THREE ESSAYS ON EXPERIMENTAL AND BEHAVIORAL ECONOMICS

by

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A Dissertation
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of
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Three Essays On Experimental and Behavioral Economics

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DEDICATION

This is dedicated to John.

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ABSTRACT

THREE ESSAYS ON EXPERIMENTAL AND BEHAVIORAL ECONOMICS

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George Mason University, 2017

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Together these three chapters offer two advances in economics. The first chapter contains a review of labor economics specifically in regard to downward wage rigidity during a recession. Firm managers report in (unincentivzed) surveys that they believe nominal wage cuts would lower morale and productivity of their workforce. Next, the results from an original controlled experiment demonstrate the behavioral roots of wage rigidity. With precise measurement, we examine if the results of the surveys about wage cuts and productivity replicate. Lastly, using the same laboratory methodology, new information about how intellectual property protection incentivizes innovation illuminates the role of entrepreneurial individuals in the process of value creation from original inventions.

CHAPTER ONE: DOWNWARD WAGE RIGIDITY FACTS AND CLAIMS

Downward nominal wage rigidity is proposed as an explanation for why unemployment rises during a recession with negative consequences for individuals and societies. Stylized facts have emerged in the past century. Firms do not cut nominal wages, even when demand for labor falls. Firms will reduce hiring or increase layoffs rather than cut wages. Workers resent nominal wage cuts and, presumably, workers decrease their productivity if wages do fall.

Microfounded models of the economy sometimes rely on the assumption that nominal wages are downwardly rigid. In this paper, I challenge that assumption and question if that behavioral phenomenon can be replicated in the laboratory, as called for by Duffy (2014). There is no doubt that wage cuts are rare but to explain that fact by calling wages "rigid" merely labels the phenomenon.

When nominal downward wage rigidity is observed, two behavioral explanations can be offered. There is evidence that people are" loss averse", such as the resistance to selling houses at a nominal loss (Genesove and Mayer 2001). An alternative explanation is a preference for interpersonal fairness and willingness to pay for it. The precise nature of fairness is different across cultures and economic circumstances, but wage cuts are often perceived as unfair treatment of workers. Understanding the operation of loss

aversion and perceptions of fairness will lead to a better understanding of wage rigidity and the causes of unemployment.

In this paper, I examine why wage rigidity is important in economics, especially to explain unemployment. This includes the evolution of economic theory and an overview of the empirical evidence for wage rigidity. The data used by macroeconomists sufficiently demonstrates that wages do not fall proportionately to declines in labor demand. However, data from experiments is needed for testing hypotheses about the cause of rigidity and for linking individual productivity to wage fluctuations.

Next I present the behavioral reasons for downward wage rigidity and controlled experiments that reveal human preferences that are relevant to wage rigidity. Experiments and the behavioral literature have made contributions such as demonstrating a clear preference for fair outcomes over maximizing a cash payment and also showing how context affects the perception of fairness. The conclusion defines open questions for better understanding wage rigidity and the exceptions to the rule, which are the cases where wage adjustment happens quickly.

Classical economists describe the market as a place where people with different goals make each other better off through voluntary exchange. Prices allocate resources to where they are used most efficiently and the maximum surplus is created when prices adjust quickly to changes in demand and supply. Competition can relentlessly drive prices to equilibrium because buyers and sellers do not have to be nice to each other or even know each other. As Adam Smith wrote, “It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their

own interest." (Smith 1776, p. 13). For example, workers moved to take jobs in the Bakken oil fields in North Dakota in 2014 not out of sympathy for the oil companies but for the wages that were well above the U.S. national average. When foreigners were buying less Lithuanian exports at 2007 prices, wages in Lithuania declined until the lower labor costs made products competitive on the world market again.

Keynesians argue that, in some cases, prices adjust so slowly as to warrant government intervention. Specifically, the cost of labor does not fall quickly enough to remedy high unemployment. Hall et al. (1975) wrote, "Keynes' General Theory is a working out of the macroeconomic implications of the short-run inflexibility of wages. Its major innovation, the theory of effective demand, makes economic sense only when wages are fixed." Downward nominal wage rigidity (DNWR) is given as a cause for this friction but it is not well understood if this should be treated as a law of human nature. One of the most convincing explanations for DNWR is that employers and workers who are exchanging labor for wages may, in fact, act "benevolently" toward one another, in contrast to the market for goods described by Adam Smith. However, there are exceptions to the rule of DNWR and from these exceptions we must conclude that DNWR is not a binding constraint.

I provide a brief overview of why macroeconomists believe that wages are rigid and what, if any, behavioral assumptions they make. Many macroeconomic models are "microfounded" which means that they make explicit assumptions about what people value and how workers respond to wage changes. Old Keynesian models (such as, the one used by Keynes himself) used DNWR as a fact to build models on. New Keynesians

have offered some non-behavioral explanations including menu costs and staggered contracts.

Like the Cambrian explosion in the fossil record, J.M. Keynes's papers mark a change in the economic literature after he proposed that classical economic theory was not enough to explain or remedy the Great Depression. Hall et al. (1975) produce a caricature of the classical school's model of unemployment:

$$u_t = u^*$$

where u_t is the current level of unemployment and u^* is the equilibrium level. This model obviously does not explain anything useful. Keynes argued that the equilibrium or "natural" level of unemployment is low - certainly lower than the level observed during the Great Depression when thousands of people could not find a job at the prevailing wage rate.

In *The General Theory of Unemployment, Wages and Prices* (1936), Keynes writes (pg. 9), "Whilst workers will usually resist a reduction of money-wages, it is not their practice to withdraw their labour whenever there is a rise in the price of wage-goods." He gives one reason for this practice:

> Any individuals or groups… who consent to a reduction of money-wages relatively to others will suffer a *relative* reduction of real wages, which is a sufficient justification for them to resist it. On the other hand it would be impracticable to resist every reduction of real wages, due to a change in the purchasing-power of money which affects all workers alike. (Keynes 1963, p. 12)

Keynes does not appeal to union wage bargaining power in *General Theory* and, even if that gives workers more power to express their preferences, it would not explain the preference for non-falling nominal wages. His speculation about coordination implies an underlying preference to not fall behind one's peers. Most successors of Keynes adopt his assumption of DNWR without further attempts to explain the phenomenon. Figure 1 shows that downwardly rigid wages create unemployment and substantial deadweight loss. There are workers who would like to supply labor at the prevailing wage rate, but firms cannot afford to hire them.

In 1958, A.W. Phillips published the statistical inverse relationship between inflation and unemployment, the Phillips Curve. Phillips (1958) begins his seminal paper by contrasting the classical equilibrium with the observation that "workers are reluctant to offer their services at less than the prevailing rates." The implication is that inflation and unemployment are causally linked because when inflation is high firms can freeze or lower real wages without angering workers, however nominal wages cannot be lowered. A simplistic interpretation is that monetary policy makers choose for society between high inflation and high unemployment.

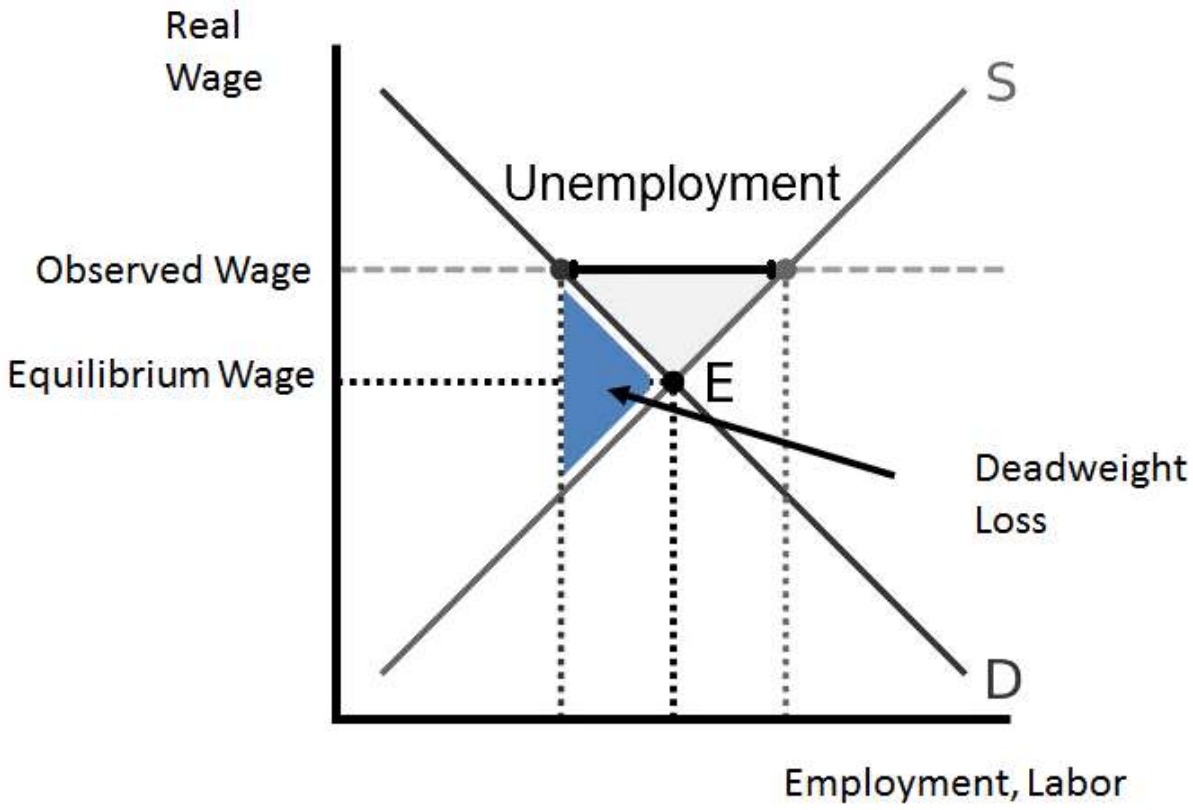

Figure 1 Deadweight loss from the failure of wages to adjust

Samuelson and Solow (1960; hereafter SS) examine the policy implications of the Phillips Curve with skepticism about the long-run outcomes and the causal mechanisms at work. They explain that they cannot separate "cost-push" from "demand-pull" and they lament that, "We simply cannot perform the controlled experiments necessary to make such a separation." The available data contained the inflation and unemployment rate but was confounded by unrelated trends and shocks. For example:

> Many economists have argued that cost-push was important in the prosperous 1951-53 period, but that its effects on average prices were masked by the drop in

> flexible raw material prices. But again in 1955- 58, it showed itself despite the fact that in a good deal of this period there seemed little evidence of over-all high employment and excess demand. Some holders of this view attribute the push to wage boosts engineered unilaterally by strong unions. But others give as much or more weight to the co-operative action of all sellers. (SS 1961)

In a subsection titled "*Some Things It Would Be Good to Know",* SS suggest that if inflation is normal it could become incorporated into the expectations of workers. The data for the U.S. loosely conforms to the Phillips Curve, but not as neatly as data for the U.K., which leads them to question if the Phillips Curve relationship holds in some circumstances and not others. They consider the following questions to be understudied:

> What geographical, economic, sociological facts account for the difference between the two countries? Is there a difference in labor mobility in the two countries? Do the different tolerances for unemployment reflect differences in income level, union organization, or what? What policy decisions might conceivably lead to a decrease in the critical unemployment rate at which wages begin to rise or to rise too fast? Clearly a careful study of this problem might pay handsome dividends. (SS 1961)

SS speculate about several reasons that inflation has a different impact on the U.S. than the U.K., and I extend their ideas to Ireland in 2015. They suggest that trade-unions in the U.K. took the lead in restraining wage growth; the U.K. unions might have been able negotiate for higher wages but it would have resulted in higher unemployment. Following the Great Recession, broad public sector cuts in Ireland may have paved the

way for private sector wage cuts. This suggests that leadership could be an important determinant of wage rigidity albeit difficult to predict. Generally, leadership can help solve coordination problems.

They foreshadow the efficiency wage hypothesis by suggesting that firms are "conscious that what they get from a work force is partly dependent on its morale and its turnover." SS also suggest that "any governmental policy which increases the mobility of labor … or improves the flow of information in the labor market will have anti-inflationary effects as well as being desirable for other reasons."

After acknowledging how little is understood about the Phillips Curve, they forecast a short-term policy tradeoff for the United States in this figure 2 showing, "the different levels of unemployment that would be 'needed' for each degree of price level change." Point A in figure 2 corresponds to price stability; maintaining 3 percent unemployment at point B requires about 4 percent inflation.

Friedman (1968) and Phelps (1967) both state that the Phillips Curve relationship usually holds true in the short-run for the reason that workers do not immediately recognize changes in their real wage. If inflation increases unexpectedly, workers will believe that real wages are higher than they actually are. Eventually, workers' expectations will align with reality again, and a policy of inflation will no longer have the effect of lowering unemployment. The implicit behavioral assumption is that individuals use their past nominal wages as a reference point until they become informed enough to use their past real wage as a reference point. People are often subject to money illusion.

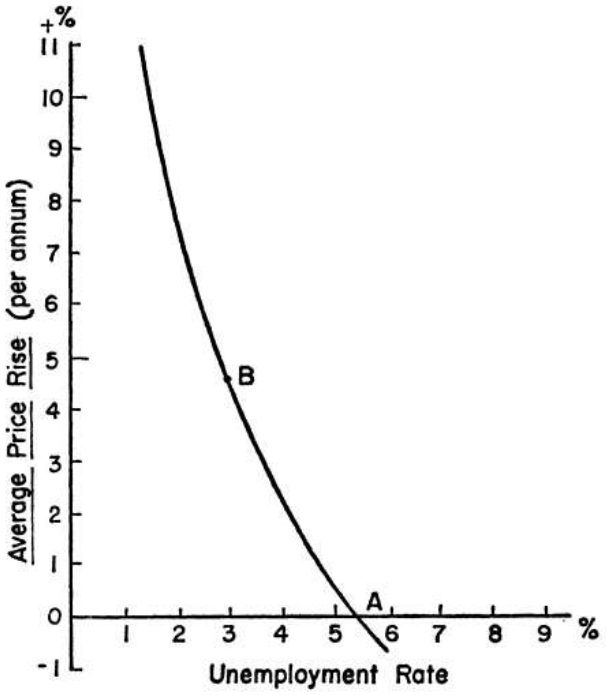

Figure 2 Modified Phillips Curve for U.S. reproduced from SS

Phelps uses this model of expectation formation:

$$\frac{d}{dt}\left(\frac{\dot{p}}{p}\right)^{e} = a\left[\frac{\dot{p}}{p} - \left(\frac{\dot{p}}{p}\right)^{e}\right]$$

where $\frac{\dot{p}}{p}$ is the rate of inflation and the *e* superscript denotes expectation. Phelps assumes that workers observe the rate of change of inflation in the past and use that information to form expectations.

Like Friedman, Phelps believes that there is a steady-state level of unemployment represented by y* in his graph reproduced in figure 3. In the long-run, monetary policy cannot drive employment above y* (this is later challenged by Akerlof).

