has important ramifications, and the value-maximizing objective allows the business manager to behave in a manner that takes advantage of that knowledge before conditions change.

Thus, this approach involves a different structure entirely than traditional classical, Keynesian, and neoclassical models, all of which rely to some extent on the profit-maximization principle, as well as real business cycle or other models that add "rational expectations" about costs of information available to business managers and then assume that managers maximize profits in the standard manner.

Questions to answer

In applying the value-maximizing approach, we consider the following questions:

- Can a practical model of firm behavior, built on the assumption that firms maximize value, be created and numerically solved, using data representative of actual operating firms?
- In such a model, can policy cost uncertainty *cause* rational employers to defer hiring or reduce employment?
- Does this approach provide analytical power worth exploring for other tasks of the business economist, such as evaluating potential investments, modeling "real option" opportunities for firms, and evaluating asymmetric and "black swan" risks in portfolios and financial institutions?

The remaining sections of the paper address these questions as follows:

- Section 2 presents the value functional approach to business valuation, including the mathematical form, the fundamental building blocks of states, actions, and probabilities of operating in those states in the future, and the optimizing behavior of business managers in such a model.
- Section 3 develops the specific model of business risk and policy decisions.
- Section 4 outlines a value functional model of employer firms; and a numerical procedure for composing, formulating into a mathematical equation, and solving the model.
- Section 5 describes the results of testing the policy cost uncertainty hypothesis using the data, assumptions, and model described in Section 4. It also discusses the insights gained from numerically solving such a model; the practical questions

outlined above; and areas where this method could be applied to numerous other issues confronting the business economist.
- Appendices contain additional information on the model, data, numerical procedure, and software used.

2. The Value Functional Approach

The neoclassical model and its defects

The neoclassical model of profit maximization grew from the work of Carl Menger, William Stanley Jevons, and Leon Walras in the late nineteenth century, and was popularized by the great English economist Alfred Marshall [1920] in the first two decades of the twentieth century.[8]

The French-born American economist Gerard Debreu [1959] synthesized this model concisely in *The Theory of Value: An Axiomatic Analysis of Economic Equilibrium.* This slim volume is surely one of the most influential texts in mathematical economics, and Debreu later won the Nobel Prize for his efforts. Indeed, Debreu's presentation is the forerunner of such contemporary microeconomics textbooks as those by Varian [1992] and Mas-Colell, Whinston, and Green [1995].

The neoclassical model conceives of the following one-period optimization problem faced by the manager of a business:

- The business produces one good from raw materials and labor.
- The price of the good is set in a competitive market, at the point where supply equals demand.
- The firm seeks to maximize its profits.

Using standard assumptions (such as diminishing returns to scale), profit maximization produces the marginal cost equals marginal revenue rule of profit-maximizing businesses. Of course, even the traditional model accounts for the incentives for new producers to enter the market if the rate of profit is high enough; pricing behavior in oligopolistic markets, barriers to entry, and effects of market changes on consumer and producer surplus. Extensions in recent decades explore principal-agent problems, game-theoretic approaches to pricing in monopolistic markets, and the role of intellectual property, networks, and technology standards. However, the core principle in these remains the maximization of profits.

There is nothing wrong with the neoclassical model as a teaching tool; indeed, it is hard to conceive economics without it. However, it largely ignores the following two categories of time-related factors:

- Uncertainty in supply, demand, technology, and government policies.
- Fixed prices, sticky wages, long-term contracts, and other limits on managerial flexibility for dealing with changing market conditions.

Although such issues are often abstracted away as market imperfections, they have become the focus of intense analysis in practical business economics, microeconomics, and academic research. Within macroeconomics, the past nine decades have been punctuated with efforts to address issues arising from these problems, including the "sticky wages" of Keynesian economics; the permanent income model of Milton Friedman, the rational expectations critique of Robert Lucas, the notions of credibility and reputation in monetary policy, and real business cycle theories.

Standard models that incorporate expectations

- *Adaptive "expectations" that are weighted averages of past prices*. The weaknesses of this method (at least within macroeconomics) were anticipated at least as far back as David Ricardo, and then formalized by Lucas and others in their famous critique of Keynesian models.[9]
- *"Rational expectations" that are forecasts based on predictions of economic theory.* Muth argued in 1961 that the "character of dynamic processes is typically very sensitive to the way expectations are formed in the actual course of events" [Muth 1961, pp. 315–316]. He then proposed the "rational expectations hypothesis," which included the

[8]Thorstein Veblein first described it as "neoclassical," noting that it relied on thinking about marginal costs and marginal utility, rather than on the notions of production costs that had dominated the "classical" economics of Adam Smith and David Ricardo.

[9]David Ricardo [1846] noted the equivalence, at least in present value terms, of the taxpayer burdens imposed by the government borrowing money and repaying it with future taxes, and simply imposing the taxes directly. This concept, known as "Ricardian Equivalence," was later formalized by the contemporary economist Robert Barro [1974]. It is sometimes asserted as an implication of rational expectations in fiscal policy, at least in analytical models with intergenerational transfers. Robert Lucas [1976] summarized a general critique of policy implications drawn from Keynesian models as follows: "Given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models."

following definition: "expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory." However compelling this logic is, business managers must operate in an environment in which certain risks are inherently political or social in nature and where future prices, costs, and the ability to buy and sell in regulated economies cannot be predicted well with economic theory. For businesses in stable, free economies such as the United States, such risks might be abstracted away without penalty when evaluating some economic problems. However, even in such countries future economic policies determined by governments cannot be predicted solely by economic theory.[10] Indeed, the complicated series of events that began with the debate and subsequent adoption of the Affordable Care Act in the United States could be seen as an object lesson in the futility of forecasting future taxes and costs solely on the basis of either economic theory or government pronouncements.[11]

- *Prices of traded commodities that span distributions of random events*. Sometimes a commodity exists, such as an inflation-protected government bond or a commodity futures price, that allows for a business to directly hedge certain business risks. However, markets for business risk and for inputs related to policy risk (including labor markets) are almost always imperfect. Therefore, business managers must incorporate into their operating decisions their efforts to adapt to the risks that they cannot hedge.

