Preferences for Fair Prices, Cursed Inferences, and the Nonneutrality of Money

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ABSTRACT

This paper explains the nonneutrality of money from two assumptions: (1) consumers dislike paying prices that exceed some fair markup on firms' marginal costs; and (2) consumers underinfer marginal costs from available information. After an increase in money supply, consumers underappreciate the increase in nominal marginal costs and hence partially misattribute higher prices to higher markups; they perceive transactions as less fair, which increases the price elasticity of their demand for goods; firms respond by reducing markups; in equilibrium, output increases. By raising perceived markups, increased money supply inflicts a psychological cost on consumers that can offset the benefit of increased output.

1. Introduction

Explaining the nonneutrality of money—the property that monetary policy affects real outcomes such as output and employment—is a classical problem in macroeconomics, addressed by many models.[1] In a broad class of models, the nonneutrality arises when firms are constrained in setting their prices.[2] Many such constraints have been explored in depth; for instance, long-term nominal contracts, price-adjustment costs, and information-collection costs. Yet a growing body of evidence suggests that firms are not constrained in setting prices so much as reluctant to raise prices for fear of alienating consumers, who are averse to paying prices that they regard as unfair. In this paper, we develop a macroeconomic model with such fairness concerns on the goods market, and we explore whether these fairness concerns can explain the nonneutrality of money.

Our model rests upon two psychological assumptions. Our first assumption is that consumers dislike paying prices that exceed a fair markup on what they perceive as marginal costs. The assumption is motivated by the seminal work of Kahneman, Knetsch and Thaler [1986], who find that despite regarding it as acceptable for firms to raise prices in response to higher marginal costs, most people find it unfair for firms to raise prices in response to elevated demand. A survey of US firms by Blinder et al. [1998], our own survey of French bakers, as well as historical pricing norms appearing in religious and legal texts also suggest that consumers dislike paying prices exceeding some fair markup on marginal cost, and that firms understand this. Because consumers typically do not observe firms' costs, their perceptions of the fairness of firms' prices depend crucially upon their estimates of firms' nominal marginal costs. Rational consumers can perfectly infer these marginal costs from equilibrium prices, wages, and other variables. Yet copious evidence suggests that people are less than rational when inferring others' private information from their actions. Our second assumption is that consumers update their beliefs about firms' nominal marginal costs less than rationally from available information. Consumers who underinfer about firms' nominal marginal costs partially misattribute the higher prices that accompany higher money supply to higher markups rather than to higher nominal marginal costs. Hence, less-than-rational consumers conclude that these higher prices are less fair.

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[1]For evidence on the nonneutrality of money, see the historical study of Friedman and Schwartz [1963], the work of Romer and Romer [2004] based on a narrative approach, and the survey of econometric studies using vector autoregressions by Christiano, Eichenbaum and Evans [1999].

[2]See Blanchard [1990], Mankiw and Reis [2010], and Sims [2010] for surveys of these models.

We embed these two psychological assumptions into the general-equilibrium model of monopolistic competition by Blanchard and Kiyotaki [1987].[3] In modeling consumers' concern for fair prices, we assume that the utility that people derive from consuming a good depends on the perceived fairness of the transaction, measured by a fairness factor that depends on the purchase price and the consumer's estimate of the good's marginal cost. When good i is sold at price P_i and has a perceived marginal cost of MC_i^p, consumers perceive its markup to be $\mu_i^p = P_i/MC_i^p$. When consumers judge the fair markup for good i to be some μ_i^f, they weight each unit of consumption of good i by a factor of $\psi_i = 1 - (\phi/\mu^p) \cdot (\mu_i^p - \mu_i^f)$. Here ϕ parametrizes fairness concerns and μ^p is the average perceived markup across all goods. When $\phi = 0$, consumers do not care about the fairness of prices, and our model reduces to the Blanchard-Kiyotaki model. When $\phi > 0$, consumers care about the perceived fairness of prices.

In our formulation, paying a price that is perceived to be unfairly high for some good lowers the marginal utility of consuming that good. Hence, the demand for good i depends on its price P_i in a standard way and on the perceived fairness of the transaction, measured by the fairness factor ψ_i. The fairness factor leads the demand for good i to have a different price elasticity than it would in a standard model without fairness concerns, in which it simply equals ε, the elasticity of substitution across goods. First, the elasticity exceeds ε. Second, it depends on the fairness factor ψ_i: with symmetric firms, it decreases with ψ, which means that the demand for goods is more elastic when transactions are seen as less fair. Our results hinge on these two properties.

Because consumers do not directly observe firms' marginal costs, their perceptions of how fairly firms price their goods depend upon their estimates of these costs. Thus, the inferences that they draw about marginal costs play a pivotal role. When consumers rationally infer marginal costs and hence markups from aggregate variables, fairness concerns simply increase the elasticity of their demand for goods, which induces firms to set lower markups. This renders the economy more competitive, so output and employment are higher than in the case without fairness concerns. But this does not alter the qualitative features of the economy. Money therefore remains neutral.