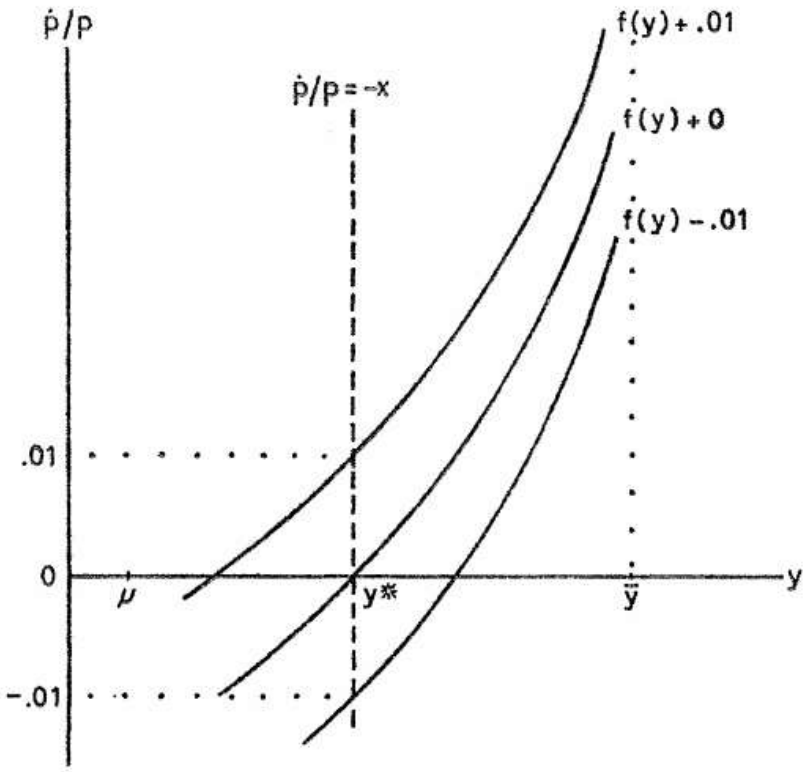

Figure 3 Quasi-Phillips Curves reproduced from SS

Phelps argues that a higher rate of inflation will lead to higher employment if expectations are sufficiently low and also that an employment level above a limit, $\bar{y}$, is not achievable at any inflation rate. Policy makers no longer choose from points on a curve but also affect the location of the curve by altering expectations. Without knowing expectations, this version of the Phillips Curve has much less predictive power.

The new model puts limits on the ability, if any, of monetary intervention to improve society. Friedman argued that the goal of monetary policy should simply be price stability so that monetary distortions do not upset individuals' economic planning,

whereas Phelps incorporated his assumptions about expectations into a recipe to maximize "social utility".

Friedman and Phelps describe a model of the economy where workers have rigid wages but perhaps not because they are completely irrational. Workers will inform themselves about the real wages when the benefits are higher than the cost. Friedman implies these things about behavior: Nominal wage rigidity holds in the short run if workers don't obtain complete information about monetary policy. Real rigidity will take effect when people realize what their real wages are. Expectations adjust faster when inflation changes are more noticeable; people notice things that are costly to ignore.

U.S. economic data in the last century can be loosely fitted to a simple Phillips Curve except for a period of both high inflation and high unemployment in the late 1970s. These years of "stagflation" showed that Friedman's adaptive expectations must be included in a monetary policy model.

In figure 4 (data from World Bank and U.S. Bureau of Labor Statistics retrieved from Federal Reserve Bank of St. Louis), the stagflation begins in the rapid rise of the inflation rate after the Bretton Woods Agreement was terminated in 1971 and it ends in the double recession of the early '80s. After the correction under the leadership of Paul Volcker who was Chairman of the Federal Reserve from 1979 to 1987, unemployment appears inversely related to the inflation rate.

Prior to the correction, economists such as Hall et al. (1975) assumed that nominal wages are rigid downward. If wages are too rigid, then the cost of disinflation was predicted to be quite high even as inflation was becoming problematic. Okun (1978)

warned that the short run costs of disinflation could be high. Tobin et al. (1980) extrapolated from his model to show that a reduction in the money supply would cause high levels of unemployment for several years.

Figure 4 Inflation Rate and Unemployment Rate for the U.S.

Sargent (1982) argued that the solution to high inflation was to use monetary policy to lower inflation while signaling a credible policy regime change to the public. The models in the economics literature in the 1970s were not helpful in predicting what

would happen during a credible disinflation, so Sargent turned to history. Austrians experienced hyperinflation after WWI but suddenly stabilized prices due to a credible regime change supported by the League of Nations. It took only one month for prices to stabilize after the Austrian crown stabilized in 1922. The Austrian government followed the protocols of the League of Nations and the Austrian people updated their expectations quickly. Unemployment did increase after the disinflation, but Sargent believes it to be less severe than the models used for the U.S. in the 1970s would have predicted.

Even though hyperinflation might be a special case, the lesson from Austria is that politics matter and that people are more rational than the early models indicated. The accelerationist models talk about workers like they aren't in the room, so to speak. Workers are part of the political discussion and can make themselves aware of economic trends, although they might have rational inattention at low levels of inflation. Following the Great Recession, Baltic countries achieved an internal devaluation which is impossible according to strict DNWR. This probably depends on leadership and culture which are both very difficult to measure. However it does tell us that the demand curve for non-decreasing nominal wages is not vertical. There are circumstances, especially when peers and leaders are also having their expectations disappointed, when workers are not bound by DNWR in the short-run.

Only a policy experiment could reveal the true extent of wage rigidity and the dynamics of expectation formation in the United States. Disinflation in the U.S. in was not as costly as economists expected. This shows that workers use more than the previous path of inflation to make decisions; they also understand policy to some extent.

Prices and wages do not adjust immediately to economic shocks. Fischer (1977) and Taylor (1980) proposed that price rigidity is partly due to staggered nominal contracts. It is costly the renegotiate a contract, so for an individual firm in any given period, it is often rational to remain in a sub-optimal price contract. Calvo (1983) presents a highly tractable model wherein only a certain fraction of firms are able to adjust prices in each period of time. Calvo pricing is standard for embedding a new Keynesian Phillips Curve into a macroeconomic model. In a model where wages are assumed not to fall, unemployment is generated after a negative economic shock.

Menu costs surely do explain small deviations in price from equilibrium, or the fact that retail prices are more stable than other economic statistics. However, staggered contracting is not a satisfactory explanation for high unemployment during recessions. If a firm can fire an employee mid-year, then it is not difficult to imagine that they could renegotiate a wage contract.

Ball, Mankiw, and Reis (2005) criticize the Calvo models along with all attempts to explain why people do not pay attention to and act on monetary policy news. It is difficult to model a person who is rational enough to form inflation expectations yet cannot check published inflation statistics. The model in Mankiw and Reis (2002) suggests that individuals do not stay completely updated on the state of the economy. This allows for more inertia than the Calvo model. Mankiw turns to a behavioral explanation that people are inattentive as opposed to being inextricably locked into contracts despite having access to all the relevant information. Mankiw (2007) writes, concerning models that treat inflation inertia as given, “Any model that builds in inflation

inertia as structural, rather than arising through expectations, will have trouble fitting data across historical regimes."

The most prominent theory for explaining why labor markets do not clear, according to Stiglitz (1984), is efficiency wages (he largely dismisses implicit contract theory). Stiglitz admits, "Those of us brought up in traditional Keynesian macroeconomics were taught [that wage rigidity is a fact of life]." Such an important assumption needs to be justified.

There are several versions of the EW theory but all state that employees are paid more than their reservation wage because the value of a worker is believed to be higher if they are paid more. Thus, for most jobs, there will be more people who would like to take the job than the firm can afford to hire.

A firm who cannot obtain perfect information about the ex-ante quality of a worker can increase the quality of the talent pool by offering higher wages (Stiglitz 1974; Weiss 1980). Conversely, a worker willing to work for very low wages is perceived to be low quality. It is difficult to assess worker quality before hiring and for many jobs it is impossible to measure all aspects of performance. Firms may get better performance from workers who are afraid to shirk because they are afraid to be unemployed and lose above-market-rate wages.

These wages that are too high in equilibrium also tend to be sticky. One reason that firms are hesitant to cut wages is that the first firm to cut wages will lose talented workers and face turnover costs (Phelps 1973; Stiglitz 1974). This coordination problem is reminiscent of Keynes's explanation that no worker wants to be the first to take a wage

cut. If some firms cannot cut wages in response to a demand shock (Taylor 1980), then firms who do have the ability to cut wages might be afraid to do so since they will be compared by workers to the firms with steady high wages.

George Akerlof proposed in 1984 that workers feel entitled to the wages they are being paid, even if wages are above reservation wages. If efficiency wages are determined by fairness norms, then it is reasonable that these norms also prohibit nominal wage cuts (or real wage cuts, depending on the workers).

Akerlof and Yellen (1990) propose several reasons for what they call the "fair wage – effort hypothesis". According to equity theory, workers think that there should be rough equality between the value of their services and their wage. People who feel underpaid will provide less effort; however, people who feel overpaid will not necessarily work harder. Several experiments have been conducted by psychologists in the 1970s that indicate workers shirk when they feel undervalued. Sociologists explain this by social exchange theory.

Relative Deprivation Theory refers to the concern with being treated fairly relative to relevant comparison groups. Psychologists cannot predict precisely whom a worker will compare against. It seems natural that employees within a certain division will compare wages with immediate coworkers but they may in some cases be concerned with how their earnings compare to friends and family. Long before economists noted relative comparison as a source of wage rigidity, personnel management textbooks considered it obvious. I will note here that a leader who coordinates a decline in wages after a negative shock could change the definition of a fair wage.

The efficiency wage theory may help ground wage rigidity in human preferences, however it is also a chicken and egg story. Without experimentation and counterfactuals, it is difficult to know if wages don't fall because of the decisions of managers, the resistance of workers, or both simultaneously.

The efficiency wage theory postulates that the market for human labor is unlike the classical market for goods. To return to Adam Smith's illustration, employers are not bargaining with a potentially malevolent baker over the price of bread. Employers are bargaining with workers who need to be, to an extent, benevolent if monitoring employees is costly. The labor market does often function quite well, and attempts to control the price of labor or the placement of people in jobs usually create distortions and result in human misery. However, the outcomes of the labor market will be different from, say, the spot market for oil.

Akerlof et al. (1996) argue that resistance to wage cuts produces not only a short-run Phillips Curve but a long-run tradeoff and so they recommend a policy of keeping the inflation rate low but positive. In their model, firms that make losses two years in a row can make cuts to the "notional real wage," inspired by the respondents to Kahneman, Knetsch, and Thaler (1986) who indicated that wage cuts are fair if a firm is losing money. Janet Yellen (2005) similarly argued at a Federal Open Market Committee meeting in 1996 that long-run positive inflation will "grease the wheels of the labor market." In the words of Akerlof et al. (1996):

> Some might argue that the behavior that we model characterizes a regime that will change, that a determined zero inflation policy would break down wage

> rigidity.… We suspect that wage rigidity is deeply rooted, not ephemeral or characteristic of a particular set of institutions or legal structures.… The psychological studies that we cite treat as fundamental the notions of fairness and worker morale that appear to underlie nominal rigidity.…
>
> We observe that rigidity breaks down at the firm level when firms are under extreme duress, a condition that employees can observe and are willing to respond to; and we account for this behavior in our model. But this does not imply that rigidity in the aggregate is susceptible to a permanent regime change following analogous macroeconomic conditions. In the Great Depression, when extreme duress became wide-spread, downward rigidity initially gave way, but it did not break down permanently.

I now turn to the surveys that they reference.

These surveys complement the empirical research and hypotheses concerning downward nominal wage rigidity. The efficiency wage hypothesis is about feelings, so it makes sense to ask people how they feel as well as to record actions.

Kahneman, Knetsch, and Thaler (1986; hereafter KTT) conducted a survey that is often still cited as evidence for money illusion. They asked urban Canadians over the phone to assess hypothetical scenarios as fair or unfair. The majority of respondents said that cutting wages or raising prices is unfair when it is framed to seem like a firm is making a profit at the expense of employees or customers who had formed a more favorable reference point in the past. It is worth noting that the replies to a question were never unanimous.

The question most relevant to this study is KTT's question 4. I reprint their question and their results from page 732 of KTT in table 1.

Table 1 Results from KTT Question 4

	Respondents who said this situation is:	Acceptable	Unfair
Question 4A:	A company is making a small profit. It is located in a community experiencing a recession with substantial unemployment but no inflation. There are many workers anxious to work at the company. The company decides to decrease wages and salaries 7% this year. (N=125)	38%	62%
Question 4B:	… with substantial unemployment and inflation of 12%... The company decides to increase salaries only 5% this year. (N=129)	78%	22%

If we were to suppose that all of the 22% who respond "unfair" in Q4B would also respond "unfair" in Q4A, then (62-22 = 40) 40% of people change their minds based on the nominal versus real wage cut factor. (That leaves 38% of people who think it's

fair to cut wages in a recession, regardless.) The amount affected by nominal illusion is shown by the hashed bar in figure 5 where I assembled data from KTT (1986).

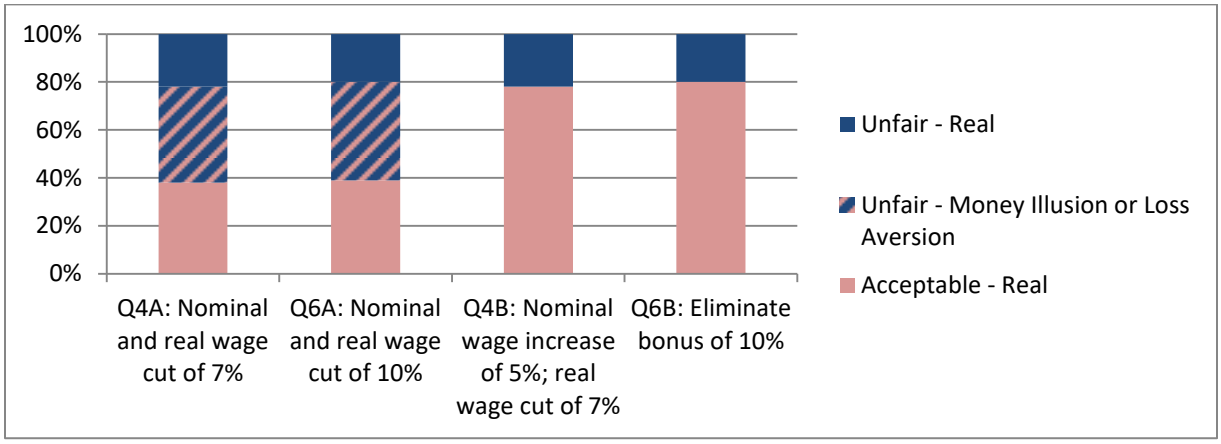

Figure 5 Survey Responses

Many respondents reply as if they have money illusion. Similarly, they respond that a wage cut is unfair but elimination of a bonus is fair, even though the actual outcomes are the same and they are told that the company is not growing as it was before. The way a real wage cut is framed can change the way it is judged. It appears from figure 5 that 40% of the population finds a wage cut during a recession acceptable regardless of inflation, contrary to the assumption of some macroeconomists. Another 40% of the population appears affected by money illusion or nominal loss aversion.

The KTT survey was replicated in China and Switzerland two decades later (Gao 2009) with largely the same results. There are small differences between cultures which indicate that some nominal wage loss aversion is learned through community but also

that it is rooted in an innate reaction to loss. There is considerable heterogeneity within each society.

The Chinese respondents were less likely to rate a wage cut as unfair. Students in China were especially likely to respond that a wage cut (or bonus elimination) is fair. Chinese people, students and non-students, were less likely to respond that an action taken by the employer was "unfair". Chinese people seem relatively more comfortable with a firm "getting ahead" at the expense of consumers or workers, although there are still significant numbers who call those actions "unfair".

Gao's (2009) question 4 deals with the elimination of a bonus and Question Q4A is phrased as: "A small company employs several people. The workers' incomes have been about average for the community. In recent months, business for the company has not increased as it had before. The owners reduce the workers' wages by 10 percent for the next year." With this framing, Chinese people seemed more accepting of wage cuts than people in Western countries (see table 2 from page 7 of Gao 2009). When the same real wage cut was framed as eliminating a bonus, the majority of Westerners said it is not unfair. There were no significant differences between the way that males and females responded.

Respondents to the Gao (2009) survey quickly internalize the reference point in the questions and many are upset by the deviation from those reference points. Overall, the people in China, Switzerland, and present-day Canada confirm the findings of KTT decades ago.