[10]As the co-author of "Pocketbook Predictions and Presidential Elections" Anderson and Geckil [2004], I must acknowledge that economic conditions (and even prevailing economic theories) affect election results. Economic theory and economic variables are also known to help predict many similar events, as explored by, for example, Fair [2002]. However, even in U.S. presidential elections, where economic conditions have a clear, empirical relationship with voter choices, a significant share of the results cannot be explained by economic conditions. Similarly, one cannot explain fiscal policy at both the state and federal levels (including such events as the "fiscal cliff," the recurring debates over the debt ceiling, and the debate and subsequent adoption of income tax laws) as being primarily determined by "economic theory."

[11]In addition to the continuing uncertainty about costs and taxes, employers as of the last quarter of 2013 were still uncertain about whether key mandates, adopted as part of the ACA statute, would be imposed as scheduled, postponed, or changed. On top of this, they would have witnessed breakdowns of individuals' online enrollment in the federal Health Exchange Marketplace and firms' online enrollment in the Small Business Health Options Program. Even careful reading of government documents outlining the enacted ACA (e.g., CBO [2011]) could not have sufficed for a confident prediction of future costs.

Therefore, augmenting a standard model with expectation variables of the types listed above will not allow us to properly test the policy uncertainty hypothesis.

Novel approach: Optimization of a value functional

We seek a model that captures the actual risks faced by the business manager and that includes a mechanism for a rational response to those risks. Such a model would ideally reflect the intuition of the neoclassical model (that investors seek profits and adjust their business scale accordingly), without suffering from the implausible straitjackets of assuming either complete markets or a one-period optimization.

One such model is the recently proposed value functional model of the firm.[12] In this model, the manager is assumed to maximize the *value* of the firm. The manager's optimization decision is based on his or her assessment of the current state of affairs and the actions available to the manager, both of which are also part of the information set in the neoclassical model. However, in the value functional model, the manager also considers the probabilities of the state of affairs changing in the future, and the future ability to change course under those circumstances.

This is different from neoclassical profit-maximization, in at least three respects.

- *Value maximization.* The manager is primarily concerned about value, rather than profits. The value given the current state is defined recursively as maximization (over the set of actions available to the manager) of the sum of the current period's net profit and the discounted expectation of next period's value. A value maximizer will act differently than a profit maximizer, and the path of decisions over time for a profit-maximizing firm (even one that takes into account expectations about future prices) will be different than for one that maximizes value.
- *Tension between investments for the future and current-period rewards.* The firm's optimization involves decisions in one period that can affect the state in the following period. This gives rise to an explicit intertemporal trade-off, between current

[12]See Anderson [2013, chapter 15] for the value functional model of the firm, whose definition of the firm requires three factors: a separate legal identity; a profit motive for its owners; and replicable business practices. This definition provides the basis for the mathematical formulation of a value functional equation involving management actions designed to maximize value for the owners of the firm. Value maximization as the principle behind practical business management decision making was introduced in Anderson [2004].

Box 1. Mathematics of the Neoclassical and Value Functional Models of the Firm

Neoclassical: Maximize Profit

Profit $\pi(s, x)$ in state s with management action x is revenue less costs:

$$\pi(s,x) = Rev(s,x) - Costs(s,x)$$

Profit maximization occurs where marginal cost equals marginal revenue:

$$\text{First Order Condition: } \frac{dRev}{dx} = \frac{dCost}{dx}.$$

Value Functional: Maximize Value

Value in the current state $V(s_t)$ is the maximum of the sum of current profits, plus discounted expected future value. The maximization takes place over the set of available actions $\{x \in \Gamma\}$ in the current state:

$$V(s_t) = \max_{x \in \Gamma}\{\pi(x_t, s_t) + \beta \times E[V(s_{t+1})]\},$$

$$0 < \beta < 1.$$

The expectation of future value is based on expected transition of the state variable, given the state and action at the current time.

$$s_{t+1} = g(s_t, x_t),$$

$$E[V(s_{t+1})] = E\{V[g(s_t, x_t)]\}.$$

Value maximization occurs, within the set of available actions $\{x \in \Gamma\}$, where any incremental current-period profits $(\partial\pi)/(\partial x) = \pi_x(s, x)$ equal the expected incremental reduction in discounted future value:

$$\text{First Order Condition: } \pi_x(s,x) = -\beta E\{V'[g(s,x)].g_x(s,x)\}.$$

This intertemporal first-order condition is known as an Euler equation.

expenditures (such as investments) designed to improve the state of affairs in the future, and current-period rewards (such as distributing profits to shareholders).

- *Use of a functional equation.* The mathematical equation at the center of the model is a *functional*, rather than a *function.* Most standard economics applications involve functions, which map one set of numbers to another.[13] The idea of a functional arises from the calculus of variations.[14] A functional is a map from a vector space (often the space of functions), to the space of real numbers. Thus, it can be characterized as a *function of functions*. The inputs to a functional are functions, and the output is one or more real numbers. One of the modern pioneers of this field, Stuart Dreyfus [1965], described a functional as a *function that takes curves as arguments*.

We contrast the mathematical elements of the neoclassical model with that of the value functional model, showing first-order conditions for a maximum in each approach, in Box 1.

The evolution of the state of affairs in the value functional approach

The mathematical form underlying the value functional approach requires a specification of a *transition function*, which governs how the state of affairs changes over time due to the actions of the business manager and other events that are outside his or her control. The transition function can account for aspects of risk that extend beyond mechanical calculations of past prices (adaptive expectations), as well as predictions based on economic theory (rational expectations). Furthermore, it need not rely on assumptions that are clearly unrealistic when applied to most operating businesses, such as complete markets or symmetric probability distributions.

The value functional approach to modeling business decisions begins with identifying the set of possible states in which the business may operate and the possible actions that the manager can take within those states. From this, the transition function distills the business manager's information and beliefs into a mapping of the probabilities of achieving each state in the future, given the current state and the action taken at the current time.