However, empirical evidence suggests that consumers may fail to attend fully to the information revealed by prices and other variables about hidden marginal costs. Following the approach

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[3]The Blanchard-Kiyotaki model is one of the canonical models in macroeconomics. The New Keynesian model—currently the most widely used model in macroeconomics—is based on it.

of Eyster and Rabin [2005], and similar to the analogy-based-expectations equilibrium of Jehiel [2005] and Jehiel and Koessler [2008], we make the assumption that consumers perceive firm i's nominal marginal cost to be $MC_i^p = \overline{MC}_i^{\chi} \cdot MC_i^{1-\chi}$, where $\overline{MC}_i$ represents consumers' prior belief about the marginal cost and MC_i the firm's true marginal cost. The parameter $\chi \in [0,1]$ measures consumers' naivety when inferring marginal cost from all the information they have available. When $\chi = 0$, consumers are rational. When $\chi > 0$, consumers are *cursed*: they underappreciate the extent to which changes in prices and other variables reveal changes in marginal costs. Cursed consumers do update their beliefs in the right direction from available information, but they stop short of fully rational inference because their beliefs move too little relative to their priors.[4] Since cursed consumers underappreciate the change in nominal marginal cost when they observe a change in price, they misattribute part of the price change to a change in the underlying markup.

When consumers are cursed, money is no longer neutral. Instead, an increase in money supply causes the markups charged by firms to fall, stimulating the economy. After an increase in money supply, cursed consumers underappreciate the increase in nominal marginal costs, so they partially misattribute the higher prices to higher markups, which they find unfair. Since the perceived fairness of the transactions on the goods market decreases, the elasticity of the demand for goods increases. In response, firms reduce their markups. But in general equilibrium, the markup is equal to the inverse of the real marginal cost, and the real marginal cost is an increasing function of employment. Therefore, a lower markup implies higher real marginal cost and thus higher employment and higher output. Prices also increase, albeit less than proportionally with money supply; in this sense, prices exhibit a mild form of rigidity.

Qualitatively, our nonneutrality result requires only an infinitesimal deviation from the standard model: any amount of fairness concern, however small, coupled with any amount of cursedness, however small, produces the nonneutrality of money. Quantitatively, however, prices are more rigid and the money supply has stronger effects on output and employment when households are

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[4]Lucas [1972] presents a model in which rational firms can only partially infer the aggregate price level from demand for their goods because they cannot distinguish between idiosyncratic demand shocks and changes to overall prices due to money supply. Lucas shows how this allows money to have real effects. In a world where information about prices travels quickly, this mechanism seems unlikely to explain much real-world price rigidity. Our model differs from his by putting the imperfect information on the consumer side rather than producer side, and having it be about costs rather than prices: unlike price data, data on marginal costs does not circulate freely, nor do consumers have the same incentive to acquire cost data as firms do price data. The two models also differ because the cursed, partial inference in our model involves a mistake, whereas partial inference in his model is entirely rational.

more concerned with fairness or more cursed.

Even though an increase in money supply stimulates the economy, it does not necessarily improve welfare. On the one hand, an increase in money supply reduces markups and thereby the inefficiency due to monopolistic competition on the goods market. On the other hand, despite actual markups falling, perceived markups rise due to consumers' mistaken inference. Higher perceived markups upset consumers who misconstrue transactions as less fair. We find that the second effect can dominate the first so that welfare may decrease after an increase in money supply. In any case, increasing money supply inflicts a first-order psychological cost on consumers.

Our model reconciles the nonneutrality of money with evidence documenting that people dislike inflation. In a survey conducted by Shiller [1997], 85% of respondents report that they dislike inflation because when they "go to the store and see that prices are higher", they "feel a little angry at someone", most commonly "manufacturers", "store owners" and "businesses", on the most commonly identified grounds of "greed". Our model explains why people perceive transactions as less fair after an increase in money supply, even when those transactions have in fact become more fair. In this way, our model helps bridge the gap between people's actual attitudes towards inflation and those implied by traditional macroeconomic models.

Finally, we contrast money-supply shocks to technology shocks. Higher technology leads to higher output but higher markups and lower employment. With improved technology, consumers fail to fully infer that lower prices reflect lower marginal costs. Hence, the perceived markup and thus the elasticity of demand falls, leading firms to raise their markups, constricting employment. Although markups increase, people wrongly believe that transactions have become fairer.

Rotemberg [2005] pioneered the study of the implications of fairness on the goods market. He assumes that consumers care about firms' altruism—their taste for increasing consumers welfare—which they re-evaluate after every price change. Consumers buy a normal amount from the firm unless they can reject the hypothesis that the firm is altruistic toward them, in which case they withhold all demand in order to lower the firm's profits. Given such discontinuity in demand, firms react by refraining from passing on small cost increases, which gives rise to money nonneutrality.