Table 2 Cutting wage v. eliminting bonus

Sample	Cutting wage		Eliminating bonus	
	Acceptable (%)	Unfair (%)	Acceptable (%)	Unfair (%)
Chinese students (N=90)	64	36	84	16
Chinese non-students (N=90)	56	44	78	22
Swiss sample (N=97, 105)	32	68	76	24
Canadians (N=100, 98)	39	61	80	20

The KTT survey confirms part of the efficiency wage theory. Workers resent wage cuts and it is easy to imagine that an irate worker will produce less. Bewley (1999) investigates the feelings of the wage-setters who are on the other side of the bargaining table. Bewley surveyed over 100 managers and a significant number reported that they do not like to cut base pay because of the emotional effect it has on employees. The majority of managers believe that pay cuts "hurt morale" and almost half specifically state that pay cuts reduce productivity. This is evidence for wage rigidity explained by the Akerlof and Yellen (1990) morale-based theory.

Campbell and Kamlani (1997) conducted a similar survey of 184 firms. Respondents say that reducing turnover is an important explanation of wage rigidity for white-collar workers. Managers believe that that effort responds more to wage decreases than to increases, and that cuts have a greater impact on the effort of low-skilled workers. Table 3 (reproduced from Campbell and Kamlani (1997, p. 778)) shows that managers believe a 10% wage cut results in a reduction of effort by more than 10%. Table 3 reports the answers to a question that was phrased thus: "Suppose you were to cut wages

by 10%. By approximately what percentage (if at all) would you expect workers' effort to fall as a result of this cut in wages?"

Table 3 Responses to Wage Cut Question

	White-collar			Blue-collar			Less skilled		
	Overall	BW	NBW	Overall	BW	NBW	Overall	BW	NBW
Mean	15.4%	15.0%	16.9%	19.4%	19.3%	19.8%	22.7%	21.1%	27.7%
Median	10.0%	10.0%	15.0%	15.0%	15.0%	20.0%	20.0%	18.0%	20.0%
>0%	85.8%	89.5%	72.0%	92.0%	95.7%	76.5%	91.3%	93.7%	84.0%
≥10%	61.7%	61.6%	64.0%	74.7%	77.1%	64.7%	78.8%	78.5%	80.0%

A recently survey on financial literacy indicates how many adults understand inflation. McGraw Hill Financial's Corporate Responsibility worked with Gallup to survey more than 150,000 adults across 148 countries to create the Standard & Poor's Ratings Services Global Financial Literacy Survey (McGraw Hill Financial 2014). This is how they presented the question to test for an understanding of inflation: Suppose over the next 10 years the prices of the things you buy double. If your income also doubles, will you be able to buy:

Less than you can buy today

The same as you can buy today

More than you can buy today

In figure 6 I show the results for 36 out of the 144 countries in which Gallup collected data and met Gallup quality standards. For many middle-income countries, the understanding of inflation is considerably better than the other questions about

investment portfolios and interest. For example, less than 30% of adults in Thailand are considered financially literate, but over 60% of adults answered the question on Inflation correctly.

In figure 6, Adults were considered financially literate if they answered 3 out of 4 questions correctly about investment risk, inflation, interest and interest compounding. (Data from MHFI 2014)

Surveys provide evidence for how people feel about wage bargaining and point to psychology as an explanation for why labor markets do not clear. The experiments discussed in Section III can more directly test if these feelings about injustice affect output of individuals. Aggregate data on wage flexibility are reviewed in the next section.

If unemployment rises after a recession, it is safe to assume that wages of job holders did not fall enough to clear the labor market. The following is a selection from a large literature that measures the apparent lack of wage flexibility and the willingness to accept real wage cuts when inflation is high. This review starts where the discussion began during the Great Depression, and then examines recent large datasets on wages and employment.

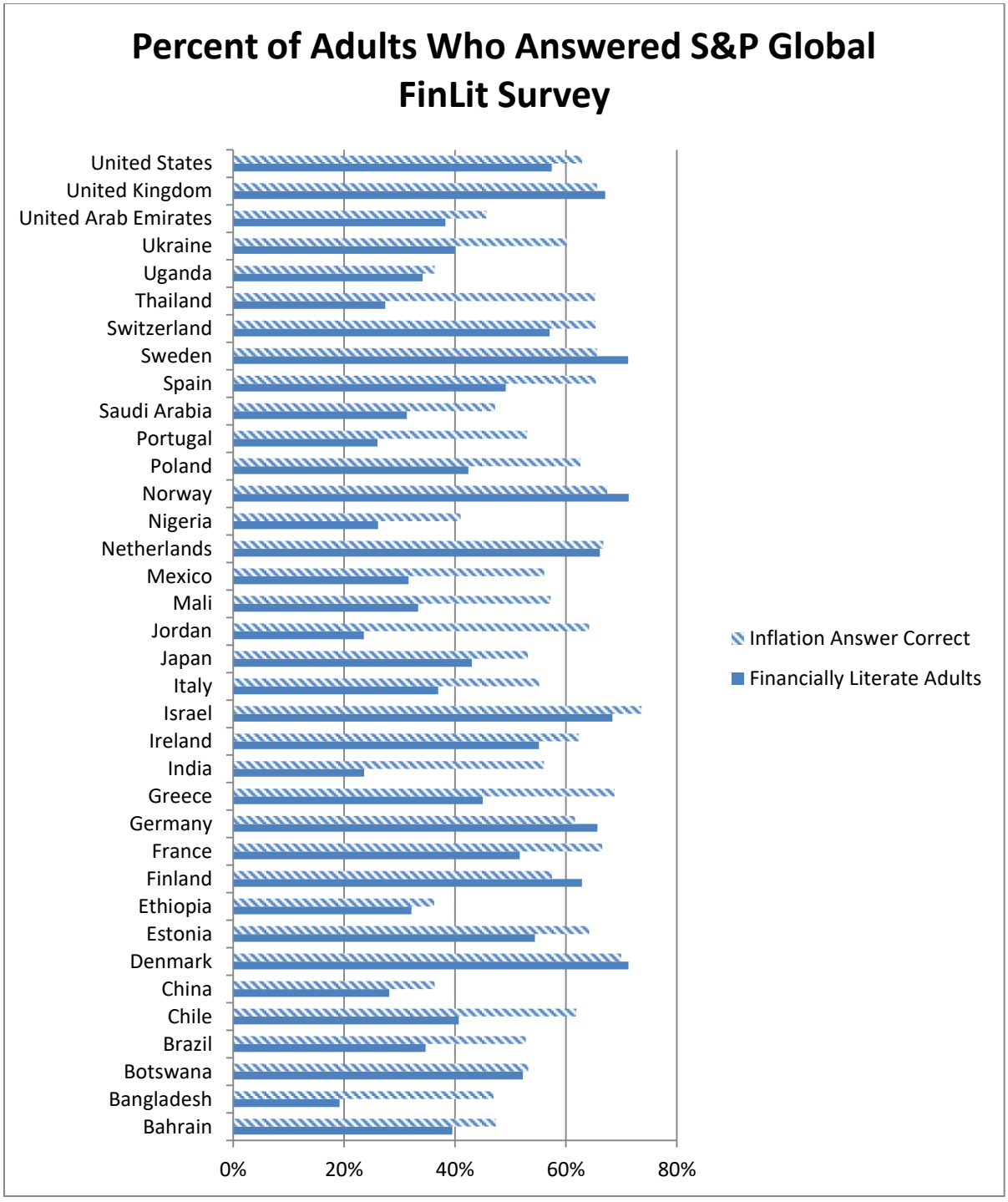

Figure 6 Financial Literacy Survey (MHFI 2014)

The 1930's provide a natural experiment between countries who left the Gold Standard early in the Great Depression and those who tried to maintain a currency peg to gold. Real wages declined in the countries who allowed their currency to depreciate and output rose faster than the comparison group. Bernanke and Carey (1996) write, "Explicitly or implicitly, most proponents of the gold standard theory have invoked "sticky" nominal wages as the reason for the protracted real impact of the monetary contraction." Further work established the link from depreciation to lower unemployment and higher output per capita. Many economists blame the Federal Reserve for not responding to the Great Depression with monetary stimulus. A modern experiment is now in progress in the Eurozone where countries like Greece who cannot depreciate their currency after a recession have protracted recessions and high unemployment. The quantitative easing response is partly inspired by the Great Depression discussion. Eichengreen and Sachs (1985, 1986) use cross-sectional data from 1935 and refine the model used by Bernanke and Carey. They allow nominal wages and price to enter the regression separately and they find that both are significant. They conclude that the "inverse relationship of output and real wages reflects largely the effects of incomplete nominal wage adjustment."

Bemanke and James (1991) discuss three channels that link deflation and depression. First, real wages must remain high if nominal wage rigidity holds. That results in lower labor demand and less labor inputs results in lower output. Second, deflation encourages saving cash and thus real interest rates must rise to attract capital. Higher interest rates result in lower investment and thus lower real GDP. Finally,

deflation contributes to financial turmoil and may foment a "crisis". A critical mass of borrowers may default on debts during a period of deflation. Only the first channel relies on wage rigidity, which is one reason why data that does not come from controlled experiments makes it difficult to conclude that deflation makes a recession worse for the reason that wages cannot fall.

One way to measure wage rigidity is simply to count how many times we observe wages falling and compare it to the number of times we would expect wages to fall if labor markets clear. In 1798, Thomas Malthus was able to observe that "it very rarely happens that the nominal price of labour universally falls; but we well know that it frequently remains the same, while the nominal price of provisions has been gradually increasing. This is, in effect, a real fall in the price of labour" (Malthus 1798, pg 34-35).

Since the time of Malthus, the quality of data on wages has improved and there are several papers that show that nominal wage freezes occur frequently and that nominal wage cuts are uncommon. Even by visual inspection of a histogram of nominal wage changes it is easy to see an asymmetry around the spike in the frequency of wage freezes. Furthermore, the effect becomes stronger during recessions when wage cuts would be expected to clear labor markets.

One of the most extensive surveys of wage data was done by Dickens et al. (2007) using data from many developed countries.

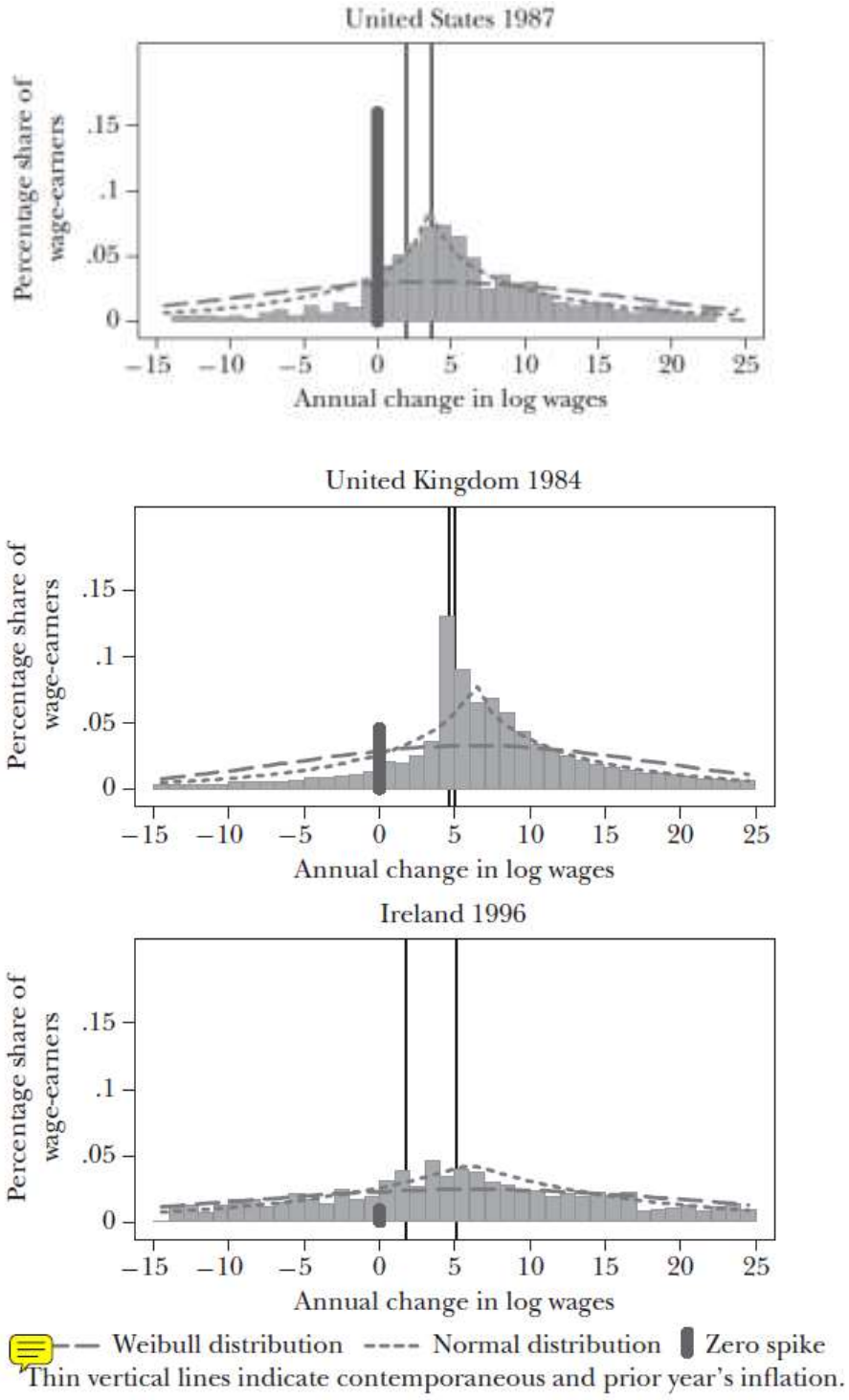

Figure 7 Wage Change Histograms (Dickens et al. 2007)

The U.K. shows less nominal rigidity than the U.S. and more real rigidity in the figure 7 reproduced from Dickens et al. (2007). Irish data shows virtually zero nominal rigidity. The authors attributed that to measurement error. This type of self-reported wage data can be subject to serious measurement error which is a major limitation of this kind of study. However, in the case of Ireland, it was shown by Doris, O'Neill, and Sweetman (2015) that people in Ireland have accepted a large number of wage cuts and the country as a whole exhibits surprising wage flexibility.

The patterns vary from country to country. Wage rigidity is very likely a learned cultural phenomenon that is tied to innate sense of pride and loss aversion and concern with status – just as we conclude from replicating the KTT study in China (Gao 2009).

Dias, Marques, and Martins (2015) use a different identification strategy than Dickens et al. (2007). They also find substantial DNWR in Europe, however they also report significant heterogeneity that can be traced to economic and cultural factors:

> Nominal base-wage rigidity emerges as especially important in Spain, Netherlands and Portugal and less significant in some eastern countries like Slovenia, Poland or Lithuania.
>
> A probit model, restricted to firms that would have their base wages cut in the absence of downward nominal wage rigidity, suggests that the degree of downward nominal wage rigidity increases with the proportion of high-skilled white-collar workers and the importance of wage agreements negotiated outside the firm, and decreases with the degree of competition faced by the firm. The

> incidence of permanent contracts, the labour share, the tenure or the proportion of workers covered by collective agreements, suggested by the economic theory as potential relevant factors, do not emerge as having a significant impact on downward nominal wage rigidity. (Dias et al. 2015)

Daly and Hobijn (2014) demonstrate not only the well-established spike in frequency at zero but an increase in wage freezes in the US after the Great Recession. Wage cuts are expected when the US business cycle turns down, so the lack of wage cuts does indicate wage rigidity. Figures 8 and 9 specifically shows that the unemployment rate is related to the wage freeze rate. Figure 8 is reproduced from Daly & Hobijn 2014 and figure 9 is reproduced from Dicken et al. 2007.