Constructing such a model is not a trivial exercise. As will be demonstrated below, even a relatively small value functional model can require a great deal of effort to specify, parameterize, and solve. However, the value functional approach makes it possible to model the market conditions, structure of the company and industry, and preferences of the business manager in a much richer manner than traditional approaches.

Incorporating policy and other risks

To use this approach to test the policy uncertainty hypothesis, we associate policy-imposed costs with possible states in which the firm may operate. We also identify transition probabilities that reflect the manager's beliefs about the probability that such states might prevail in the future. These transition probabilities describe the uncertainties on which we focus in this analysis. Other uncertainties inherent in business are assumed to be uncorrelated with policy uncertainty. We use an equity discount rate to account for this underlying risk.

[13]For example, the profit, revenue, and costs of firms in the neoclassical model are typically expressed as functions. Using differential calculus, we can find the first derivative (or "marginal") of these functions; seeking the maximum of the profit function then produces the *marginal cost = marginal revenue* rule.

[14]The pioneers in the calculus of variations include Leonhard Euler (1707–83), Johann Bernoulli (1667–1748), and Joseph-Louis Lagrange (1736–1813). Karl Weierstrass (1815–97) reformulated and extended the theory in the nineteenth century.

Box 2. Elements of the Value Functional Model

1. State Vector s
   The state of affairs presented to the company consists of the burden of current government policies and the current employment level or scale for the firm. All the information useful in predicting future states is encapsulated in the current set of conditions.[16] We use a five-element state vector to capture all combinations of "baseline (2010)" and "high (2014)" policy costs and "big" and "small" scale, plus a "closed" state to account for firms that shut down.
2. Action Vector x
   The subject company has four elements within its action set: hiring workers, keeping the same number of workers, laying workers off, and selling the company's assets and closing down. All of these directly affect the scale of the firm.
3. Reward Matrix R
   The Reward matrix represents the reward of distributed profits and capital gains to the shareholders of the firm while operating in each possible combination of state and action, plus the payoff from sale of assets in the event of a "sell" action. As the State vector is size $S = 5$, and the Action vector is size $A = 4$, the Reward Matrix must be size $S \times A = 5 \times 4$. Consistent with the human transversality conditions that ensure a solution, all the elements of the reward matrix are real-valued and within a reasonable upper bound.
4. Transition Probability Matrix P
   The transition function controls how the state changes over time, including the effect of decisions (actions) taken by the firm's manager, and random elements. In this case, the firm's action to hire, or not hire, directly affects the scale of the firm's operations. However, the policy regime is not controlled by the business manager, who assigns a probability to both possible regimes for the next time period. The matrix is of size $S \times S \times A = 5 \times 5 \times 4$, with each "frame" of the matrix representing a different action, and the rows and columns within each frame representing the probability (contingent on the relevant action) of moving from one state to another.
5. Discount Factor β
   We use an equity discount rate that is consistent with long-term returns from publicly traded corporations.[17] We also use a slow trend in nominal growth for the industry. The discount factor incorporates both these elements. Consistent with the human transversality conditions that ensure a solution, we assume $0<\beta<1$.
6. Optimization Problem
   The firm optimizes the following value functional equation, which is a two-period "Bellman" equation:

$$V(S) = \max_{x \in \Gamma} \{R(s,x) + \beta[V(E(s_{t+1}))]\},$$

$$E(s_{t+1}) = E[P(s_{t+1} \mid s_t, x_t)].$$

3. A Model of Policy Risk and Business Decisions

Methodology outline

The methodology for testing the policy uncertainty hypothesis includes the following steps:

1. *Create a value functional model of a representative firm*, in which the manager of the firm observes the demand for the company's products and services and current costs and related government policies as well as possessing ambiguous information about future government policies and the possible costs they may impose on the company. With this information, the manager can hire workers, maintain the same workforce, lay workers off, or sell the assets of the business and close. Such a model, which is a significant extension of the one outlined in Anderson [2013, chapter 18][15] is described in Box 2.
2. *Create a model income statement* for firms in which policy-related costs are represented in the way they are actually incurred by business owners.[18] Populate the model with data for firms in a specific industry and two possible government policy regimes. The cost regimes are "baseline cost 2010," indicative of the income tax, payroll tax, and benefit costs that prevailed at the time the Great Recession was ending; and "high cost 2014," indicative of the taxes and costs a business manager in that industry would consider possible, though not certain, to prevail once the tax and other policy changes (including Affordable Care Act requirements, potential fines and taxes) being actively debated in the years 2011–13 were implemented.
3. *Create a reward matrix that summarizes the per-period, after-tax profits from the firm* (or net proceeds in the event that the firm is sold) by using these income statements for every combination of state and action. Income statements for a representative firm in the restaurant industry, in two different sizes and with two different cost regimes, are shown in Table 1. The reward matrix for the representative

[15]The extensions here include: selection of specific industry and size of company data; creation of an expansive income statement model; inclusion of a "sell assets and close" action, extended numerical results, and sensitivity and robustness tests.

[16]This form of a model is sometimes called a Markov Decision Problem ("MDP"), the key variables have the Markov property, meaning that all the useful predictive information is summarized in the current-period's variables.

[17]This is a simplifying assumption, as most companies are not publicly traded, and investors in those companies should be expected to have underlying discount rates that vary significantly. Note that the use of an equity discount rate implies that general economic uncertainty affecting businesses is taken into account in this model.

[18]This includes matching specific taxes and costs to specific parts of the income statement, and properly levying income taxes on income imputed or distributed to shareholders. Most private firms in the U.S. are organized as pass-through entities for tax purposes, are not publicly traded, and meet the standard definition of "small". (See Anderson [2009]). Therefore, the primary representative firms in this analysis are small, privately held firms filing taxes as an S corp. See Appendix II for results for representative C corps.