In this paper, we retool the psychological assumption of Rotemberg [2005] that consumers refuse to purchase from firms whose prices reveal a lack of concern for their welfare by assuming that consumers experience less enjoyment of a good the less fair they regard its price. Despite broad

similarities, the two assumptions differ conceptually: unlike Rotemberg's, our assumption implies that consumers would withhold demand from unfair firms even if doing so did not hurt the firms. Importantly, the two assumptions yield different macroeconomic models. In our model, consumers do not withhold demand from unfair firms to punish them but do so because they enjoy consuming unfairly priced goods less. This allows us to move away from Rotemberg's discontinuous buy-normally-or-buy-nothing formulation to one in which consumers continuously reduce demand as the unfairness of the transaction increases. The greater tractability of our continuous formulation allows us to do comparative-statics exercises and welfare analysis. It also allows us to express estimable quantities, such as the pass-through of money-supply shocks to prices and the elasticities of employment and output with respect to the money supply, as closed-form expressions of the parameters of the model. Last, the simplicity of our formulation clarifies the role of inference about marginal costs in explaining the nonneutrality of money. We find that fairness concerns are necessary but not sufficient to obtain nonneutrality; it is only when fairness concerns are combined with partial inference about marginal costs that money is nonneutral.

2. The Model

We extend the model of Blanchard and Kiyotaki [1987] to include fairness concerns on the goods market. The model is static. The economy is composed of a continuum of households indexed by $j \in [0,1]$ and a continuum of firms indexed by $i \in [0,1]$. Households supply labor services, consume goods, and hold money. Firms use labor services to produce goods. Since the goods produced by firms are imperfect substitutes for one another, and the labor services supplied by households are also imperfect substitutes, each firm exercises some monopoly power on the goods market, and each household exercises some monopoly power on the labor market.

2.1. Households and Firms

Fairness matters on the goods market. Specifically, an amount c_{ij} of good i bought by household j at a unit price of P_i when the perceived marginal cost of production is MC_i^p yields the fairness-

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adjusted consumption

$$z_{ij} = \psi_i \cdot c_{ij},$$

where the fairness factor ψ_i is a function of the fair markup $\mu_i^f \geq 0$ and the perceived markup $\mu_i^p \equiv P_i/MC_i^p$. The perceived markups are endogenous variables determined by households' inferences about marginal costs; the fair markups are parameters. For concreteness, we assume that all households care about fairness in the same way and that the fairness factor takes the form

$$\psi_i = 1 - \frac{\phi}{\mu^p} \cdot \left(\mu_i^p - \mu_i^f \right). \tag{1}$$

The deviation $\mu_i^p - \mu_i^f$ of the perceived markup from the fair markup is scaled by ϕ/μ^p, where $\phi \in [0, 1]$ is the fairness parameter and $\mu^p \equiv \int_0^1 \mu_i^p \, di$ is the average perceived markup across all goods.[5] The fairness parameter indicates the importance of fairness concerns: when $\phi = 0$, households do not care about fairness; as $\phi > 0$, they care about the perceived fairness of the transaction. When $\phi = 0$, $\psi_i = 1$ for all i and our model reduces to the Blanchard-Kiyotaki model. A higher ϕ means that a consumer is more upset when consuming an overpriced item and more content when consuming an underpriced item. We divide ϕ by μ^p as a normalization.

The fairness factor ψ_i is unity when households perceive good i to be priced at its fair markup. When households perceive good i to be priced above its fair markup—that is, when $P_i > \mu_i^f \cdot MC_i^p$—the fairness factor is below one, and households are antagonized by consuming what they perceive to be an overpriced good. It is as if households lost the fraction $1 - \psi_i > 0$ of each unit of consumption of good i bought at an unfair price, which will reduce their marginal utility of its consumption. Analogously, when households perceive good i to be priced below its fair markup, they enjoy heightened utility from consuming what they perceive to be an underpriced good. As the fairness factor depends only on markups, households evaluate fairness in real rather than nominal terms. Finally, the fairness factor is differentiable everywhere in P_i. In fact, the fairness factor is linear in P_i, so households enjoy a price any amount below the fair price as much as they dislike a price that same amount above the fair price.

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[5]We focus on situations where perceived markups satisfy $\mu_i^p \leq \mu_i^f + \mu^p/\phi$ so the fairness factor remains positive. These conditions are always satisfied in a symmetric equilibrium.

Household j's fairness-adjusted consumption of the different goods aggregate into a consumption index

$$z_j \equiv \left(\int_0^1 z_{ij}^{\frac{\varepsilon-1}{\varepsilon}} \, di \right)^{\frac{\varepsilon}{\varepsilon-1}},$$

where $\varepsilon > 1$ is the elasticity of substitution between different goods. The index describes the household's love of variety; as $\varepsilon \to \infty$, goods become perfect substitutes.