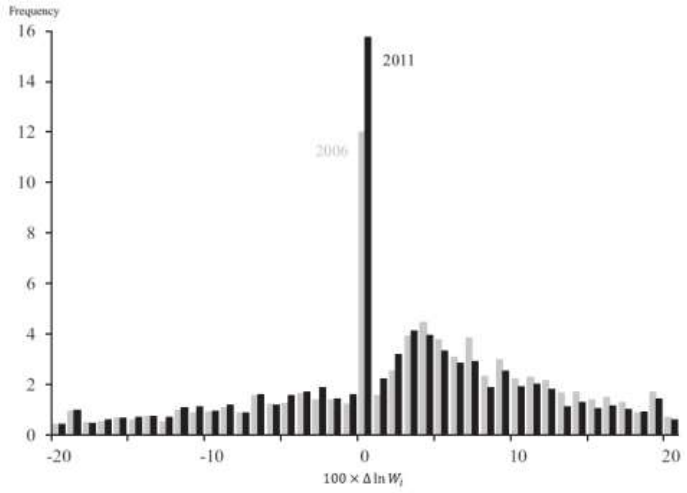

Figure 8 12-Month Log Wage Changes in 2006 and 2011

FIG. 2. Fraction of Workers Reporting the Same Wage as 1 Year Prior and the Unemployment Rate.
SOURCE: Bureau of Labor Statistics and Current Population Survey. 12-month centered MA of rate of wage change.

Figure 9 Wage Change from the U.S., U.K., and Ireland

Daly and Hobijn (2014) simulate their data using a model with **a** representative household. Each period, household members receive a disutility shock such that some people would like to be able to work for a lower wage than they did in the last period. Rigidity is inserted by assuming that a randomly selected fraction, $\in [0,1)$, of household members cannot change their nominal wage downward. This constraint forces some fraction of people into unemployment. Higher inflation (or productivity growth) results in less unemployment because fewer workers get stuck at too-high wages. The model simulates the important features of their data and can also produce a negatively sloped Philips Curve, however it is strange from a behavioral perspective.

Workers in the United States in recent decades do seem to expect that wages will not fall. Gordon (1996, p. 62) speculated that "nominal wage reductions would no longer

be seen as unusual if the average nominal wage was not growing. Workers would not see them as unfair, and firms would not shy away from imposing them.'' If the American people had, say, a decade of stagnant or falling wages, perhaps they would adjust their expectations and wages would no longer be rigid downwards. Gordon (1996) and Akerlof et al. (1996) both question whether the overwhelming data on wage rigidity points to a human universal trait or is an artifact of the particular circumstances of the 20th century.

Fehr and Goette (2005) respond to that skepticism. They analyze wages in Switzerland in a low-inflation period in the 1990s. After 4 years of low inflation, they do not observe less nominal wage rigidity than during higher inflation periods. However, the recent experience of the Baltic countries after the Great Recession (Kang and Shambaugh 2014) prove that under duress an entire country is capable of adjusting wages downward. Wage rigidity is emotionally intuitive and often observed, but it is not a law because it is not observed in all contexts.

Keynes split from classical economists when he said that markets do not always clear and that nominal wages do not fall. For a while, there was a rift in the economics profession between classical market models and Keynesian models. Today both sides have reconciled because macroeconomists use microfoundations. There is still disagreement over how fast "sticky", as opposed to "rigid", wages adjust and what role the government should play in a recession. Many questions remain about whether and when wages are too sticky. Some countries in the European economy adjusted much faster than other and economies that experience a rapid external devaluation can recover

employment quickly after a crisis. So, any model that requires a quagmire for either nominal or real wages would fail to predict the outcomes in every country after every recession, although the authors of the models may not intend them for that purpose anyway. In the section I will review several recent papers concerning wage rigidity with a focus on the models that they use and the implicit behavioral assumptions.

Goette, Sunde, and Bauer (2007) develop an econometric model to demonstrate that wage rigidity is pervasive in the three countries that are analyzed in that issue of The Economic Journal: Germany, Italy and Great Britain. They see considerable heterogeneity among individuals in each country; there are also wage cuts for a fraction of people. Also note the difference between countries:

> For Germany, Bauer et al. (2007) find that 30% to 70% of wages are set under the real rigidity regime and 13% to 20% of wages under the nominal rigidity regime. The results of Devicienti et al. (2007) show that in Italy the probability of a worker being in the real wage rigidity regime varies between 45% to 65% and the probability to be in the nominal wage regime varies between 22% and 24%. Finally, Barwell and Schweitzer (2007) provide evidence that on average 41% of the workers in the UK fall into the real wage rigidity regime, whereas only slightly more than 14% fall into the nominal wage rigidity regime. (Goette et al. 2007)

The difference between countries can be explained, in part, by measurable institutional differences:

> Our results also indicate that union wage growth in particular is able to explain real wage rigidities. We are unable to distinguish between explanations for these findings that are based on the bargaining power of workers and explanations that are based on efficiency wages paid by firms. (Goette et al. 2007)

Specifically, Barwell and Schweitzer (2007) find that workers who tend to be in the fraction of people who have downward real rigidity also tend to be older, in the public sector or covered by union agreements.

Goette et al. (2007) report that real wage rigidity is declining over time, which can be explained, at least in part, by institutional changes. Also, they find that low inflation decreases real wage rigidity, which is likely because when inflation is low the wage negotiations by unions do not have to take it into account. However, they find that low inflation leads to more downward nominal wage rigidity. Relative to high inflation, low inflation will perhaps cause workers to pay less attention to their real wage and use their nominal wage as a reference point. This has important implications for expectation formation.

Goette et al. (2007) present a world where some people have perfectly flexible wages, but some fraction do not. Many models, such as that used by Mankiw and Reis in 2002, assume that a fraction of the population can change prices while the rest cannot. This technique is reminiscent of Calvo (1983) and it has many possible behavioral explanations but is always a bit ad hoc, which is the accusation that macroeconomists where trying to escape when they adopted microfoundations in the first place. Lucas

(1973) proposed that people have imperfect information while Calvo (1983) suggested that some people and firms are contractually obligated not to change prices, even if they receive new information.

It is also possible that some fraction of the rigid fraction of the population are explained by an efficiency wage story: the firms are afraid of low morale and the workers retaliate against wage cuts that they view as insulting.

Galí (2011) presents a model for the New Keynesian Wage Phillips Curve (NKWPC). Like the original Phillips Curve, the NKWPC establishes a relationship between wage inflation and the unemployment rate. One important difference between the NKWPC and the old version is that the NKWPC is microfounded and has structural parameters. If the degree of wage rigidity, represented by θ_w in his model, is zero, then the economy has full wage flexibility. Galí also builds expectations into his model.

The Galí model assumes a representative household which gets utility from consumption and disutility from work. The household maximizes expected utility subject to budget constraints. Gali introduces wage rigidity by following Calvo (1983) and stipulating that workers "get to reset their (nominal) wage with probability $1 - \theta_w$ each period." He further explains, "Thus, a fraction of workers θ_w keep their wage unchanged in any given period, making that parameter a natural index of nominal wage rigidities. Once the wage has been set, the quantity of workers employed is determined unilaterally by firms, with households willingly meeting that demand (to the extent that the wage remains above the disutility of work for the marginal worker)."

Galí (2011) claims that the "structural nature of [his NKWPC] stands in contrast with the purely empirical basis of Phillips (1958) original curve, whose only theoretical underpinning was the plausibility of the principle that 'when demand for labour is high and there are very few unemployed we should expect employers to bid wage rates up quite rapidly.'" The NKWPC can be fit with parameters to simulate reasonable outcomes such as unemployment, however Galí admits that the model is unrealistic:

> It is far from the objective of the present paper to claim that the staggered wage setting model of Erceg, Henderson, and Levin (2000) provides an *accurate description* of the US labor market. It is clear that some of its underlying assumptions—most noticeably, the unilateral setting of the wage by a monopoly union—are at odds with arrangements prevailing in most sectors. Yet, as a matter of fact, the EHL structure underlies most of the medium-scale DSGE models that have been developed in recent years, by both academics and institutions. Identifying and testing further predictions coming out of those models would seem a worthy undertaking and a source of guidance in any effort to improve the frameworks available for policy analysis. (emphasis mine)

Thus, being microfounded does not make a model "accurate" nor does it avoid making unrealistic assumptions that conveniently fit empirical data. The agents in this model perfectly provide labor until the marginal utility becomes negative and are otherwise completely rational, except for this arbitrary rule that some of them cannot renegotiate their wage even when they would want to. There is no reason why households would commit to not renegotiate at the beginning of period t, even if it means becoming

unemployed. Some wages, especially for government or union workers, really are renegotiated at long intervals, but many people could renegotiate if it meant keeping their job; a mystery is why firms don't give them a chance to do so.

Such an arbitrary rule as Calvo contracts seems like it was inserted just to achieve the same relationship between inflation and unemployment that Phillips observed in the 1950's. The ad hoc assumption has been buried under a layer of complexity, but it is still there. Such models can be used to simulate the effects of policy but they are unlikely to be able to predict a case like Ireland where there was some internal devaluation after the Great Recession.

A more realistic agent would have preferences that explain efficiency wages. People enjoy not falling in relative status to their peers and they have utility for being fairly treated. To explain DNWR, one does have to depart from the completely rational agent who only values money, but we could create a much more realistic model than the current NKWPC. One of Calvo's advertisements for his model was its tractability, and adding preferences for fairness would certainly complicate the model.

In an attempt to do just that, Ahrens, Pirschel, and Snower (2014) claim to provide an "explanation of wage adjustment [that] is thoroughly microfounded, without recourse to ad hoc assumptions." The Ahrens model also consists of workers who want to maximize consumption and minimize disutility from working. Loss-averse workers get more disutility from working if they are offered a wage below their reference wage which creates a kinked labor supply function. After a small negative economic shock, the firms in this model find it preferable to freeze wages than to cut them below the reference

wage. Ahrens et al. successfully create a model with three observed features of the business cycle:

(1) for small labor demand shocks, wages are fully rigid,
(2) for medium-sized shocks there is upward wage adjustment for positive shocks, but complete down-ward wage rigidity for negative shocks and
(3) for large shocks, wages decline less strong to negative shocks than they increase to equiproportionate positive shocks.

They explain the behavioral underpinnings as follows:

> In the spirit of prospect theory, the utility losses from wage decreases are weighted more heavily than the utility gains from wage increases of equal magnitude. Consequently, employment responses are more elastic to wage decreases than to wage increases. The result is a kinked labor supply curve, for which the kink depends on the workers reference wage. In the spirit of Kòszegi and Rabin (2006), we model the reference wage as the workers rational wage expectations. (Ahrens et al. 2014)

Simulating these features of wage dynamics is an accomplishment and their model is more behaviorally realistic and internally consistent because the agents always do what is in their own best interest according to their assumed preferences without the arbitrary Calvo contract constraint. However, they omit many of the relevant behavioral factors that are part of the policy discussion. They do not discuss unemployment, shirking, peer

comparison or nominal money illusion. They essentially reduce the problem to be about pure loss aversion. I think the interpersonal relationships and perceptions of fairness are also crucial to include.

A recent model that is more useful for analyzing a combination of loss aversion and shirking in a labor exchange context is presented by Hart and Moore (2008). In their model, people form expectations from an ex ante contract, negotiated under competitive conditions. This could be applied to an employee accepting a non-indexed nominal wage contract. When it comes time to deliver the service, if a party in the contract does not get what she feels entitled to, she will shade her effort down to the perfunctory level instead of providing excellent performance. An example they give is that if a caterer feels they are treated badly by a wedding planner, he may provide the quantity of food for which he signed the contract but his staff may not be friendly. The important behavioral assumptions are that people form reference points from past contracts and that they desire to retaliate against their counterpart if they feel they are treated unfairly. This results in deadweight loss.

A recent paper by Schmitt-Grohé and Uribe (2016) emphasizes the existence and importance of nominal wage rigidity. They use observations of nominal rigidity to suggest a capital control policy. Their picture (figure 10 from Schmitt-Grohe & Uribe 2016) of the Eurozone periphery countries powerfully summarizes the effect of nominal wage rigidity on unemployment that is often observed.

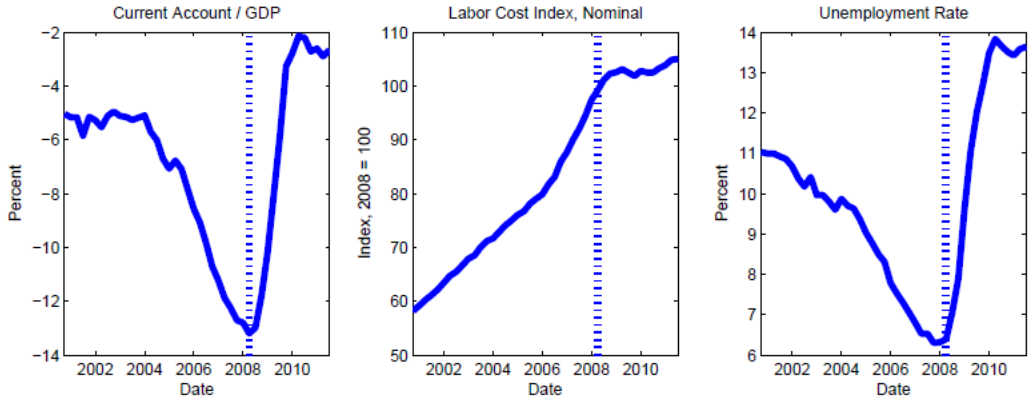

Figure 10 Business Cycle in Peripheral Europe 2000-2011

The economies of countries like Estonia were fueled in the early 2000s by capital inflows and both nominal and real wages rose rapidly. When the capital inflows dried up after 2008, the nominal wages remained at their peak levels and massive involuntary unemployment resulted.

Schmitt-Grohe and Uribe assume that wage rigidity is closer to a law of nature than a consequence of a downward sloping demand for stable wages. They frame the problem of the recession as nominal wages being allowed to rise so high that the bust must come with high unemployment (assuming that an external devaluation is not possible because of a currency peg). Their solution is to cut off what they believe to be the source of the problem – the capital inflows during "expansions".

They provide some empirical justification for taking nominal wage rigidity so seriously. Figure 11 (Schmitt-Grohe & Uribe 2016; source is BLS and INDEC) provides evidence for the persistent of nominal wage rigidity in the face of 40% unemployment at the peak of Argentina's economic crisis.

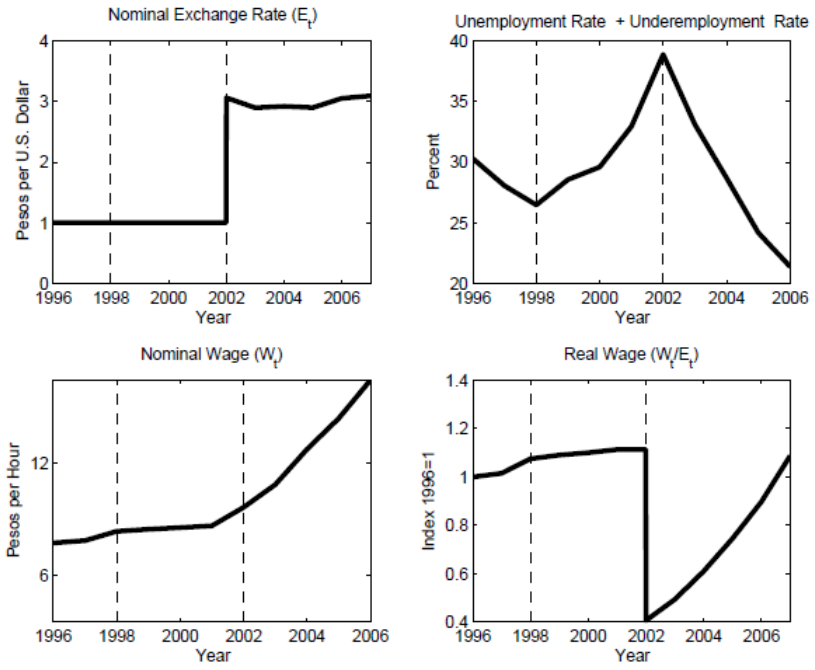

Figure 11 Nominal Wages and Unemployment in Argentina

After the exchange rate in Argentina was allowed to adjust to the market rate, real wages were allowed to plunge with no change in nominal wages and unemployment subsequently declined to pre-crisis rates. They provide more evidence of wage rigidity in the Eurozone in table 4 (Schmitt-Grohe & Uribe 2016; source is Eurostat).