Table 1. Income Statements for a Representative Restaurant

State description	Baseline cost 2010	High cost 2014
	Big staff	Big staff
Action taken in this state	Maintain employment	Lay off employees
	—	—
Revenue	$1,711,000	$1,711,000
COGS	663,868	663,868
	—	—
Gross margin	1,047,132	1,047,132
Wages	360,337	360,337
Health benefits	13,517	38,741
Payroll taxes	36,214	38,952
Operating costs	475,033	584,918
Net capital expenditures	42,775	42,775
	—	—
Operating margin (EBIT)	119,256	−18,591
Interest expense	18,821	18,821
Extraordinary items	0	0
	—	—
Pretax income	100,435	−37,412
Income taxes	29,528	−13,693
	—	—
Net income	70,907	−23,719
	—	—
Memo items:		
Operating margin	0.070	−0.011
Pretax margin	0.059	−0.022
Net margin	0.041	−0.014

Operating margin is earnings before interest and income taxes, as a share of revenue (EBIT/Rev); Pretax margin is after entity-level taxes; Net margin is after income taxes paid by equity investors on distributed or imputed income

Source: Author's research (model of income statement); BizStats, Almanac of American Business Ratios, IRS SOI (cost ratios for representative firm).

Table 2. Reward Matrix for Representative Restaurant

	Layoff	Maintain	Hire	Sell
Baseline cost 2010, Big staff	52,214	70,907	52,214	101,864
Baseline cost 2010, Small staff	30,207	43,292	30,207	66,019
High cost 2014, Big staff	−43,673	−23,719	−43,673	42,775
High cost 2014, Small staff	−6,241	7,475	−6,241	36,172
Closed	0	0	0	1

Source: Author's research as described in the text. See also Table 1.

Note: Reward matrix entries represent the current-period after-tax distributed profits (or losses) for every combination of state and action. For "sell" actions, this is the net proceeds of sale of the business operations. The periodic profit on an already-closed company is set at a number close to zero.

Table 3. Transition Probabilities for Government-Imposed Costs "Modest Guess 2014" Assumption

	Likelihood Per Year(%)
If "baseline cost":	
Remaining "baseline cost"	60
Moving from low cost to high cost	40
If "high cost"	
Remaining "high cost"	95
Moving from high cost to low cost	5

Note: Table entries describe probability of moving from one type of state to another, each time period. Complete transition matrices are displayed in the appendix.

restaurant is presented in Table 2; note that it includes as entries the after-tax profits calculated in the income statements listed previously.

4. *Create transition probability matrices* that, for each action, describe the likelihood of going from one state to another in the next time period. The key parameters for constructing these matrices are the subjective probabilities business managers associate with taxes and costs remaining the same. These parameters are presented in Table 3; the related matrices appear in Appendix I.
5. *Numerically compose and solve the decision problem*. Computation problems have been an enormous barrier to practical use of value functional methods. However, recent innovations in software and in the design of models now allow for models of business decisions for representative firms to be readily composed and solved.[19] We describe the procedure in Box 3.
6. *Examine the solution*, which consists of the value of the firm in each state, and the optimum action for the firm's manager to take to achieve that value in each state. Both types of information are relevant to the

[19]Both the existence of a solution to a functional equation, and the practical ability to find it, present difficult issues. In this case, we can make use of a proposition and an existence theorem that, together, provide confidence that a solution can be found. First, under the proposition stated by Anderson [2013], such a model of a firm fulfills a set of "human transversality conditions," including a profit function bounded by the use of replicable business practices, a discount rate between 0 and 1, and other business constraints. The proposition further states that models of firms that meet these conditions fulfill the requirements for the existence theorems outlined in Stokey and Lucas [1989, chapter 4]. Therefore, at least theoretically, the model we outline here has a solution. The practical ability to compose and solve such a problem benefits from improvements in the conceptualization of the state, which is described in Ljungqvist and Sargent [2012, Chapter 1] and Anderson [2013, chapters 15, 16].

Box 3. Composing and Solving the Value Functional Model

1. The value functional model was composed as a discrete-time, discrete-state Markov Decision Problem, with the following six elements described in Box 2: *{s}, {x}, R, P, β, t*. These represent the state vector, action vector, reward matrix, probability transition matrix, discount factor, and time index. As noted in the text, the model meets the human transversality conditions that guarantee the existence of a solution.
2. The model was composed, error-checked, formulated mathematically, and then solved using recently developed toolbox designed for this purpose, along with vector-processing mathematical software. This software suite included the Rapid Recursive® toolbox (a product of Supported Intelligence LLC) and Matlab® (a product of The Mathworks, Inc.).
3. The primary solution algorithm was Value Function Iteration, a method identified by Bellman [1957] in his original exposition of what he called "dynamic programming." Value function iteration involves starting with a first guess of the value in each state, and then repeatedly solving the Bellman equation shown in Box 2, updating the results each time until they converge.[20] Once composed, error-checked, and formulated mathematically, solving the decision problem for representative firms in different industries typically required about 100 iterations, and less than 1 second of computer time, for each firm.
4. Additional results, including all input parameters and selected output data, as well as information on the software used, are included in the Appendices.

policy uncertainty hypothesis. If the value-maximizing action for firms that are currently profitable (and can expect to be *more* profitable by hiring under the current cost regime) is to "hire," then the model and data do not support the policy uncertainty hypothesis. On the other hand, if the value-maximizing action for these firms is to refrain from hiring, to lay off workers, or to sell assets and close, then the hypothesis is supported. We leave open the possibility that, for some firms and not others, the value-maximizing action is to refrain from hiring.

7. *Conduct robustness tests*, including choosing firms from different industries, varying the degree of cost and tax increases under the high cost regime, and varying the subjective probabilities associated with higher costs.

Data

The data necessary for this method includes all of the following:

- *Business-level data on income statement ratios for specific industries.* These data were obtained from two primary sources: a large sample of income tax returns filed by firms in different industries and bank loan applications.[21]
- *Tax rate data for both state and federal individual income taxes*, as well as aggregate data on corporate income tax burdens.[22]
- *Information on the beliefs of business managers* on the tax and cost changes that were likely, though not certain, to occur. These were estimated as described below in the section on "Beliefs Regarding Policy Costs." Note that, for beliefs about future tax changes, we used the actual tax changes that were adopted into law as of January 2013.
- *Information on the beliefs of business managers* on the likelihood of taxes and costs increasing in or after 2014; as well as the likelihood of such costs persisting or returning to the 2011–13 levels. These inherently subjective parameters were based on the author's judgment, based on the historic record of fluctuations in income tax rates and the historic record of persistence in payroll taxes for such programs as unemployment insurance, Medicare, and Social Security.