Households derive utility from consumption of goods, leisure, and money holdings. The utility of household j is

$$u_j = \ln(z_j) - \frac{1}{1+\xi} \cdot n_j^{1+\xi} + \frac{1}{\eta} \cdot \ln\left(\frac{M_j}{\hat{P}} \right). \tag{2}$$

The utility depends on the fairness-adjusted consumption index z_j, the amount n_j of labor supplied, and the ratio of nominal money balances M_j to the fairness-adjusted price index

$$\hat{P} \equiv \left[\int_0^1 \left(\frac{P_i}{\psi_i} \right)^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}.$$

As we will see, $\hat{P}$ is the price of one unit of z_j. Hence, $M_j/\hat{P}$ indicates the number of units of z_j that can be purchased with M_j. Since it is z_j that enters the utility function, $M_j/\hat{P}$ indicates the value of the transaction services provided by the nominal money balances held by household j. It is therefore natural to divide M_j by $\hat{P}$ in the utility function. The parameter $\eta > 0$ measures households' propensity to spend money out of income, and the parameter $\xi > 0$ measures the curvature of the disutility from labor.

Household j maximizes utility subject to the constraint imposed by firms' demand for labor service j and the budget constraint

$$M_{0j} + W_j \cdot n_j + \Pi_j - M_j - \int_0^1 P_i \cdot c_{ij} di = 0, \tag{3}$$

where $M_{0j} > 0$ denotes household j's money endowment, W_j the nominal wage of labor service j, and Π_j household j's nominal profits. Households take prices, profits, and money supply as given.

Firm i hires labor to produce output using the constant-elasticity-of-substitution production

function

$$c_i = a_i \cdot n_i^{\alpha}, \tag{4}$$

where c_i is its output of good i, a_i is its technology level, $\alpha < 1$ is the extent of diminishing marginal returns to labor, and

$$n_i \equiv \left(\int_0^1 n_{ij}^{\frac{\nu-1}{\nu}} dj \right)^{\frac{\nu}{\nu-1}}$$

is an employment index. In the employment index, n_{ij} is the quantity of labor service j hired by firm i, and $\nu > 1$ is the elasticity of substitution between different labor services.

Taking wages as given, firm i maximize profits

$$\Pi_i = P_i \cdot c_i - \int_0^1 W_j \cdot n_{ij} dj \tag{5}$$

subject to the constraints imposed by its production function and households' demand for good i.

We assume that each firm's technology level and hence its marginal cost are unobservable to other firms and households—they are the firm's private information. We assume throughout that firms do not take into consideration how their prices affect households' inferences about marginal cost. Formally, firm i takes MC_i^p as independent of P_i in households' fairness factor $\psi_i = 1 - (\phi/\mu^p) \cdot (P_i/MC_i^p - \mu_i^f)$; as we will see, the fairness factor ψ_i matters to firm i because it enters the demand for good i. When all firms share the same technology, as we later shall assume, there is always an equilibrium with this feature. Nevertheless, we assume non-strategic firms throughout to ease exposition.[6]

2.2. Motivation for our Model of Fairness

A trove of empirical evidence supports our assumption that people care about the fairness of the markup charged by firms. The idea that people express hostility to price increases unexplained by

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[6]If firms had different technology levels, this assumption would matter when households care about fairness, because in that case there may exist other equilibria where firms signal their marginal costs. In this paper, we do not delve into these signaling equilibria. Of course, the assumption would have no consequence when households do not care about fairness, since households then have no interest in marginal cost.

cost increases dates back at least to Okun [1981], who points out that "price increases that are based on cost increases are fair, while those based on demand increases often are viewed as unfair". In a seminal survey study, Kahneman, Knetsch and Thaler [1986] establish that consumers deem it fair for firms to raise prices in response to increases in marginal costs but not in response to increases in demand.[7] By assuming that people dislike paying more than a fair markup on marginal cost, our model incorporates this finding.

We assume that consumers react angrily to a price increase that involves an increase in markup. Kahneman, Knetsch and Thaler establish such a pattern. For example, they describe the following situation: "A hardware store has been selling snow shovels for $15. The morning after a large snowstorm, the store raises the price to $20." Only 18% of consumers regard this pricing behavior as acceptable, whereas 82% regard this behavior as unfair.