In the model, Schmitt-Grohe and Uribe allow nominal wages to adjust by the parameter γ. They use the value 0.99 for γ because it was the most flexible scenario they found in recent data. Thus wages are almost completely rigid in their model. It is remarkable that Spain experienced 20% unemployment in 2011 yet still had rising nominal wages.

Table 4 Unemployment and Nominal Wages in the Eurozone

Country	Unemployment Rate 2008Q1 (in percent)	Unemployment Rate 2011Q2 (in percent)	Wage Growth $\frac{W_{2011Q2}}{W_{2008Q1}}$ (in percent)	Implied Value of γ
Bulgaria	6.1	11.3	43.3	1.028
Cyprus	3.8	6.9	10.7	1.008
Estonia	4.1	12.8	2.5	1.002
Greece	7.8	16.7	-2.3	0.9982
Ireland	4.9	14.3	0.5	1.0004
Italy	6.4	8.2	10.0	1.007
Lithuania	4.1	15.6	-5.1	0.996
Latvia	6.1	16.2	-0.6	0.9995
Portugal	8.3	12.5	1.91	1.001
Spain	9.2	20.8	8.0	1.006
Slovenia	4.7	7.9	12.5	1.009
Slovakia	10.2	13.3	13.4	1.010

I offer several comments on this paper. Broadly, they suggest a serious government intervention into financial markets in order to prevent crises in the future, but they fail to mention that government policies often contribute to wage rigidity. Spain, for example, had laws that make it very costly to fire a full-time worker which makes it difficult for the economy to adapt to economic shocks. Also, I think they do a good job of demonstrating the extent and importance of nominal wage rigidity, but the average Wage Growth that they present in the third column of table 4 masks important instances of *flexibility* in the Eurozone.

Latvians had a reference point of over 20% wage increases (see table 5; source table 10 (Masso and Krillo 2011)) and within one year switched to negative nominal wage growth. Paas and Eamets (2007) document that the Baltic states had flexible wages before the crisis which is likely why they were able to adjust so quickly. Ireland also had

relatively flexible wages before and after the crisis (Doris, O'Neill, and Sweetman 2015). Doris et al. (2015) use highly disaggregated data to show that although the average nominal wage rate in Ireland appears fairly rigid during the recession, about half of the population, including both public and private sector employees, were taking wage cuts while about 40% of the population was simultaneously still receiving pay raises. Thus, averages such as the one used by Schmitt-Grohe and Uribe (2016) can be misleading as to how flexible the labor market is.

Table 5 Nominal Wage Growth in the Baltics in 2008 and 2009

	2008	2009
Estonia	14.10%	-4.60%
Latvia	21.10%	-3.80%
Lithuania	19.60%	-4.30%

I propose that workers have a strong preference for non-falling nominal wages, but they still consider rational trade-offs. Typical workers can accept nominal wage cuts if the benefits appear high or the costs appear low. An example of this strong preference, but also rationality, can be found in the excellent natural experiment identified by Kaur (2014).

Kaur uses variation from rainfall in rural India as stochastic shocks to the economy. She uses wage data to show that workers use wages from the previous year as

a reference point, finding that unemployment increases instead of wage cuts after a negative shock. This rural economy has very few institutional barriers to wage cuts, so it is surprising to find such a powerful effect.

Kaur's figure is reproduced as figure 12 below. The histogram of nominal wage changes shows that nominal wage freezes are common, just as we saw with Dickens et al. (2007), and that nominal wage cuts are rare. Real wages, however, appear much more flexible.

Kaur also did a survey of agricultural laborers and landed farmers indicating that nominal wage cuts are considered "unfair" while real wage cuts during time of high inflation are not, confirming the KTT survey results.

Kaur demonstrates that nominal rigidity is evident and that workers consider nominal wage cuts to be unfair. An innovation made possible by her precise data set is to show that the effect of droughts on employment is not the same in all districts. For certain crops, labor flexibility is more important because if these crops are not harvested promptly it will result in large profit losses. She finds less wage rigidity in regions where the crops (soybeans are an example) are "more sensitive to labor inputs." It is possible that farmers of sensitive crops tend to settle in communities where this flexibility is allowed. Whatever the reason for increased flexibility, this indicates that fairness is a good for which people will not pay an infinite price.

Panel A: Nominal Wage Changes -- Entire Sample

Panel B: Real Wage Changes -- Entire Sample

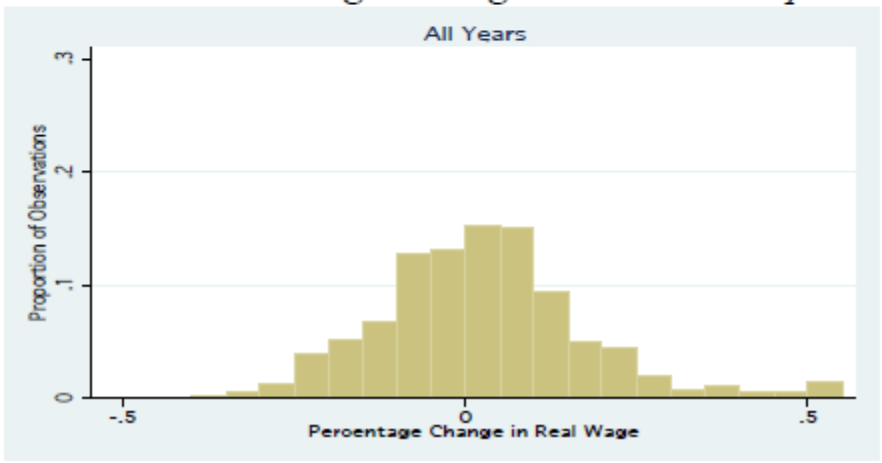

Figure 12 Distribution of Wage Changes

Kaur uses a model that allows workers to shirk. Although her data is excellent as empirical studies go, she is unable to verify that individuals would shirk if their wages are cut because she does not have data on individual productivity and cannot provide a counterfactual the way a controlled experiment can. Like the other empirical studies, she

only has data on wage and on unemployment. A lab experiment can give wage, unemployment, and individual productivity.

In her model all workers are equally productive and all of them retaliate against wage cuts by cutting effort but in reality it could be that some workers would work hard regardless of wage fluctuations and others would retaliate fiercely.

An insightful study on what causes downward wage rigidity and how wage expectations form was done by Knell and Stiglbauer (2012). They present 4 alternative reference norms and test them empirically using data from Austria (which has fairly strong unions):

1. external norm: look at wages in other sectors for a reference point
2. price-indexation norm: look at current or past price level, assumption made often in DSGE literature
3. habit-persistence norm: look at own past wage
4. wage leadership: look at an industrial sector that takes the lead in setting wage expectations

Their tests indicate that the leadership of the metals sector in Austria best explains wage expectations. They write, "Taken together, the theoretical and empirical results suggest that differences in reference norms or the existence of wage leadership can be at least partly responsible for the observed cross-country differences in inflation persistence and in wage rigidity."

In Ireland where many wage cuts were observed after the recession, the leadership of the public sector in reducing wages across the board may have changed the reference

wage in the private sector. An important conclusion from exceptions, such as Ireland, to the rule of DNWR is that the definition of "fair" can change because of economic shocks or under the guidance of leaders.

Every model of wage rigidity has failings and oversimplifications. Rodrik (2015) says that it is not useful to try to make *the* model the model that can predict and explain every phenomenon. Economists should appreciate the diversity of models in our toolkit and know when to apply which model. In this case that might mean applying a model that assumes wage rigidity in the correct circumstances and not in others.

> What makes a model useful is that it captures an aspect of reality. What makes it indispensable, when used well, is that it captures *the most relevant aspects of reality in a given context*. Different contexts – different markets, social settings, countries, time periods, and so on – require different models. (page 10)

Rodrik accepts that some assumptions are not realistic and that is acceptable if the model produces realistic results. However, he considers it very important that "critical" assumptions be realistic. I propose that the assumption of wage rigidity is unrealistic because it is sometimes violated. It is important for Keynesians to determine if the assumption of wage rigidity is "critical," by which he means that "these assumptions would produce a substantively different result if they were altered to be more realistic."

I suggest that cases where wages are flexible might require a tipping point model with a leader instead of, or in addition to, a competitive market model. Rodrik expects economists to become frustrated if they look for absolute fundamental laws of behavior because, he writes on page 45, "Economics is a *social* science, and society does not have

fundamental laws- at least, not in quite the same way that nature does. Unlike a rock or a planet, humans have agency; they choose what they do."

To settle the fierce debate over external validity of conclusions drawn from various forms of economic inquiry, Rodrik claims on page 112, "Ultimately, model selection is not unlike external validation in lab or field experiments."

In conclusion, economists in the last century identified a barrier to economic adjustment that prevents wages from falling when unemployment rates rise. However, the exceptions to DNWR are not well understood and cannot be predicted by models, microfounded or not, that use DNWR as an assumption. Experiments can be useful in disentangling the effects of pure nominal loss aversion and interpersonal comparison on the reference point used by workers. Keynes himself advocated relative status in a community as the reason that nominal wage cuts are more offensive than when everyone's real wage falls due to inflation. Surveys show that managers assume productivity will fall when nominal wages are cut, but only an experiment can tell if managers or workers are primarily responsible for creating aggregate unemployment after a recession. An only an experiment can measure individual output so as to tell us if the managers are correct in predicting that workers will retaliate.

CHAPTER TWO: THE BEHAVIORAL DETERMINANTS OF NOMINAL WAGE RIGIDITY

High unemployment is one of the most harmful symptoms of a recession. In theory, a fall in demand need not reduce the number of working people if wages adjusted with a commensurate salary cut. Economic research has showed that nominal wages usually do not fall during a recession, even if the unemployment rate rises quickly. Sometimes wages do not move down despite unemployed individuals who want to work below the prevailing wage. Data from national wage surveys and individual interviews has been used by researchers to establish the extent and cause of wage rigidity. The objective of this research is to use an experiment to answer questions that cannot be answered with existing data on sticky wages. We expect to contribute to the understanding of the behavioral shirking explanation for wage rigidity proposed by Akerlof (1984). This mechanism is described in theoretical models of loss averse employees by Ahrens et al. (2014) and Benjamin (2016).

Wages and employee compensation comprise more than 40% of U.S. GDP; thus the welfare loss from a small inefficiency in the labor market is substantial. Economists since Keynes (1936) speculate that, in many circumstances, the price of labor in the U.S. does not adjust downward during a recession. This is one reason why Janet Yellen said in 2005 that inflation can be used to "grease the wheels of the labor market" and why the

Federal Reserve, and the European Central Bank, pursued an easy money policy after the Great Recession.

Two important ideas have emerged from economists debating this policy. First, managers are concerned about employee morale (Akerlof 1984; Akerloff and Yellen 1990). A wage cut is believed to lower morale and therefore productivity. Thus, a small wage cut may reduce productivity so much that the company will lose more from lower output than it will gain by reducing the cost of labor. Layoffs are believed to not reduce morale which makes them preferred to wage cuts. This practice contributes to high aggregate unemployment during recessions. Second, many workers do not pay sufficient attention to the inflation rate to notice small real wage cuts. This can explain the Phillips (1958) Curve, the negative relationship between inflation and unemployment.

There is evidence from large datasets that nominal wage cuts are rare, even during recessions. Dickens et al. (2007) show that many developed economies exhibit this pattern. They find that wages in the U.S. are sticky around nominal reference points while wages in the U.K. appear sticky around the expected real wage. Very little is understood about the differences in wage rigidity between countries. Ireland, for example, had more wage cuts after the Eurozone financial crisis than Spain. Daly and Hobijn (2014) demonstrate that nominal wage freezes are common in the U.S. and that there was an increase in the frequency of wage freezes in the U.S. after the Great Recession. The lack of wage cuts indicates nominal wage rigidity.

While there is some evidence that inflation can lower unemployment in the short run (Schmitt-Grohe and Uribe forthcoming), this policy instrument does not work in a

predictable way or in every circumstance. There is a large body of literature on wage rigidity, yet very little is understood about the individual relationships between employers and workers that ultimately cause aggregate rigidity. Economics theorists often simply make wage rigidity an assumption. Empirical work has established convincing evidence that wage rigidity exists, but aggregate wage data or even firm-level records of wage contracts cannot reveal workers' attitudes and individual productivity.

Without an experiment, it is nearly impossible to collect the necessary data: an accurate and incentivized measurement of what managers believe about worker morale and how, in fact, the individual workers' productivity is affected by a wage cut. Fehr and Goette (2005), who find evidence for wage rigidity in a large national dataset, say, "The ideal data set for examining nominal rigidity would be a representative sample of firms' personnel files including precise information on wages, individuals' productivity, and other individual characteristics." These pieces of information can be gathered in a controlled experiment.

In the language of behavioral economists Kőszegi and Rabin (2006), workers are loss averse around a nominal reference wage. Several studies have explored how reference points form and how they affect labor supply decisions. Abeler et al. (2011) observe that workers in a laboratory adjust their effort level to target an expected wage. Similarly, taxi drivers work less hours on a day when their wage per ride is higher, seemingly in an attempt to target an expected daily income that equals their reference daily income (Camerer et al. 1997). There is a growing body of evidence that people

avoid taking a loss relative to a reference point, which could help explain the disappointment experienced when workers are told that their nominal wage will fall.

Ahrens, Pirschel, and Snower (2016) and Benjamin (2016) develop theoretical models of wage rigidity that rely on worker loss aversion. If the worker is loss averse, then the profit-maximizing firm faces a kinked labor supply function from workers. In a sufficiently small recession, it is more profitable to keep wages constant than to save on labor costs at the expense of causing resentment among workers. Benjamin develops a theory specifically for the gift exchange game often used in the laboratory to study labor decisions.

Controlled experiments have contributed to our understanding of how fairness and reciprocity affect human behavior in many contexts. Our objective is to contribute specific knowledge about how these universal human preferences affect wage negotiation, especially during a recession when high unemployment is usually the outcome.

The gift exchange game has a simple subgame perfect equilibrium. The worker will choose the lowest effort level and using backward induction, the firm will set the lowest wage. In many independent replications of (Fehr, Kirchsteiger, and Riedl 1993), workers and firms have achieved some level of cooperation. To model this behavior as an exhibition of preferences, we assume that workers have some value for reciprocating above-minimum effort in exchange for above-minimum wage offers. Many such models of preference have framed the second-mover's preferences as preferences over final distributions often including inequality aversion. We follow (Cox, Friedman, and

Gjerstad 2007) who formalize the rather simple rule of thumb that many subjects desire to return a kind action for a kind action. If we instead explicated a model over final distribution, we would get a similar result. See (Benjamin 2015) for a model of cooperation in the gift exchange game motivated by distributional preferences.

Absent some type of loss aversion (and assuming away all menu costs), most models would predict that wages would fall in a recession. First we present a general utility model for the worker. Using the model, second, we determine the profit-maximizing strategy for a firm managing this representative worker who cannot be fired or managed through a piece-rate incentive scheme.

$$\max_{e \geq 0} u(e) = w - c(e) + g(e; w)$$

In a simple utility model, we assume that the benefit of real wage, w, less the cost of effort, e, would be supplemented by a preference for reciprocating high effort for a generous wage. As is typical in the literature, we assume that $c' > 0$ and $c'' > 0$. Note the optimal solution, $\hat{e}(w)$, to this problem does not depend on the wage history of the worker.