We discuss each of these in more detail below.

States

Business managers might contemplate that, at the least, there are "baseline cost" and "high cost" periods of time, determined by political events that are largely beyond their control. Most businesses have the ability to adjust the scale of their operation by hiring or laying off workers. Therefore, they would identify, at the least, a "big" and "small" scale of operation. In addition, a business manager always has the possibility of shutting down.[23] Combining these produces a

[20]Descriptions of this solution algorithm are contained in Stokey and Lucas [1989] and Ljungqvist and Sargent [2012].

[21]The IRS Statistics of Income data is the base for the *Almanac of American Business & Financial Ratios* (Troy [2008]). Private bank loan applications, as well as IRS data, are the base for the *Bizstats* data. We also reviewed Census Bureau (2010) data.

[22]The statutory income tax rates for U.S. individual income tax rates are available from many sources, including the IRS. See the references below for additional information. Aggregate corporate income tax burdens are often compiled in a manner that makes federal income taxes on these businesses difficult to distinguish from other state, federal, and local taxes. Therefore, the reported income tax burden for companies in specific industries was used as a guide for the current federal and state business income, gross receipts, and value-added taxes.

[23]Here, the state is inherently two-dimensional, in that it allows for both scale of firm and policy cost regime to vary, plus a third dimension for allowing the business to close. However, listing all possible combinations of these three dimensions would run headlong into the curse of dimensionality, which has bedeviled value functional methods since they were first outlined by Bellman

parsimonious representation of five possible states in which a business could operate:

1. Baseline cost 2010, small scale
2. Baseline cost 2010, big scale
3. High cost 2014, small scale
4. High cost 2014, big scale
5. Closed

Consistent with this five-element state vector, we specify four elements of an action set: hire workers, maintain the current number of workers, lay off workers, or sell the business. We thus have a state space with $S = 5$ elements and an action space with $A = 4$ elements, meaning that the total number of state-action combinations is $5 \times 4 = 20$.

Transition probabilities

The transition function accepts as arguments the current state, current action, and any random elements; it produces the next-period's state. In Box 1, the transition function was implicitly shown as part of the expectation of the manager for the next period's value. In Table 3, we summarize the probability distributions incorporated in the transition function for this problem.

As we have specified the state and action spaces in discrete terms, the transition function in this case is a transition matrix. Here, we need a probability of reaching each state from the current state, for each possible action. That implies a transition matrix of size $S \times S \times A$, which in this case is $5 \times 5 \times 4$. As these are probabilities, the sum of each row (which indicates the probability of moving to other states from one current state, given one current action) must equal 1, and no element can be negative. The transition matrices for the two policy regimes are shown in Appendix I.

Beliefs regarding policy costs

We assume that business managers in the United States are aware that major payroll tax burdens on employers, such as Social Security, Medicare, and Unemployment Insurance, were based on laws enacted decades ago; and that once such programs were adopted, they remained in place with the support of a large constituency of current and potential future beneficiaries. In contrast, managers also observe that income taxes are subject to nearly constant debate, and that income tax rates have both risen and fallen in recent decades.

Thus, business managers in the United States in the years following 2010—after the trough of the recession, the adoption of the Affordable Care Act, and the federally supported extension of unemployment insurance benefits and the implicit requirement for higher unemployment insurance taxes—would have ample reason to believe that the costs of these new programs would remain in effect for years into the future.

A description of beliefs for a representative business manager during the 2011–13 time period is described in Table 3, as two sets of probabilities about remaining in a "high cost" or "baseline cost" state. We call these a "modest guess" set of beliefs, as they imply that managers in 2011 believed they would probably escape major cost and tax increases for at least one year, but not beyond 2014.[24] This set of beliefs also incorporates the assumption that managers expect the higher cost regime, once imposed, to remain in place for a long time. This matches their historical experience with payroll tax burdens that largely finance Social Security, Medicare, and unemployment insurance. We assume in this analysis that such a set of beliefs, which is broadly consistent with the reports from business managers summarized above, characterizes a significant number of business managers and owners during this time period.

Transition probabilities do not imply political affiliation

It is important to note that the transition probabilities and states identified here incorporate subjectively formed beliefs about the politics, traditions, laws, and culture of the country, as well as the empirical evidence available to business managers on actual income, payroll, and other taxes and benefit costs. Given the outcome of the last two electoral cycles in the United States, nearly every state is currently represented by federal government officials from different political parties, and likely different views on tax and health-care policies. Thus, business managers are exposed to differing political views in every state, and have strong financial incentives to make business decisions based on actual conditions rather than on political affiliation.

[1957]. Careful model design allows us to collapse the relevant combinations into five total states.

[24]If the most likely transition occurred for the first two years, and then the second most likely in the third year, it would correspond to no cost or tax increases in 2012 and 2013, and significant cost and tax increase in 2014. As actually occurred, taxes increased in 2013, and costs increased for some firms before 2014. This analysis was conducted before the October 1, 2013 rollout of the troubled health-care "exchange" website, and therefore the subjective probabilities here do not take into account any changes in views of uncertainty that occurred after that date.