We also assume that consumers do not mind a price increase that follows a cost increase as long as the markup remains constant. Kahneman, Knetsch and Thaler indeed find this, for instance in response to the following situation: "Suppose that, due to a transportation mixup, there is a local shortage of lettuce and the wholesale price has increased. A local grocer has bought the usual quantity of lettuce at a price that is 30 cents per head higher than normal. The grocer raises the price of lettuce to customers by 30 cents per head." 79% of consumers regard the grocer's behavior as acceptable, and only 21% find it unfair.[8]

We assume not only that consumers bristle at unfair markups, but also that firms understand how consumers behave. Blinder et al. [1998] find evidence that they do. 64% of firms say that customers do not tolerate price increases after increases in demand; 71% of firms say that customers do tolerate price increase after increase in cost. These responses suggest that the norm for fair pricing must take the form of a fair markup over marginal cost. Indeed, based on a survey of businessmen in the UK, Hall and Hitch [1939] report that the fair price is widely perceived to be a markup over average cost. Okun [1975] observed through discussions with business people that "empirically, the typical standard of fairness involves cost-oriented pricing with a markup".

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[7]These findings have been confirmed in many studies, especially using laboratory experiments. See Rotemberg [2009] for a survey of the evidence on people's attitude towards prices.

[8]For symmetry we also assume that consumers regard it as unfair for firms not to pass along cost decreases, despite weaker evidence for this assumption. For example, Kahneman, Knetsch and Thaler describe the following situation: "A small factory produces tables and sells all that it can make at $200 each. Because of changes in the price of materials, the cost of making each table has recently decreased by $20. The factory does not change its price of tables." Only 47% of respondents find this unfair, even though the markup has increased.

To better understand how firms take concerns for fairness into account, we interviewed 31 bakers in France in 2007. The French bread market makes a good case study because the French bread market is large, bakers set their prices freely, and French people care enormously about bread.[9] Following the approach of Bewley [1999], the interviews were only loosely directed. We sampled bakeries in cities and villages around Grenoble, Aix-en-Provence, Paimpol, and Paris. The number of interviews is small, yet the responses shed light on fairness constraints on pricing.

Overall, the interviews show that bakers' efforts to preserve customer loyalty constrain price variations. Price adjustments are guided by norms of fairness to avoid antagonizing customers; in particular, cost-based pricing is widely used. Bakers explained that they would raise the price of bread only in response to cost increases: when the price of flour goes up (generally once a year in September at the end of harvest), when utilities go up (especially gas, required to operate the oven), or when wages go up. Some bakers explained that their largest costs were the wages of their employees, which are linked to the minimum wage. Since the minimum wage is updated every July 1st and the bakers only change their price in response to a cost change, they only change their price once a year on July 1st. They emphasize that prices increase only in response to cost increases, with any increase announced long in advance and explained carefully.

In fact, bakers attach such importance to convincing their customers of fair markups that their trade union decomposes into minute detail the cost of bread and the rationale for any price rise, calculating the markups for various types of bread and explaining their evolution over time.[10]

Bakers seem to set their prices as a fixed markup over their costs but also deliberately refuse to increase prices in response to increased demand. Several bakers explained that they refuse to change prices during the week-ends (when more people typically shop at bakeries), during the holiday absences of local competitors (when their demand and market power rise), or during the summer tourist season (again, when demand rises). Bakers feel that a price rise would be unfair and would anger and drive away customers.

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[9]In 2005, bakeries employ 148,000 workers, for a yearly turnover of 3.2 billion euros [Fraichard, 2006]. Since August 1978, French bakers have been free to set their own bread and pastry prices, except during the inflationary period between 1979 and 1987 when price ceilings and growth caps were imposed. For centuries, bread prices caused major social upheaval. Miller [1999] explains that before the French Revolution, "affordable bread prices underlay any hopes for urban tranquility". During the Flour War (May 1775), mobs chanted "if the price of bread does not go down, we will exterminate the king and the blood of the Bourbons". Following these riots, the king capped the price of bread at 2 sous per pound, the "ordinary" price of bread in the 18th century [Kaplan, 1996].

[10]The webpage is at http://www.boulangerie.net/forums/bnweb/prixbaguette.php.

Surveys of consumers, firms, and French bakers suggest that a norm of fair markup over marginal costs is widespread today in the Western world. Religious and legal texts written over the ages suggest that the norm corresponds to a general principle of fairness. For example, Talmudic law specifies the highest markup that is fair and allowable in trade. The law posits that a good cannot be sold at a markup higher than 20% over the cost of producing the good—1/6 of the final price.[11] If the price deviates by more, the buyer is entitled to a refund. Norms of fair pricing also appear in legal texts. For instance, during most of the 18th century in France, bread prices were fixed by local authorities. The authorities determined bread prices that were "fair" for bakers and consumers; these fair prices were announced in official decrees. For example, in the city of Rouen, the official bread prices took into account the price of grain and the costs of rent, milling, wood, and labor, and they granted a "modest profit" to the baker [Miller, 1999].

2.3. Solution to the Households' and Firms' Problems

Here we present the solution to the households' utility-maximization and firms' profit-maximization problems. The derivations are standard and relegated to Appendix A.