If a firm is setting a wage in the gift exchange environment, they maximize the following profit function:

$$\max_{R \geq rw \geq 0} \pi_{Firm} = (R - rw) * \hat{e}(w)$$

The optimal wage, w^* given by backward induction is increasing in the exogenous profit parameter, R.

$$w^* = R - \frac{\hat{e}(w^*)}{\hat{e}'(w^*)}$$

Thus, if R falls in a recession, the profit-maximizing wage will be cut, absent any other concerns by management.

The optimal strategy for a firm might change if workers have nominal wage loss aversion. We can insert that consideration into the worker's utility function the following way:

$$u(e) = w - c(e, I_{n_1<n_0}\lambda) + g(e; w)$$

Some parameter λ captures the degree to which workers feel an increased cost when their nominal wage in the current period, n_1, is less than their previous nominal wage, n_0. An indicator function, $I_{n_1<n_0}$, only activates λ in the event of a wage cut.

If the cost of effort in the face of a wage cut is sufficiently high, then a firm might not profit by cutting wages in a recession. If a manager believes that a wage cut will significantly reduce morale, as several studies have indicated, then they would tend to keep wages rigid during a recession.

Outside of this simple model, managers in firms have many other margins on which they can adjust such as hiring and hours assigned to current staff. Thus, unemployment or underemployment are likely consequences for behavioral and/or belief-based wage rigidity.

CHAPTER THREE: AN EXPERIMENT ON PROTECTING INTELLECTUAL PROPERTY

Intellectual property (IP) laws restrict the use of non-excludable ideas. Without IP protection, in theory, as soon as a creator brings a new product to the market a competitor would start copying and selling the good at marginal cost. The reason given for IP protection is that if markets do not reward creators for their costly effort then there is no incentive to innovate. The argument *against* IP protection is that a creator can charge monopoly prices and restrict access to their products, thereby resulting in lost welfare (Stiglitz 2008). Also, IP laws may raise the cost of further innovations because many new ideas must build upon old ones. The access versus incentive debate weighs the loss from restricted consumption and reduced incremental innovations against the gains from providing incentives for people to create more valuable knowledge goods (Landes and Posner 2003).

In engaging this debate, Benkler (2006) claims that much of the valuable information we have is created voluntarily without any proprietary claims or marketing intentions. The open-source software movement is an example of people who willingly contribute content for no immediate payment and without asking for restrictive copyrights. Boldrin and Levine (2002; 2008) also argue that competitive markets are sufficient to provide us with knowledge goods and that IP laws are harmful. Mokyr (2009) examines the role of patent protection in motivating innovation during the

Industrial Revolution in Britain and concludes that it was not of central importance to inventors. By contrast, Moser (2005) studies innovations in the 19th century and concludes that having a legal monopoly on one's invention *is* an important incentive. She finds that when Switzerland and Holland did not have patent laws they experienced less innovation in industries where trade secrets could not help an inventor protect his IP, such as machinery, which others can imitate easily. The IP question is usually stated as a static cost-benefit analysis. However, the benefit of IP protection is in the future while the cost of IP protection is backward-looking. The cost is the lost welfare that could have been realized on products already created and sold under monopoly conditions. This is problematic for research because IP advocates and critics are, in an important sense, talking past each other. A replicable laboratory experiment is an apt tool for investigating this dynamic puzzle because neither future discoveries nor alternative histories can be measured in the naturally occurring economy.

We aim with this paper, in the form of an experimental design and a new set of facts, to bring something concrete and common to those discussing this important economic, legal, and policy question. In a laboratory experiment with random assignment of participants to treatment conditions, proponents of IP laws can continue to look forward in expectation that IP protection will provide their alleged benefits, but they must concurrently look backward on the results to observe how the counterhypothesis fares. Similarly, opponents of IP protection can continue to look backward to the consequences of monopoly pricing, but they must simultaneously look forward to what happens when there is no IP protection. Our experiment replicates several important

facts relevant to both advocates and critics of IP protection. Critics will find that prices are indeed higher when IP is protected, that creators reap substantial profits with their protected monopoly positions, and that IP protection is not necessary to induce people to create non-rivalrous knowledge goods. Advocates will observe rampant piracy, a common term for intellectual property theft, when there is no IP protection and that the protected IP treatment is ultimately the most encouraging for creating non-rivalrous knowledge goods. But "ultimately" is the operative word, for none of these observations tie together the complete story of the *process* by which knowledge goods and its associated wealth are created in our experiment. Our experiment reveals an unseen linchpin of IP that can be neither taken for granted, nor assumed away. We find that an entrepreneurial disposition is at least as important as the legal institution for creating wealth through innovation. Our results indicate that IP protection encourages entrepreneurship.

Each session consists of 18 periods, called "days", during which 10 subjects earn cash by producing, trading, and consuming two types of goods: gray and color. Gray goods are rivalrous and color goods non-rivalrous. Each participant is identified by a letter *A* through *J* and endowed with a house which displays his or her letter. Participants can produce goods during the first 155 seconds of the day.

One of the central assumptions underlying the protection of intellectual property is that it incentivizes people to forego other productive pursuits, say of rivalrous non-knowledge goods, in favor of creating non-rivalrous knowledge goods. Thus, as an active and explicit opportunity cost for producing non-rivalrous color goods, the gray

goods are an important feature of our design. Half of the subjects are endowed with the ability to produce light gray goods and the other half dark gray goods. To produce a single light or dark gray unit, a subject simply clicks on the window of his or her house which appears lit (in yellow). Gray production takes 4 seconds during which time a loading bar fills up on their house. The loading bar is visible to all participants on this home screen. Light and dark gray goods are perfect complements: a subject earns 9 US cents for each pair of light and dark gray goods that he or she possesses at the end of the day. Trade is a necessary feature of the gray economy so that the decision to sell colors is not the only activity in the experiment that involves market transactions. In the next subsection we discuss the institutional trading rules for trading light and dark gray goods.

The production and trading of gray goods is the subjects' default way to earn money in the experiment. It is against this opportunity that subjects must weigh the (Knightian) uncertain choice of producing a non-rivalrous color good that they may be able to consume and sell for profit. To produce a color good, a subject clicks the "Enter Studio" button on the home screen. The subject then leaves the home screen and is presented with a color creation palate. (The lone lit window on their house darkens while a subject is in the studio.) The subject's task in the studio is to create one of 125 different colors by combining 5 different levels of red, green, and blue.

Figure 13 displays the studio interface. Subjects can see the color they are creating in the preview bar. Once the subject clicks the "Produce Color Good" button inside the studio, it takes 8 seconds (twice as long as a gray) to produce the item. The

green progress bar fills over 8 seconds as the good is made. The subject is then returned to home and the color appears in their inventory. They must click the "Convert" button to learn the value of the color. To produce another color the subject must return to the studio and repeat the process.

The 125 colors can be thought of as arranged in a 5x5x5 cube, each with a red, green, and blue light component, which we will represent with the 3-tuple (r, g, b). For example, (1, 2, 5) appears as gold. The value of a given color is a function of the simple vector distance d between a color (r, g, b) and the favorite color of the day (r^*, g^*, b^*), i.e., $d = \sqrt{(r - r^*)^2 + (g - g^*)^2 + (b - b^*)^2}$. Because there are fewer colors that surround a color on an edge of the cube, we use a different function depending upon whether the favorite color of the day is on an edge or in the center of the cube. Table 6 displays the mapping of the distance to values.

The existing stock of knowledge is a commons that cannot be overfished but is always becoming outdated because the next generation has new tastes and new problems to solve. Thus, we inform the subjects that each day there is a new "favorite" color that is worth 40 cents to everyone. They are also informed that colors which are "close" to the favorite are worth less than 40 cents and that colors which are "far" away are worth nothing. Their creative challenge is to discover how to find valuable colors among the 125 options in the studio, which, in turn involves discovering the value function and a search strategy for zeroing in on the favorite color once a 5-, 9-, or 12-cent color is discovered.

Figure 13 Studio Interface

Table 6 Color Values as a Function of Distance from Favorite

d	**Center Favorite**	**Edge Favorite**
0	40	40
1	30	30
$\sqrt{2}$	9	12
$\sqrt{3}$	5	9
2	0	5
> 2	0	0

Table 7 Usage Fees for Consuming Color Goods

Number of Color Goods	Usage fee	Number of Color Goods	Usage fee
1	0	15	5
2	1	16	6
3	1	17	6
4	1	18	6
5	2	19	7
6	2	20	7
7	2	21	7
8	3	22	8
9	3	23	8
10	4	24	8
11	4	25	9
12	4	26	9
13	5	27	9
14	5	28	10

As subjects consume more color goods (they can only consume one unit of each color), they are charged a small, non-decreasing "usage fee" (decreasing marginal utility). The usage fee is small enough such that the favorite color and the six colors (five, in the case of an edge) 1 unit away from it are always profitable to consume, provided the price that the subject pays is sufficiently low. This feature introduces the potential for deadweight losses from monopoly pricing of a color good. It also makes the creation of additional color goods (slightly) more costly, particularly if its value turns out to be zero. Table 7 displays the usage fee function.

To reinforce the different nature of the rivalrous gray goods and non-rivalrous color goods, we inform the subjects that "[i]f you send a **gray** good to another person, you give up the item" and "[u]nlike gray goods, if you send a color item to other people it is not removed from your holdings."

Subjects can exchange gray goods via a public bulletin board on which they can post goods for any price from 0 to 9 cents. Posters have the option of posting their offer anonymously or not and can edit their offer at any time. By clicking on the "Accept" button, the software automatically completes the exchange of x cents for a light or dark gray good. Alternatively, subjects can asynchronously use the "Send Items" button to send a gray good to any person, and another person can use the "Transfer Cents" button to send money directly to another person. This feature is useful for pairs of subjects who would like to directly exchange dark and light gray units with each other, with or without the exchange of money. It is worth noting that the subjects must rely on reputation via

repeated interactions to enforce any contracts agreed to in the chat room that involve using the "Transfer Cents" and "Send Items" buttons.

Figure 14 Timeline of a Day

Similarly, subjects can post color goods in a separate bulletin board, again either anonymously or by their letter name. The value of color goods is included in the table to eliminate potential problems of asymmetric information. More details on the rules of the color good bulletin board will be discussed in the treatment subsection below.

A public chat area is open at all times on the right side of the screen, and under the chat box is a record of actions such as transfers that are relevant to the subject (see Figure 15 for a complete view of the screen). The summary section on the left side of the screen maintains a real time accounting of their inventories and earnings. At the beginning of each day, we give each subject a loan of 250 cents to use for trade, which is automatically subtracted from their earnings at the end of the day.

As mentioned above, subjects can produce goods only during the first 155 seconds of the day. The remaining 75 seconds of the day can only be used for trade and chat. The chat room and bulletin boards are open continuously for all 230 seconds of the day. Figure 14 summarizes the structure of an experimental "day".

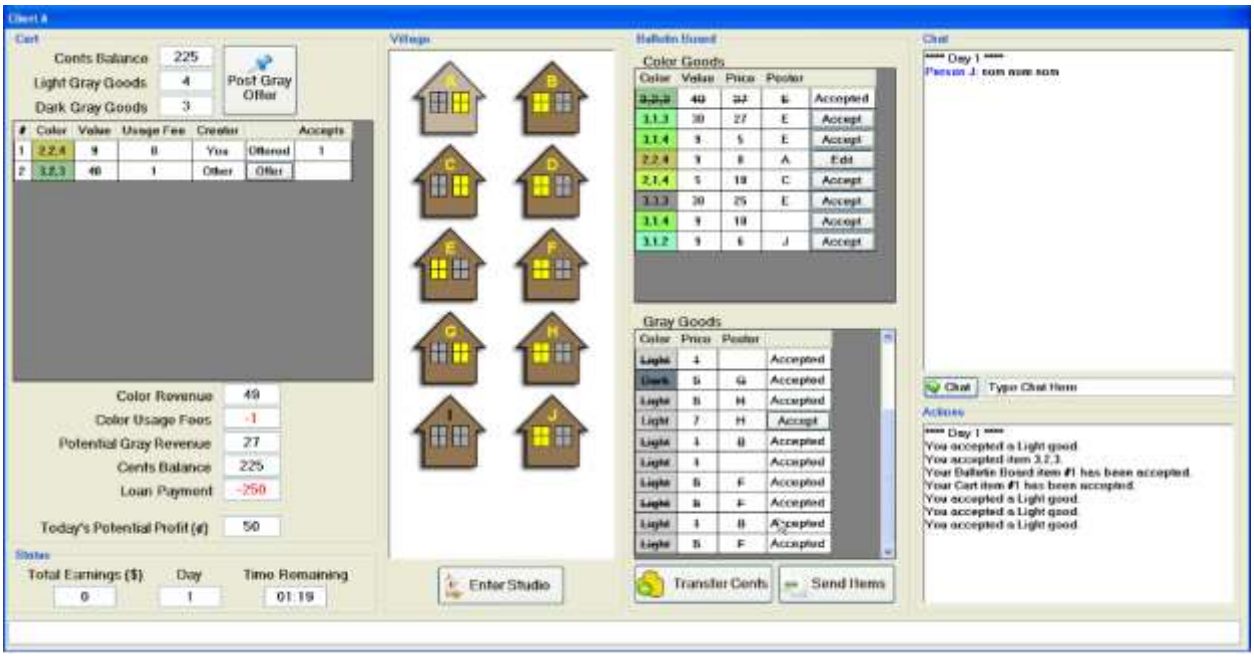

Figure 15 Full Screenshot of Subject Interface

A. Treatments

One of the benefits of a laboratory experiment is that we, the experimenters, can perfectly enforce intellectual property rights by setting the permissible actions of the participants through the software interface. Moreover, we can ask the counterfactual question of what happens when we remove the software enforcement *without any change in the instructions* to the participants that might nudge their decisions or alert them that the circumstances could be different.

In what we will call the *IP* treatment, once a subject creates a color in the studio, no other person can go into the studio and create it. Only the creator can sell or transfer a color good to another person. If a subject sells a color good to another person, the buyer cannot post it on the bulletin board, nor transfer it via the "Send Items" button. The

option to do so is simply not presented to subjects in this treatment. Because items cannot be produced in the last 75 seconds of the day, a creator can wait until the last portion of the day to post which colors are valuable so as to search out for him- or herself as many valuable colors as possible without divulging the general location of the "favorite".

In the *No IP* treatment, any person can go to the studio during the production time and create a color that another has already created. Any person who purchases a color can also repost it on the bulletin board and sell it to others for any price. Subjects can use the "Send Items" button to secretly transfer colors to other people, bypassing creators in a way that file-sharing networks do online. The "Transfer Cents" button, available in both treatments, gives people the option of compensating color good creators through other means if creators are not making a profit from selling them on the bulletin board.

Because subjects trade the rivalrous gray goods via a multilateral bulletin board and/or the bilateral "Send Items" and "Transfer Cents" buttons, there is nothing different about how people can trade color goods. (That is why we incentivize trade in the gray economy via Leontief preferences.) Thus, if subjects do not engage in IP production and trade, we can rule out the explanation that they did not know how. The institutional format is the same; the question is what type of system and behaviors emerge for the non-rivalrous color goods when intellectual property is perfectly enforced and when it is not.