Reward matrix

The Reward matrix includes an element representing the net, after-tax, distributed profits of the firm, for each combination of state and action. By convention, each row of the Reward matrix represents a state, and each column an action. To generate this matrix, we used the following method:

1. We started with the reward to the firm's owners for the "maintain current employment" action, under the "baseline cost 2010" regime. For this baseline we used the profit of a representative firm in the United States, which could choose to hire more workers and operate at a larger scale. Assuming continued baseline policy costs, the representative firm would expect to earn larger profits after absorbing some costs of expansion.
2. From this baseline we adjusted for costs and taxes under the "high cost 2014" states. These became the entries for the high cost, large- and small-scale elements, for the "maintain" action. These are in the center column of the R matrix.
3. From this we create the "hire" and "layoff" action columns, which are based on the "maintain" column with adjustment costs incorporated that reflect severance and other payments for companies reducing their scale, and hiring and training costs for those expanding their scale. Note that, after absorbing these adjustment costs in one period, the company ensures that it has adjusted its scale of operations to "big" or "small" for the next time period.
4. For the "sell assets and close" action, we calculate an amount that an owner could expect to receive for selling the business operation (net of any saleable inventory or land and buildings), to a competitor interested in consolidating operations or to other businesses wishing to acquire the company's assets but not to continue operating it. This is above a "fire sale" amount, but well below the multiple of revenue or income that an expanding, profitable firm in that industry might expect. We calculate this as the greater of a fraction of revenue and a multiple of income, which ensures that a positive sale value exists even if the company is losing money in any one period. Note that this implies that employment will *contract*, not expand or stay the same, if the business is sold.

The Reward matrix is shown in Table 2, which includes the net profit figures for each of the income statements presented in Table 1. Here the matrix size is $S \times A$; each row is a current state; and each column a current action. For example, if the current state is "baseline cost, small scale" and the action is "maintain," the reward is $43,292.

Policy and adjustment cost parameters

The parameters used for the low-cost and high-cost policy regimes are based on modest assessments of likely changes in policy, based on information available to business managers in the years 2011–13. The policy changes considered are limited to increases in payroll taxes, income taxes, and benefit costs. These are summarized in Table 4. Also presented in the table are costs of adjusting from big to small scale and vice versa, which involve training, severance, and other costs.

Table 4. Policy Cost and Adjustment Cost Parameters for Representative Restaurant

Parameter	"Baseline Cost"	"High Cost" Increment	Notes
Payroll taxes (including FICA, Medicare taxes, FUTA, SUTA)	10.1% (as fraction of wages)	+0.7%	Some taxes apply to only a portion of the wage base for each employee.
Income taxes	29.4% (on imputed income for S corps)	+7.2%	Enacted laws, as of January 2013, impose additional NIIT and Medicare tax of 0.039 and 0.009 for high earners. Increased AMT and higher marginal income tax rates also affect many business owners.
Benefit costs (including health insurance premiums and cost of administration)	3.7% (as fraction of wages)	+5 to 7%	Includes health insurance and administration of benefits. Fixed plus variable incremental costs makes fraction different at different scales of the firm. Some nonhealth benefit costs are included in operating expenses category due to data source limitations.
Adjustment costs	5% (as fraction of wages + benefits)	No increment	Applied each time the firm moves from big to small scale, or vice versa.

Source: Author's Research. Representative Firm is Restaurant, S Corp. See also Table 1 and 2.

4. Results and Conclusions

Empirical results

Consistent with the proposition that value functional equations with inputs within the human transversality conditions are solvable, we were able to find solutions to the value functional problems for multiple representative firms, under a variety of assumptions. The results can be summarized as follows:

- *The likelihood of higher costs causes rational avoidance of hiring for some firms*. Some firms, facing a possibility of higher costs and taxes in the future, rationally choose to avoid hiring workers in the current time period. As shown in Table 5 for a restaurant, the value-maximizing decision is to "maintain" (not hire workers) when they face the baseline costs.
- *Value maximization is a different objective than profit maximization, and causes different behavior*. The results from the value functional model of firm behavior are not the same as from the neoclassical model. For the representative firm in Table 5, the firm's value-maximizing choice was not to expand, even though it could have earned higher profits if it were to hire workers.[25]
- *Even weak assumptions about the probability of cost increases cause contractionary behavior for some firms.* These employment-contracting results occur for many firms even with weak assumptions about the likelihood of cost increases. As noted above, we assume business managers adopted subjective probability assumptions of a 60 percent chance that (baseline 2010) policy costs remain in effect each year. Clearly, during the relevant time period, many business managers felt that there was a high likelihood of policy-imposed taxes or costs *increasing*. At least as of 2013, they were correct for income taxes.[26]
- *Modest assumptions about the size of cost increases are sufficient to cause contractionary behavior.* These results occur even without particularly strong assumptions about the size of future potential cost increases. Indeed, the income tax changes presumed in the "high cost" regime have already been enacted for high-earning taxpayers subject to the Net Investment Income Tax and Additional Medicare Tax, as well as increases in marginal income tax rates and changes in the Alternative Minimum Tax.
- *Value-reducing effects reinforce other effects.* The *values* of the firms under the high-cost regime were almost always lower than under the low-cost regime. Should financing constraints affect these firms, the lower values may cause them to be unable to maintain their workforces at the current levels or to hire new workers. This effect reinforces the finding that policy uncertainty can cause rational business managers to defer or reduce hiring.
- *Firm managers behave as if they have "real options."* The behavior of the modeled firms confirms one of the findings of the real options literature: the standard discounted cash flow methodology fails to take into account managerial flexibility, and often gives incorrect guidance to managers facing uncertainty.[27] The value functional model produces effects that are consistent with those described in that literature: managers will act as if they understand and value real options embedded in their business environment, and will execute them when it is in their interest to do so.
- *The results are robust to multiple variations of assumptions, but vary considerably by industry, size of firm, and tax form*. Several different variations of this problem were evaluated, including those with different income statement ratios (as might be expected in different industries); different probabilities regarding policy cost changes; different adjustment costs; and different policy-imposed costs. The key results—that the neoclassical model

Table 5. Results of Analysis: Representative Restaurant

State	Reward (if "Maintain" Workforce)	Value	Value-Maximizing Business Decision
Baseline cost, Big staff	$70,907	$184,659	*Maintain employees (do not hire)*
Baseline cost, Small staff	$43,292	$164,437	*Maintain employees (do not hire)*

[25]See Table 2, where the profits for "big staff" are higher than for "small staff" in the baseline cost regime. The model includes one-time adjustment costs to either hire, or lay off workers, so the immediate reward in a period of "hiring" or "laying off" would be somewhat lower, and they would begin earning the full profits from the new scale at the beginning of the next period. As we are considering the 2011–13 time period, many employers could have absorbed the (relatively small) adjustment costs and received the higher profits from operating at a larger scale before 2014 arrived.