To maximize their utility, households make two decisions: first, they choose how to divide their wealth across goods and money balances; second, they choose which wage to post for their labor services. Integrating over all households, we find that the demand for good i is given by

$$c_i^d(P_i) = \frac{z}{\psi_i} \cdot \left(\frac{P_i/\psi_i}{\hat{P}} \right)^{-\varepsilon}, \tag{6}$$

where $z \equiv \int_0^1 z_j dj$ describes the level of aggregate demand. The price of a unit of z_i is P_i/ψ_i so the ratio $(P_i/\psi_i)/\hat{P}$ is the relative price of z_i. The demand for good i increases with aggregate demand but decreases with its relative price.

We also find that it is optimal for household j to equate the marginal rate of substitution between money and fairness-adjusted consumption with their price ratio. This gives an equation

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[11] See the statement of Shmuel, page 49b of Bava Metzhia, Nezikin, http://www.halakhah.com/pdf/nezikin/Baba_Metzia.pdf.

linking fairness-adjusted consumption to nominal money balances:

$$\frac{z_j}{\eta \cdot M_j} = \frac{1}{\hat{P}}. \tag{7}$$

Households choose which wage to post given firms' demand for their labor

$$n_j^d(W_j) = n \cdot \left(\frac{W_j}{W}\right)^{-\nu}, \tag{8}$$

where $W \equiv \left(\int_0^1 W_j^{1-\nu} dj\right)^{\frac{1}{1-\nu}}$ is the nominal wage index, and $n \equiv \int_0^1 n_i di$ describes the level of employment in the economy. The labor demand faced by household j increases with the level of employment in the economy but decreases with the relative wage W_j/W set by the household. We find that to maximize utility, household j sets its wage at a markup of $\nu/(\nu - 1) > 1$ over its marginal rate of substitution between leisure and money holdings:

$$W_j = \frac{\nu}{\nu - 1} \cdot n_j^{\xi} \cdot \eta \cdot M_j. \tag{9}$$

To maximize profits, firms also make two decisions: first, they choose how much of each type of labor to hire; second, they choose which price to post for their good. Integrating over all firms, we find that the demand for labor j is given by (8). We also find that it is optimal for firm i to mark its price up over its marginal cost by setting

$$P_i = \frac{e_i}{e_i - 1} \cdot \frac{W}{a_i \cdot \alpha \cdot n_i^{\alpha - 1}}. \tag{10}$$

The markup is $e_i/(e_i - 1) > 1$, where $e_i \equiv -(P_i/c_i) \cdot (dc_i^d/dP_i)$ is the price elasticity of firm i's demand, normalized to be positive. We use (6) and the fact that $\psi_i = 1 - (\phi/\mu^p) \cdot (P_i/MC_i^p - \mu_i^f)$ to compute e_i:

$$e_i = \varepsilon + (\varepsilon - 1) \cdot \frac{\phi}{\mu^p} \cdot \frac{\mu_i^p}{\psi_i}.$$

The concern for fairness modifies two properties of the price elasticity e_i of the demand for good i, and these modifications have important implications. Without fairness concerns ($\phi = 0$),

the elasticity e_i is equal to ε, the elasticity of substitution across goods. But including fairness concerns ($\phi > 0$) makes households more sensitive to prices, which raises e_i above ε and thus reduces the monopoly power of firm i. Indeed, with fairness concerns, an increase in the price of good i increases the opportunity cost of consumption, as without fairness concerns, but it also decreases the enjoyment of consumption by increasing the perceived markup and thus reducing the fairness factor, which further reduces the demand for good i.

Furthermore, without fairness concerns, the elasticity $e_i = \varepsilon$ is a parameter of the model. But with fairness concerns, the elasticity e_i becomes an endogenous variable that depends on the fairness factor ψ_i and the relative perceived markup μ_i^p / μ^p. In a symmetric equilibrium with identical firms, $\mu_i^p / \mu^p = 1$ so

$$e_i = \varepsilon + (\varepsilon - 1) \cdot \frac{\phi}{\psi_i}. \tag{11}$$

The elasticity e_i decrease with ψ_i, which means that the demand for good i is more elastic when transactions are seen as less fair.

2.4. General Equilibrium

We describe the general equilibrium in a symmetric setting. All households receive the same endowment of money and profits; all firms share a common technology. In equilibrium, all households post the same wage and all firms set the same price. Since the equilibrium is symmetric, all the exogenous and endogenous variables are the same for all the households and firms; we drop the subscripts i and j from all the variables to denote their values in the symmetric equilibrium.

A symmetric general equilibrium can be described by its price level P and its employment level n. All the other variables can be recovered from the pair (P, n). We now derive the two equations that determine (P, n) and characterize the general equilibrium.