B. Procedures

We initially conducted six sessions in each treatment, for which we recruited a total of 120 undergraduates at Chapman University. No subject participated twice, and many had participated in other economic experiments. Subjects were seated at visually-isolated computer terminals, read self-paced instructions, and were free to ask questions at any time. Each of the first 12 sessions consisted of 10 participants, 5 men and 5 women, contained 18 days of 230 seconds each, and lasted no longer than 90 minutes (approximately 10 minutes for instructions, 69 minutes for the session proper, and approximately 10 minutes for private payment). Each subject was paid $7 for showing up on time, plus what their decisions earned them in the session. Not including the show-up payment, mean earnings for all 207 subjects was $15.42, with a standard deviation of $9.24.

If a subject uses every second of the production phase, he or she can produce 38 light or dark gray units (38 x 4 seconds = 152 seconds). Assuming that a different subject spends the same amount of time producing the complementary gray good, a dark-light gray pair of traders can exchange 19 units to individually earn $1.71 (=19 x $0.09) per day, or $30.78 over 18 days. To do this, a subject must forego any communication in the chat room and postpone all trading until the last 75 seconds of the day. If all ten subjects only produce gray, total earnings per day for the group would be $17.10.

In contrast, the value from consuming all of the color goods with a value greater than 5 cents in a day generates earnings of $2.61 ($2.62) per day for a center (edge) favorite color, net of usage fees. Half of the 18 favorite colors are in the center and half

on an edge, and so over 18 days there are potential earnings of $47.07/participant from consuming all the color goods (with a value greater than 5 cents). If all ten subjects spent the entire time producing colors, discovered all goods with a value greater than 5, and sold every one of these colors to every other participant, total earnings per day would be $26.15 (on average). However, if a proper subset of the 10 subjects is sufficient to discover and sell the valuable colors goods to everyone else, then pairs of light and dark gray participants can consume color goods *and* produce and consume gray goods. The result would be total earnings greater than $26.15 per day for all 10 subjects, specifically, $26.15 + $3.42*p*, where *p* is the number of pairs producing and consuming light and dark grays in addition to the color goods. The point is that a group that engages in color production has the potential to earn twice as much as a group that only makes and trades gray goods.

Our hypotheses follow from the intuitive proposition that perfect and costless protection of non-rivalrous property incentivizes individuals to spend more time producing intellectual property by granting creators the exclusive right to sell it for financial gain. This is the assumed benefit of IP. Because intellectual property is non-rivalrous *ex hypothesis*, producing a greater volume of IP can benefit everyone, which in this experiment translates into higher earnings. Here are our primary hypotheses regarding our two treatments:

Hypothesis 1: Participants in the *IP* treatment spend more time creating color goods than participants do in the *No IP* treatment.

Hypothesis 2: The *IP* treatment generates more value from color goods than the *No IP* treatment.

Hypothesis 3: Total earnings are higher in the *IP* treatment than in the *No IP* treatment.

Hypothesis 4: The price of color goods (as a percent of value) is higher in the *IP* treatment than in the *No IP* treatment.

Hypothesis 5: Sales revenue to color creators is higher in the *IP* treatment than in the *No IP* treatment.

Before we present results, we acknowledge that our design is more complex than many economic experiments. Our specific research question calls for offering subjects a complex continuum of choices and interactions. Innovators in society are faced with an array of options. For example, someone can try to create a new product and then give up if the first design is not well-received. Our open-ended design allows us to learn what we consider to be the major contribution of our paper: the *process* by which knowledge goods and wealth are created.

While we recognize the benefits of simple designs and formal theoretical frameworks for studying choice behavior in the laboratory, we submit that binary choice designs do not teach experimenters about the process by which individuals make their decision. Thus, the findings from simple experiments complement the results of more complex environments and vice versa. A methodological insight from our experience is that open-ended designs allow experimentalists to study emergent institutions (see, e.g.,

Wilson et al. 2012). Knowing what people choose is important, but it is especially crucial to learn how those choices, and not others, come to be available in a society.

We present the results of our experiment as a series of 5 findings corresponding to our five hypotheses above. The data that we report is exclusively drawn from the second half of the experiment (the last 9 of 18 days) to mitigate the effects of different groups converging to their particular sets of behaviors and outcomes as they explore the confines of the environment and institution in this experiment. Unless otherwise noted, the conclusions of the treatment effects do not change for the data set comprised of observations from the first nine days, though the statistics themselves surely do. For example, every session earned more money in the second half of the experiment than the first. We begin by assessing the hypothesis on the amount of time spent discovering color goods in the studio.

Finding 1: *Sessions in the* IP *treatment do <u>not</u> spend more time in the studio than sessions in the* No IP *treatment.*

Evidence: Figure 6 reports total number of seconds spent in the studio by session. The average *IP* session spends 1,953 seconds in the studio, which is *less* than the average of 2,118 seconds for *No IP* sessions (see dashed lines in Figure 16). Using a Wilcoxon rank sum test, we fail to reject the null hypothesis of equal amounts of time ($U_{6,6} = 22$, p-value = 0.71, one-sided test).

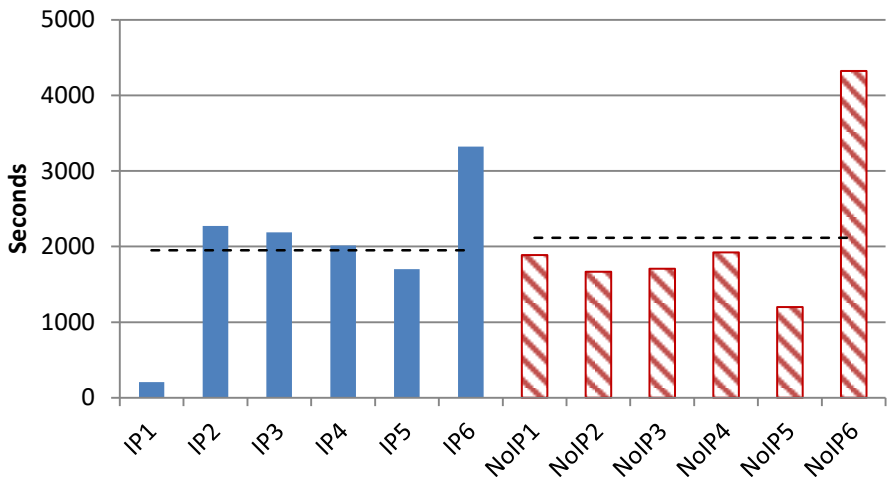

Figure 16 Time in Studio

We do not observe more time spent in the studio in the *IP* treatment than in the *No IP* treatment. The session with the most time in the studio of all the sessions is in the *No IP* treatment, *No IP6*, and the session with the least amount of time in the studio is in the *IP* treatment, *IP1*. Although we present the subjects in the *IP* treatment with an opportunity to profit from sole ownership over the color goods they create, we cannot force those in *IP1* to take advantage of it by entering the studio to create them. This demonstrates that IP protection is not sufficient to induce creative activity; an entrepreneurial mindset is necessary. Nor is IP protection necessary, as *No IP6* demonstrates. These are important points, which we will return to at the end of this section.

Spending time in the studio may be directly correlated with the total value of the color goods created in the studio, but it need not be the case. How people spend their time

in the studio and the quality of the search processes can differ by the incentives of *IP* and *No IP* treatments. For example, most of the people in a *No IP* session could each spend a little amount of time in the studio with the hope of personally consuming a valuable discovery, but given the lack of incentive to profit from a single discovery or two, the subjects spend most of the production time making grays. Conversely, a select few participants in an *IP* session could spend most if not all of their time in the studio searching for colors with the incentive to profit from selling their discoveries. Hence, while subjects in a *No IP* session may collectively spend as much total time in the studio as subjects in an *IP* session, the subjects in the two treatments discover different amounts of total value depending upon the amount and quality of time spent in the studio.

> ***Finding 2:*** IP *sessions on average do <u>not</u> produce more value in the color studio than* No IP *sessions.*
>
> *Evidence*: Figure 17 reports the total value of color goods discovered by session. The average total value discovered is $11.12 in *IP* sessions ($13.20 excluding *IP1* which does not search for colors) and $9.36 in *No IP* sessions. Using a Wilcoxon rank sum test, we fail to reject the null hypothesis of equal value generated across treatments, including and excluding *IP1* (respectively, $U_{6,6} = 21$, p-value = 0.35, one-sided test and $U_{6,5} = 21$, p-value = 0.16, one-sided test).

We do not observe more color value created in the *IP* treatment than in the *No IP* treatment. The second and third highest amounts of color value created are in the *No IP* treatment (*No IP1* and *No IP6*). The additional success of *No IP1* in creating color value makes it difficult to conclude that the success of the *No IP* treatment relative to the *IP*

treatment is a fluke. Lastly, it is notable that even though *IP6* spends (exactly) 1,000 *fewer* seconds in the studio than *No IP6*, its participants discover *more* total value of color goods. We will discuss these observations more fully later in the section.

***Finding 3*:** IP *sessions on average do not earn more money than* No IP *sessions.*

Evidence: Figure 8 reports the total earnings by session broken down by gray and color consumption. *IP* and *No IP* sessions earn on average $120.50 and $111.14, respectively, over the last 9 days of the experiment. Using a Wilcoxon rank sum test, we fail to reject the null hypothesis of equal earnings ($U_{6,6}$ = 24, *p*-value = 0.39, one-sided test).

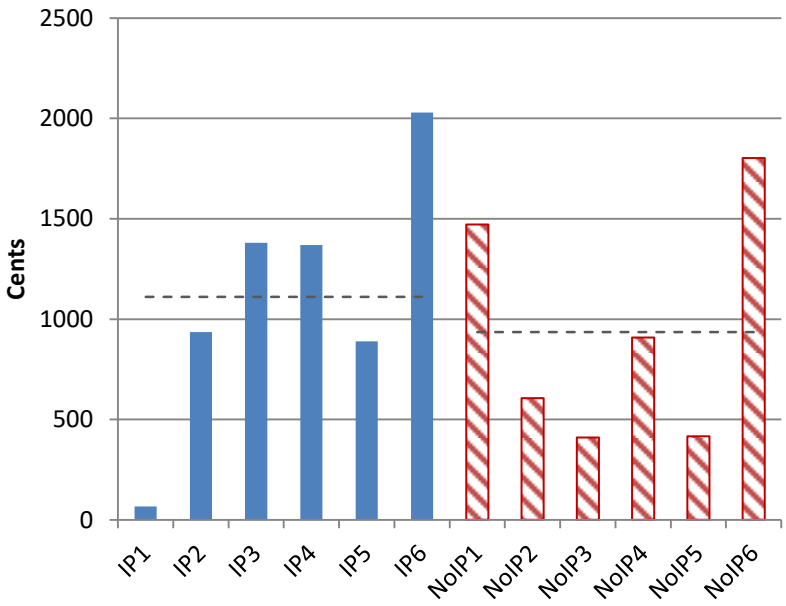

Figure 17 Total Color Value Discovered

Given Finding 2 on the amount of color value discovered by treatment, Finding 3 is not surprising. But notice that there are sessions with tall (short) bars in Figure 17 and corresponding short (tall) total bars in Figure 18. Not only do participants not spend more time in the studio in the *IP* treatment, but more time in the studio does not necessarily result in discovering more color value, which in turn does not always lead to higher group earnings.

One explanation for the lack of treatment effect on total earnings is that IP protection only has a meaningful effect when a color market exists. Our experiment reveals two auxiliary assumptions that are often taken for granted, namely, that with IP protection participants will seek to discover color goods and that once valuable color is discovered, the creator will sell the colors to others. Simply put, IP protection is not sufficient for generating high total earnings; our experiment reveals that something more is necessary: entrepreneurs who create a market where there currently is none. In *IP1* the participants largely ignore colors and in *IP3*, the lowest-earning *IP* session, subject C singlehandedly discovers an impressive amount of color value, but he offers none of it for sale.

Perfect IP protection is also not necessary for generating high total earnings because as the highest-earning *NoIP* session, *No IP1*, shows, participants may respect the IP of an entrepreneur without any exogenous enforcement. We will more fully discuss these and other observations on IP protection and the necessity of entrepreneurship following our next two findings on the prices and sales revenue of color goods.

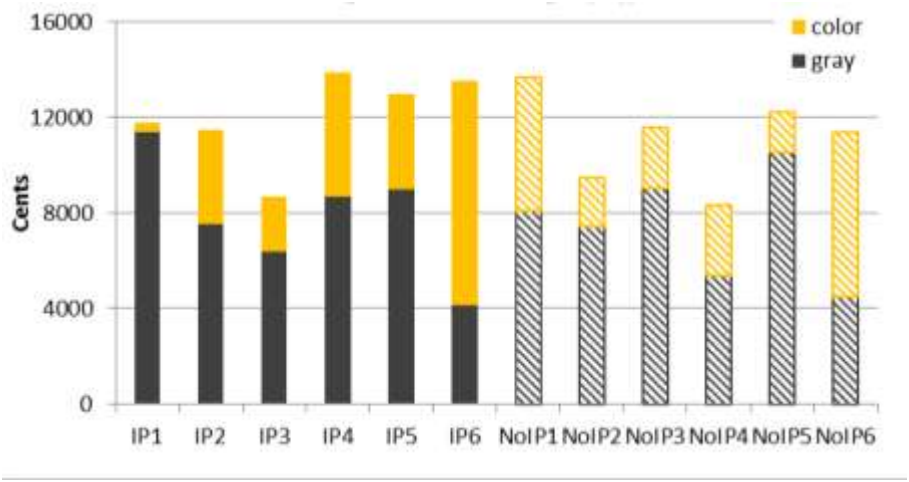

Figure 18 Total Earnings by Type of Good

Finding 4: *Transactions prices are higher in the* IP *treatment for the highest value colors worth 12, 30, and 40¢.*

Evidence: We analyze the 1,719 color transactions in the second half of the experiment using a linear mixed effects model for repeated measures. Table 8 reports the results of the model with the transaction prices as a ratio of the price paid to the value of the color good as the dependent variable. The treatment effect, *IP*, and the value of the color good (*Value5, Value9, Value12*, *Value40*) are modeled as (zero-one) fixed effects. We also include a fixed effect, *Pirate*, for whether a sale in *No IP* treatment is made by someone who is not the original creator of the color, plus all two-term interactions between *IP* and *Pirate* with the different values of the good. The 12 independent sessions are modeled as random effects, e_i. Specifically, we estimate the model

$$Price_{ij} = \mu + e_i + \beta_{IP} IP_i + \beta_5 Value5_j + \beta_9 Value9_j + \beta_{12} Value12_j + \beta_{40} Value40_j + \beta_{Pir} Pirate_j + \beta_{IP5} IP_i \times Value5_j + \beta_{IP9} IP_i \times Value9_j + \beta_{IP12} IP_i \times Value12_j + \beta_{IP40} IP_i \times Value40_j + \beta_{Pir5} Pirate_j \times Value5_j + \beta_{Pir9} Pirate_j \times Value9_j + \beta_{Pir12} Pirate_j \times Value12_j + \beta_{Pir40} Pirate_j \times Value40_j + \varepsilon_{ij}$$

where $Price_{ij}$ is the ratio of the price paid to the value of the good sold in day *j* of session *i*, with $e_i \sim N(0, \sigma_1^2)$ and $\varepsilon_{ij} \sim N(0, \sigma_{2,i}^2)$. We accommodate heteroskedastic errors by session when estimating the model via maximum likelihood. As the benchmark, μ measures the price of a 30¢ good sold by the original creator of the color in the *No IP* treatment. We hypothesize that $\beta_{IP} > 0$ and $\beta_{Pir} < 0$, i.e., *IP* monopolists charge higher prices than sellers without such protection and that pirates in the *No IP* treatment sell for prices lower than the original creators of the good. All other tests are two-sided.

IP protection significantly raises the price of 30¢ and 40¢ colors by 18 percentage points and 12¢ by 12.5 [=100 × (.177 – .052)] percentage points (*p*-value = 0.0119). Surprisingly, the two lowest possible values of colors are cheaper in the *IP* treatment than in the *No IP* treatment. Consistent with conventional expectations, pirates in the *No IP* treatment sell for prices significantly lower than original creators of color goods (6 percentage points, *p*-value = 0.0158).