[26]The "fiscal cliff" tax changes that were adopted at the end of 2012 went into effect in 2013. Thus, at least in 2013, there was a 100 percent "chance" of a tax increase for many employers.

[27]Dixit and Pindyck [1994] is a seminal reference on the failure of standard discounted cash flow analysis in finance (and the related concept in economics of the neoclassical investment rule) to properly analyze investment opportunities when managers have real options. For a compendium of other readings on real options, see Schwartz and Trigeorgis [2001].

Box 4. Strongly Affected and Largely Unaffected Employers

Strongly Affected
Small businesses with fewer than 30 employees; and "small" businesses with 30–100 employees or contractors.
Entrepreneurs involved in multiple small businesses, such as franchisees.
Companies in sectors with typical per-tax margins of 3 percent or less
Employees/Contractors that work for companies subject to significant compliance risk.
Restaurants; retailers; professional services.
Largely Unaffected
Federal government agencies
Large publicly traded companies with centralized HR functions
Employers with highly paid or unionized workforces (e.g., manufacturing, tech, health care, banking)
Colleges, universities, and public school districts (full time faculty and staff)

does not capture the rational value-maximizing actions of business managers, and that policy cost uncertainty can encourage managers to sell their firms, defer hiring, or reduce hiring—are robust to modest (and sometimes significant) changes in these factors for typical private firms. However, the results vary for companies in different industries, and with different scale and filing taxes under different forms. We summarize the results for different types of firms in Box 4 and further in Appendix II, and the results of a full suite of robustness tests in Appendix III.

Limitations and extensions

This approach yields important conclusions, and suggests a method that could provide rich insights into economic problems involving uncertainty and management flexibility.

However, the approach has certain limitations that bear mentioning:

- Subjective beliefs about transition probabilities are very difficult to measure, partially because they are a complicated topic to discuss formally. Thus, specifying a transition matrix involves some interpretation of data that could arise from surveys, voting behavior, prices, or direct interviews. Here, we relied heavily on observations about beliefs among business managers summarized above.
- The number of states in this example—five—is potentially much richer than contemplated in most standard models. This requires the economist to describe numerous combinations of state and action, which is much more difficult than specifying a standard model.
- Although the results are robust to modest changes in inputs, we did not explore many extensions to this analysis. In particular, we did not explore how subjective beliefs changed during the 2011–13 period; how such beliefs differed among employers in different states or industries; whether implementation risks, forecasts of tax burden changes, or other costs were the most salient factors; or the extent to which societal benefits and costs also affected the decision calculus of individual employers.
- Costs for employers in the 2014 period remain uncertain, even as 2013 draws to a close. However, it is the *likelihood* of cost changes that drives much of the results.[28] Thus, this analysis could have been entitled "policy cost likelihood and persistent unemployment."
- Like any novel method, the value functional method requires additional explanation even to an expert audience, and the interpretation of the results requires more effort.

Implications for economic policy

Generalizing these results to the current policy debate is straightforward:

First, policymakers should be aware that an environment in which employers think costly burdens are likely to be imposed upon them tomorrow is likely to reduce employment today. Indeed, the likelihood of future cost and tax increases depresses employment *even if the costly burdens are not yet imposed and may not be*.

Second, the expectations about the future that matter are those formed by the decision-maker, *not by the government, nor by experts*. Thus, marketing messages about the societal costs and benefits of a policy change, studies predicting future fiscal effects, and the output of macroeconomic models all matter less than the subjective beliefs of the people that are affected. As these relevant beliefs include transition probabilities, the decision maker's assessment of political, cultural, and institutional factors are critical.

Third, standard neoclassical models; as well as expectations-augmented models based on current market prices, adaptive schemes, or predictions based on relevant economic theory; may not capture the full effect of a change in the policy regime. Employers, as well as contractors and employees, can be expected to follow a value-maximizing course of action that is based on a rich calculus of what is likely to happen in

[28]Examining the robustness table in Appendix III reveals that a wide variety of likelihood assumptions produce contractionary results for some firms.

the future, and what they believe they will be able to do in response. Such a calculus is not a part of the neoclassical model; but it can be incorporated, at least in a simplified form, in a value-functional model.

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Software

The model was composed and solved using the Rapid Recursive Toolbox for Matlab, which is distributed by Supported Intelligence LLC. Their website is: http://www.supportedintelligence.com.

Matlab is mathematical software distributed by The MathWorks, Inc. Their website is: http://www.mathworks.com.

APPENDIX I

Transition probability matrices

Table A1. Baseline Policy Regime Transition Matrix

	Base_B	Base_S	HC_B	HC_S	CL
Frame 1: Layoff					
Base_B	0	0.6	0	0.4	0
Base_S	0	0.6	0	0.4	0
HC_B	0	0.05	0	0.95	0
HC_S	0	0.05	0	0.95	0
CL	0	0	0	0	1
Frame 2: Maintain					
Base_B	0.6	0	0.4	0	0
Base_S	0	0.6	0	0.4	0
HC_B	0.05	0	0.95	0	0
HC_S	0	0.05	0	0.95	0
CL	0	0	0	0	1
Frame 3: Hire					
Base_B	0.6	0	0.4	0	0
Base_S	0.6	0	0.4	0	0
HC_B	0.05	0	0.95	0	0
HC_S	0.05	0	0.95	0	0
CL	0	0	0	0	1
Frame 4: Sell					
Base_B	0	0	0	0	1
Base_S	0	0	0	0	1
HC_B	0	0	0	0	1
HC_S	0	0	0	0	1
CL	0	0	0	0	1

Note: each row is a current state, each column is a next-period state, and each frame represents the result of one action.
For example, if the action is to "maintain" (Frame 2) and the current state is High cost-Small scale (fourth row), the probability of remaining in that state is 95 percent (fourth column).