Combining the marginal-rate-of-substitution condition (7) with the production constraint (4) gives the first equation characterizing the general equilibrium:

$$\alpha \cdot \ln(n) = \ln(M_0) + \ln(\eta) - \ln(a) - \ln(P). \tag{12}$$

Here we have used the property that in a symmetric equilibrium, $z = \psi \cdot c$, $\hat{P} = P/\psi$, and $M = M_0$. The equation expresses employment as a decreasing function of the price level. The reason is that higher employment leads to more output and thus a lower marginal utility from consumption. Since, in equilibrium, households must remain indifferent between consumption and money holdings, the marginal utility from holding money must fall. Therefore, real money balances M_0/P must be higher, which requires the price level P to be lower.

We now derive the second equation characterizing the general equilibrium. We proceed in several steps. We begin by combining (12) with households' wage-setting equation, given by (9), to express the real wage W/P as a function of employment:

$$\ln\left(\frac{W}{P}\right) = (\xi + \alpha) \cdot \ln(n) + \ln(a) + \ln\left(\frac{v}{v-1}\right). \tag{13}$$

The real wage increases with employment because the disutility from labor is convex and the utility from consumption concave.

We then express firms' real marginal cost mc as a function of employment. The real marginal cost is the real wage divided by the marginal product of labor: $mc \equiv (W/P)/\left(a \cdot \alpha \cdot n^{\alpha-1}\right)$. Using (13), we obtain

$$\ln(mc) = (1+\xi) \cdot \ln(n) - \ln(\alpha) + \ln\left(\frac{v}{v-1}\right). \tag{14}$$

The real marginal cost increases with employment because the real wage increases with employment and the production function has diminishing marginal returns to labor.

Next, we express the markup set by firms as a function of the markup perceived by households. Firms' price-setting equation, given by (10), implies that the markup set by firms is $\mu = e/(e-1)$, where $e = \varepsilon + (\varepsilon - 1) \cdot (\phi/\psi)$ is the price elasticity of the demand for goods, given by (11). Hence, when the markup perceived by households is μ^p, the markup set by firms is

$$\mu(\mu^p) = \frac{1}{\varepsilon - 1} \cdot \left(\varepsilon - \frac{\phi}{1 + \phi \cdot \mu^f/\mu^p}\right). \tag{15}$$

The following lemma describes how $\mu(\mu^p)$ depends upon ϕ and μ^p.

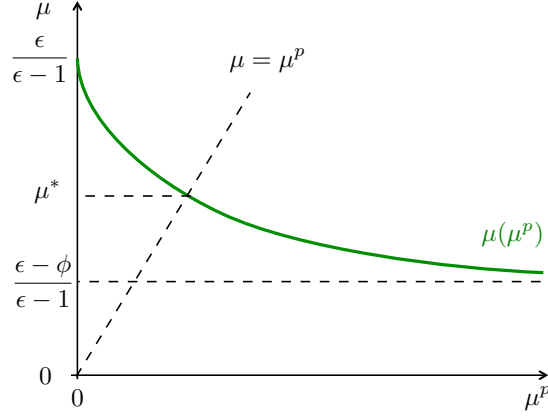**LEMMA 1.** *When households do not care about fairness ($\phi = 0$), the markup $\mu(\mu^p)$ charged by*

Figure 1: Relation Between the Markup Set by Firms and the Markup Perceived by Households

Notes: The graph represents the markup $\mu(\mu^p)$ set by firms to maximize profits when the markup perceived by households is μ^p. The properties of the function $\mu(\mu^p)$ are described in Lemma 1.

firms is $\varepsilon/(\varepsilon-1)$. When households care about fairness ($\phi > 0$), the markup $\mu(\mu^p)$ lies below $\varepsilon/(\varepsilon-1)$ but above 1, and it decreases in ϕ. Furthermore, it reverts to $\varepsilon/(\varepsilon-1)$ when $\mu^p = 0$, decreases in μ^p, and converges to $(\varepsilon-\phi)/(\varepsilon-1) \geq 1$ as $\mu^p \to +\infty$.

Two important properties arise when households care about fairness. First, because the price elasticity of the demand for goods is greater than ε, the markup charged by firms is lower than the standard markup of $\varepsilon/(\varepsilon-1)$. Second, because the price elasticity of the demand for goods decreases with the fairness factor (see equation (11)), and the fairness factor decreases with the markup perceived by households, the markup charged by firms decreases with the perceived markup. Figure 1 illustrates the results of the lemma.

By definition, the markup on the goods market is the inverse of the real marginal cost: $\mu = 1/mc$. Hence, combining (14) and (15), we obtain the second equation characterizing the general equilibrium:

$$(1+\xi) \cdot \ln(n) = \ln(\alpha) - \ln(\mu(\mu^p)) - \ln\left(\frac{\nu}{\nu-1}\right). \tag{16}$$

The equation expresses employment as a decreasing function of the goods-market markup. The reason is that employment is an increasing function of the real marginal cost, which is a decreasing function of the goods-market markup. In equation (16), employment also decreases with the labor-market markup, $\nu/(\nu-1)$.