Table 8 Estimates of Linear Mixed-Effects Model for Transaction Prices

	Estimate	Std. Error	Degrees of Freedom	*p*-value
$\boldsymbol{\mu}$	0.483	0.048	1694	<0.0001
$\boldsymbol{IP}$	0.177	0.067	10	0.0119†
$\boldsymbol{Value5}$	0.017	0.036	1694	0.6419
$\boldsymbol{Value9}$	0.076	0.020	1694	0.0002
$\boldsymbol{Value12}$	-0.043	0.019	1694	0.0280
$\boldsymbol{Value40}$	0.064	0.018	1694	0.0004
$\boldsymbol{Pirate}$	-0.059	0.027	1694	0.0158†
$\boldsymbol{IP \times Value5}$	-0.390	0.038	1694	<0.0001
$\boldsymbol{IP \times Value9}$	-0.270	0.022	1694	<0.0001
$\boldsymbol{IP \times Value12}$	-0.052	0.021	1694	0.0153
$\boldsymbol{IP \times Value40}$	-0.009	0.020	1694	0.6546
$\boldsymbol{Pirate \times Value5}$	-0.054	0.065	1694	0.4005
$\boldsymbol{Pirate \times Value9}$	-0.049	0.045	1694	0.2675
$\boldsymbol{Pirate \times Value12}$	-0.036	0.073	1694	0.6201
$\boldsymbol{Pirate \times Value40}$	0.012	0.058	1694	0.8289
			1719 obs.	

†One-sided test.

Finding 5*: *Conditional on an active market for colors, sales revenue to creators of color goods is higher in the* IP *treatment than in the* No IP *treatment.

Evidence: Figure 19 plots sales revenue of color goods by session. Excluding the antipreneurs of *IP1* and *IP3*, the average sales revenue from color goods in the *IP* treatment is a whopping $35.64 when compared to the average sales revenue of $10.49 in the *No IP* treatment.

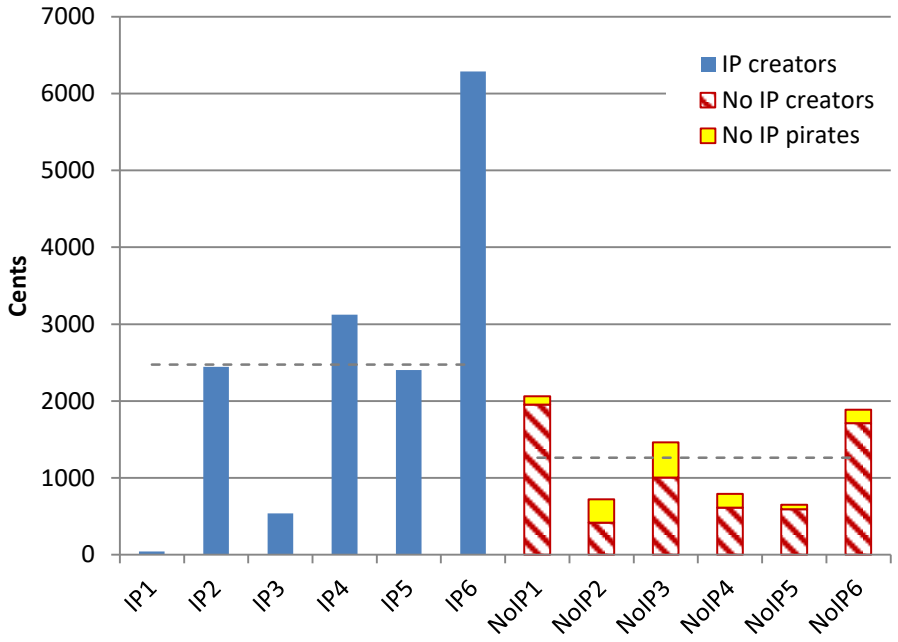

Figure 19 Sales Revenue of Color Goods

By virtue of their monopoly rights, color creators in *IP2*, *IP4*, *IP5*, and *IP6* turn the higher prices in Finding 5 into higher sales revenues in Finding 6. Sales revenues in the *IP* treatment dwarf those in the *No IP* treatment, even when including the revenue to pirates. These two findings importantly show that in the *IP* treatment there is considerable value to discovering color goods in the studio and selling them to the other participants, but these treatment effects and session-level measurements mask how the 10-person economies generate these outcomes. In the following subsection we drill down to the subject level for an explanation that ties all five of these findings together.

As we mention above, entrepreneurship is the key to understanding the results of our experiment. The six highest earners in the experiment all spend considerable amount of time in the studio and successfully market the color goods they make. We will refer to the individuals as "entrepreneurs", all of whom earned at least $24.00 in the second half of the experiment.

Some individuals appear like entrepreneurs on only one dimension. NoIP6–I is the seventh highest earner but his earnings are mostly generated from producing and consuming grays; he is not an entrepreneur because he does not commit to the studio. IP3–C spends time in the studio and finds many color goods, but he sells none. NoIP6–C expresses the same antipreneurial attitude. We define innovation in this experiment as spending time in the Studio and producing valuable colors. Subject IP3-C is an "innovator," but his choice is an example of the evidence that led us to conclude that invention is only half of the necessary formula for creating wealth via innovation. NoIP6–E spends enough time in the studio to appear like an entrepreneur, but his sales revenue from color goods is only 447¢. NoIP6–E does not succeed because subjects in *No IP6* pirate his goods. NoIP1-C succeeds as an entrepreneur because subjects in No *IP1* pirate very little relative to the amount of color activity in that session.

We define piracy in our experiment as remaking a color that has been posted by a creator or reselling a color good created by another. The comparison between *No IP6* and *No IP1* is clear in Table 9 and Figure 21. Table 9 reports that pirates in *No IP6* remake 39 color goods that the original creator of the color had already posted to the bulletin board. Figure 21 plots the sum of the amounts by which pirates post prices *less*

than the original creator posts for the same good. This statistic captures the amount by which pirates undercut original creators of valuable color goods. *No IP6* again tops the sessions, and *No IP1* is near the bottom. As an entrepreneur, NoIP1–C spends 1,104 seconds in the studio discovering 1,292¢ of color value (79% of the total value for the session) and his fellow subjects respect his ownership of those colors paying him 1,683¢ for those goods. (His sales revenue is low relative to the *IP* entrepreneurs due to the low prices he charges for the colors.) NoIP6–E spends 948 seconds in the studio discovering 857¢ of color value, but can only sell that value for 447¢ to his fellow participants. His fellow *No IP6*ers would rather remake the good themselves than pay him for it, and they resell the good for less.

Table 9 Remakes of Color Goods

Session	Number
No IP1	1
No IP2	2
No IP3	1
No IP4	27
No IP5	3
No IP6	39

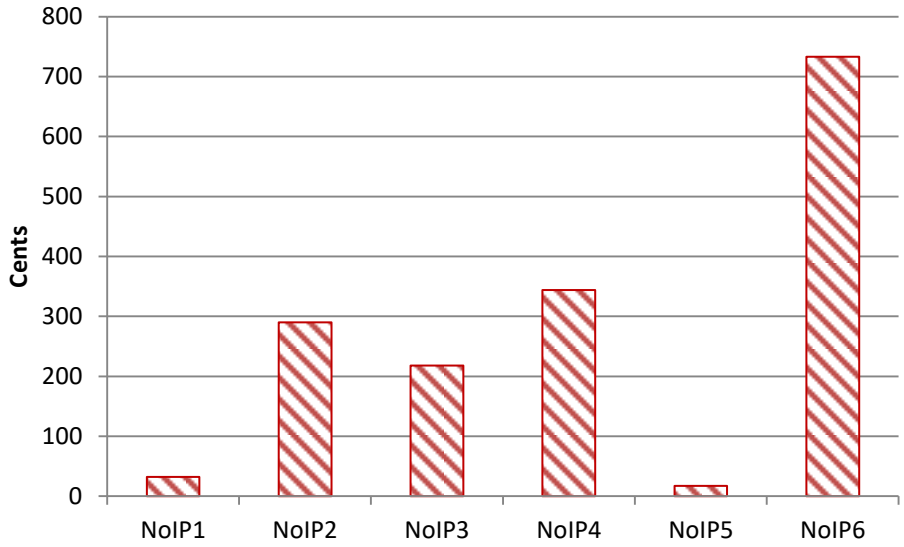

Figure 20 Sum of Price Undercutting by Pirates

The chat room discussion in *No IP3* illuminates a problem that might explain why this session did not see many gains from color goods. On day 11 Person *H* says, "someone should make a really red color and someone else shoul[d] make a really blue color […] for 0 price". *H* recognizes the value of *someone* making a trip to the studio, but, not surprisingly, no one responds to his suggestion. Other subjects in *No IP3* also recognize the potential value of colors and even offer suggestions in the chat for finding the good colors. Collectively they spend almost as much time in the studio as the most successful groups, but no individual commits to the search process nor do the group members provide incentive for *someone* to do so.

The upshot is that entrepreneurs are necessary for generating wealthy economies in our experiment, and while IP protection is neither necessary nor sufficient for generating wealth by discovering color goods, entrepreneurs only express themselves in

the *IP* treatment, or in the *No IP* session where most subjects behave as if they are in the *IP* treatment.

In the *No IP* treatment, non-creators can give non-rivalrous copies of color goods away via the same tools by which they could transfer rivalrous gray goods. That is, non-creators could privately and directly give away a color good to any other participant. How often did this occur? Never once. Without suggestion or discouragement, *No IP* pirates could also "file-share" by anonymously posting colors on the bulletin board for a zero price. This occurred only 6 times out of 704 transactions in the last half of the experiment (four in *No IP3* and two in *No IP4*), and not one of those transactions, we might add, was for a 30¢ or 40¢ good. It appears that our subjects in both treatments consider posting colors to be a for-profit activity.

By design, the instructions in both treatments are exactly the same. Subjects in our *No IP* treatment seem to take it as given that the "offer" button appeared next to every color in their inventory. Similarly, subjects in the *IP* treatment never once comment that they did not have the option of distributing colors they had not created. Though we observe activity in the *No IP* treatment that could be labeled as IP theft, never once in a *No IP* chat room is an action labeled as such. Out of 4,980 words, *No IP* creators never once complain about pirating; never once describe reposting or remaking a color good as "theft" or "stealing"; and no one ever suggests that they somehow compensate the people who invest time in producing color goods through a cents transfer or an intentional effort to buy the good from them. This stands in stark contrast to previous research in which undergraduates are rather vocal in calling out certain actions

as “stealing” and “theft” although they were never prompted to consider the goods as property. In computerized experiments with virtual goods, Kimbrough, Smith, and Wilson (2010) and Jaworski and Wilson (2013) report that these words are some of the first and most frequently posted sentiments in the chat room when people remove rivalrous blue and red chits from one another’s possession without consent. In that environment, the moral outrage indicates that subjects believe that rivalrous goods in their designated houses are theirs and to remove them is a violation of a property right. In designing our experiment we were curious whether we would observe the same moral outrage evoked by IP piracy, and we find that it is not, or it is at least never expressed as such. This is perhaps evidence that property rights for non-rivalrous IP goods are perceived quite differently than they are for rivalrous goods.

This experiment demonstrates that entrepreneurship plays a critical role in creating wealth when intellectual property protection is either exogenously enforced or endogenously and voluntarily respected. The precise generative mechanism by which entrepreneurship does this has not yet been specified here or, to our knowledge, elsewhere. What we observe (and what we and most honest readers did not foresee) is that IP protection interacts to express the indispensably important element of individual entrepreneurship—an “alertness to previously unnoticed changes in circumstances which may make it possible to get far more in exchange for whatever they have to offer than was previously possible” (Kirzner 1973, p. 16). The first contribution of this paper is to establish the importance of these facts of entrepreneurship with respect to intellectual

property protection, which future theories must address if intellectual property protection is to be used as an economic tool.

Our paper is not the first empirical project to fail at finding clear benefits of intellectual property protection. Bessen and Meurer (2008), Lerner (2009), and Mokyr (2009) all similarly conclude that patents have little impact on innovation from empirical data. Individual entrepreneurship plausibly played an important role in the economies they studied but perhaps their data was not sufficiently disaggregated to reveal it. The difference in this study is that we are able identify, person by person, each instance of an entrepreneur in a way that no field study on IP protection and innovation has. Our next step is to explore *within-subject* the effect of IP protection on the individuals we have identified as entrepreneurs. With more sessions, we can also ask whether our sighting of an antipreneur (those who make colors but don't sell them) was an improbable fluke. Our next and final section lays out such a treatment condition, our procedures, and the results from this second experiment.

The theoretical and empirical literature on entrepreneurship classifies unique individuals who create wealth the same way we do. Shane and Venkataraman (2000) define entrepreneurship as a process by which "opportunities to create future goods and services are discovered, evaluated, and exploited." Entrepreneurship combines inventing with business and marketing acumen. Shane, Locke, and Collins (2003) study entrepreneurial motivation with the assumption that people intrinsically vary in their inclination and ability to pursue entrepreneurial opportunities. Entrepreneurs are sometimes classified in the literature by their tolerance for ambiguity. Risk tolerance

may also be important, although entrepreneurs often do not have sufficient information to construct a precise useful probability distribution of outcomes, as is the case in our experiment. Using a survey, Palich and Bagby (1995) determine that entrepreneurs do not necessarily have a higher risk tolerance, but they are more likely to try new things because they are more optimistic. Cardon et al. (2009) outline a theoretical framework of "entrepreneurial passion" and review empirical studies on that topic. Combining our methodology with techniques for identifying entrepreneurs in the population would be a productive path for future research.

Shane, Locke, and Collins (2003) state the problem that previous empirical work cannot fully disentangle the intrinsic differences that inspire entrepreneurship from the differences in opportunity that individuals encounter. An advantage of a laboratory experiment is that it can control for the variation in opportunity. Every individual enters our economy with the same knowledge and equal opportunity to spend time in the studio and post to the color bulletin board, so their unique characteristics must account for their behavioral differences. The other source of variation is the different institutional environment that *IP* and *No IP* are randomly assigned to face study. We are unaware of any previous study that examines how the entrepreneurial drive interacts with the institutional framework of IP. What follows is a next step in the inquiry that will reveal more about how entrepreneurs in our experiments and the markets they serve behave under different IP institutions.

Our conclusion is that IP policy makers and researchers must specifically address entrepreneurs in their discussion of how IP laws encourage economic growth. Innovation

by inventors is not an engine of wealth creation unless that invention is introduced and embraced by the market. We observed that IP protection does not inspire entrepreneurship automatically where its latent tendency is not already present in a group of ten. Societies of millions do not lack entrepreneurial individuals; however those individuals are very sensitive to institutions and specifically to IP laws. We found that IP protection encourages entrepreneurs to emerge by allowing them to profit from their innovations in the market.

We do not claim that our design captures all the complexities of intellectual property protection. Future research could investigate other ways to reward people for their ideas through prizes or licensing and other ways to improve distribution and mitigate efficiency losses such as academic fair use. Our method would be useful for exploring the effect of IP polices beyond the binary treatments we implemented. As suggested by Gilbert and Shapiro (1990) and others, there might be an optimal degree of intellectual property protection between full and none that would reward entrepreneurs but also protect against some of the losses that result from monopoly power. Other types of costs, such as large sunk costs, would also be interesting avenues to pursue, as well as finding ways to prevent piracy in a *No IP* world. We have implemented an environment most favorable for intellectual property protection with costless, perfect enforcement. It is an open question as to whether or not relaxing this assumption would choke off entrepreneurship in the *IP* treatment. In future research our findings on entrepreneurs could also be generalized to include firms that engage entrepreneurial individuals.

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BIOGRAPHY

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