APPENDIX II

Representative C corp results

To test our model for robustness, we examined its performance when applied to different industries and firms with different tax structures. We investigated two representative C corporations in the manufacturing industry: one manufacturing transportation equipment and the other industrial machinery.

There are important differences between these C corps and the S corps described in the body of this article:

1. Wages and benefits take a much higher share of revenue for service industry employers than for most manufacturers. Manufacturers also typically face more procyclical demand.
2. For a firm organized as an S corporation, income is taxed only at the shareholder level. This means that the firm itself does not pay income tax; rather it passes those responsibilities on to its shareholders. In a C corporation, however, the income is essentially taxed twice: once when earned by the firm, and then again when distributed to shareholders. However, many such shareholders are participants in tax-exempt or tax-deferred pension and retirement plans, so their income tax burden on company earnings is diffused.
3. Large, publicly traded corporations generally have centrally managed employee benefit plans and workforces that are much larger than the thresholds for "small" business in the ACA. Thus, the incremental benefit administration cost for such firms in the "high cost" regimes are likely to be a smaller fraction of wages than for small, privately held companies.

We present results for one representative manufacturer below. It has revenues of approximately $150 million; has much higher material costs relative to revenue than typical employers in

Table A2. Extended Results for Representative Manufacturer

	Value	Best Policy	Current Profit
Baseline cost 2010, Big staff	$26,869,563	Maintain	$3,755,137
Baseline cost 2010, Small staff	$24,995,816	Hire	$2,175,390

Source: Author's research as described in text.

Table A3. Income Statements for Representative Manufacturer

Income Statement		
State description	Baseline cost 2010, Big staff	High cost 2014, Big staff
Industry	Trans Equip MFG, C corp	Trans Equip MFG, C corp
Revenue	$150,000,000	$150,000,000
COGS	$124,950,000	$124,950,000
	—	—
Gross margin	$25,050,000	$25,050,000
Wages	$5,400,000	$5,400,000
Benefits	$3,000,000	$3,378,000
Payroll taxes	$512,853	$531,507
Operating costs	$6,687,147	$7,512,147
Net capital expenditures	$4,050,000	$4,050,000
	—	—
Operating margin (EBIT)	$5,400,000	$4,178,346
Interest expense	$1,050,000	$1,050,000
Extraordinary items	$0	$0
	—	—
Pretax income	$4,350,000	$3,128,346
Income taxes	$594,863	$444,812
	—	—
Net income	$3,755,137	$2,683,534
	—	—
Memo items: Operating margin	0.0360	0.0279
Pretax margin	0.0290	0.0209
Net margin	0.0250	0.0179

Operating margin is earnings before interest and income taxes, as a share of revenue (EBIT/Rev); Pretax margin is after entity-level taxes; Net margin is after income taxes paid by equity investors on distributed or imputed income

service industries; pays relatively high average wages and benefits; pays a relatively low total corporate income tax as a share of revenues; has dividends that are subject to income taxes paid by those investors that are fully taxable persons; and operates in an industry where a large-scale supplier, even if it currently unprofitable, has a substantial value to potential acquirers.

The results indicate that this manufacturer rationally hires workers, even if it expects that, at some time in the future, costs and taxes will go up. The immediate gain in profits from achieving a higher scale more than outweigh, for this firm, the potential future risks. The decision rule for a value-maximizing firm is different than for a profit-maximizing firm. However, as is illustrated in Table A5, for this firm under these assumptions, the results are the same. In contrast, the decision rules produced different results for the representative restaurant in Table 5 of the body of this article.

Table A4. Reward Matrix for Representative Manufacturer

	Layoff	Maintain	Hire	Sell & Close
Baseline cost 2010, Big staff	$3,335,137	$3,755,137	$3,335,137	$6,879,281
Baseline cost 2010, Small staff	$1,881,390	$2,175,390	$1,881,390	$4,437,825
High cost 2014, Big staff	$2,244,634	$2,683,534	$2,244,634	$5,986,278
High cost 2014, Small staff	$1,189,523	$1,492,973	$1,189,523	$3,869,144
Closed	$0	$0	$0	$1

Source: Author's research as described in the text. See Table A3.

Note: Reward matrix entries represent the current-period after-tax distributed profits (or losses) for every combination of state and action. For "sell" actions, the entry is the net proceeds of sale of the business operations. The periodic profit on an already-closed company is zero or a number close to zero.

Table A5. Decision Rule by Economic Model, Representative Manufacturer

State	Neoclassical Model: Policy	Value Functional Model: Policy
Baseline cost 2010, big scale	Maintain	Maintain
Baseline cost 2010, small scale	Hire	Hire
High cost 2014, big scale	Maintain	Maintain
High cost 2014, small scale	Hire	Hire
Closed	Stay closed	Stay closed

Source: Author's research as described in the text. See Table A2 and A4.

APPENDIX III

Robustness test results

This appendix demonstrates the robustness of the results of the model to changes in various model parameters. In the table below, shaded cells indicate parameterizations of the model that result in contractionary behavior by the subject employer, either through the maintenance of small staff levels when the profit-maximizing action would be to hire workers, laying off of workers, or selling assets and closing when costs go up.

The baseline assumptions are detailed in the body of this paper. To test the robustness of the results, we varied the following parameters: cost increases from 2010 to 2014, possible selling price of the subject company, the probability of costs staying at the baseline level, and the probability of costs remaining high after a change. Not shown in the table, but also included in a suite of robustness tests, were variations on the adjustment costs, which had the expected results of dampening or increasing, but not eliminating, the contractionary hiring behavior.

Table A6. Robustness Test Results

Parameter	Restaurant, S Corp	Transportation Equipment Manufacturer, C Corp	Professional Services Firm, S Corp
Cost increase			
High cost increase	*	~	*
Modest cost increase	*	~	*
Tax increase only	~	~	~
No cost increase	~	~	~
Possible selling price			
Low	*	~	*
High	*	~	*
Likelihood of cost change			
60/95	*	~	*
60/75	*	~	*
50/50	*	~	*
40/95	*	~	*
40/75	*	~	*

Note: *Contractionary; ~No Significant Effect