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Equations (12) and (16) do not currently determine the pair (P,n) because the markup perceived by households, μ^p, is not expressed as a function of (P,n) in (16). We cannot say how μ^p depends on (P,n) because we have not specified how households infer μ^p from economic variables. Below we consider two inference processes: rational inference in Section 3 and cursed inference in Section 4. Once the inference process is specified, we will express μ^p as a function of (P,n), and the system of (12) and (16) will determine the pair (P,n).

3.   The Case with Rational Inference

In this section, we analyze the economy when households rationally infer firms' marginal costs. We find that when households care about the fairness of prices but are able to infer marginal costs rationally, money remains neutral. Although the analysis of the economy with fairness concerns and rational inference cannot explain the nonneutrality of money, it does provide a useful stepping-stone toward the analysis of the economy with fairness concerns and cursed inference in Section 4. In that section, we show that fairness concerns combined with cursed inference explain the non-neutrality of money, even though fairness concerns alone do not.

Rational households understand the behavior of firms and other households, and they use this understanding as well as their observations to infer firms' hidden marginal costs. Using their understanding of the economy, rational households can derive the expression (14) for firms' real marginal cost. They therefore know that firms' nominal marginal cost is given by

$$MC = \frac{\nu}{\alpha \cdot (\nu - 1)} \cdot n^{1+\xi} \cdot P. \tag{17}$$

By observing the price level P and employment n, they are able to infer firms' true nominal marginal cost. With rational inference, the economy has the following properties:

PROPOSITION 1. *Consider an economy in which households make rational inferences. The goods-market markup is the fixed point μ^* of the function $\mu(\mu^p)$ given by (15). An increase in the fairness parameter ϕ renders the economy more competitive: the goods-market markup decreases; output, employment, and the real wage increase; the price level decreases, as do real profits when $\mu < 1 + \alpha$. Importantly, the goods-market markup is independent of money supply*

and technology. Hence, money-supply and technology shocks have the following effects:

- *Money is neutral: the money supply has no effect on employment, output, real wage, or real profits; the price level is proportional to the money supply.*

- *Output, real wage, and real profits are proportional to technology; the price level is inversely proportional to technology; employment is independent of technology.*

The proofs of all the propositions in the paper, including this one, appear in Appendix A. The main result of this proposition is that when households make rational inferences, money is neutral: employment and output do not depend on the money supply. When people do not care about fairness ($\phi = 0$), this result replicates the famous finding of Blanchard and Kiyotaki [1987] that money is neutral in an economy with monopolistic competition. The proposition shows that the neutrality result also holds when people care about fairness ($\phi > 0$).

The neutrality of money comes from the property that the goods-market markup is independent of money supply and technology. In general equilibrium, the goods-market markup is the inverse of the real marginal cost, and the real marginal cost only depends on employment. We infer that employment is independent of money supply and technology. All the other properties follow from this result, illustrated in Figure 2. The equilibrium pair $(\ln(P), \ln(n))$ lies at the intersection of the two curves. Because of the properties of the goods-market markup, the vertical curve is independent of money-supply and technology shocks. These shocks only shift the downward-sloping curve, so they affect the price level but not employment.

When households are rational, the concern for fairness only increases the price elasticity of the demand curves faced by firms, leading to reduced markups, but does not modify the qualitative properties of the general equilibrium. In fact, an isomorphism exists between the models with and without fairness concerns: for each $\phi > 0$ and $\varepsilon > 1$, the equilibrium coincides with the equilibrium of another economy with $\phi = 0$ for some $\varepsilon' > \varepsilon$. Monopolistic competition gives rise to inefficiently low production because firms price in excess of marginal costs; therefore, the concern for fairness improves efficiency by reducing markups. Greater efficiency means higher output, employment, and real money balances. The effect on real profits depends on parameter values. Macroeconomists conventionally estimate μ to be between 1.05 and 1.3, and α between 0.66 and 1. With these estimates, $\mu < 1 + \alpha$ and the concern for fairness decreases profits.
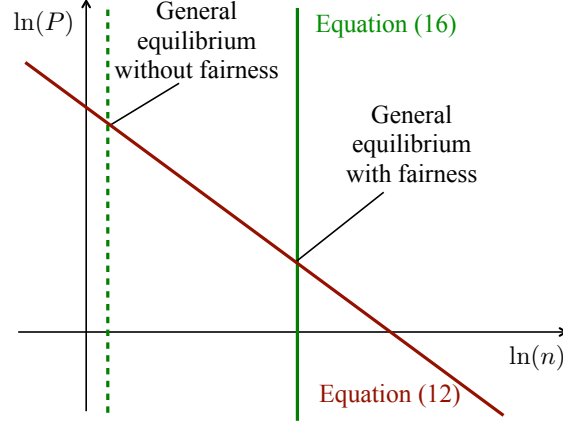
Figure 2: The General Equilibrium with Rational Inference

4. The Case with Cursed Inference

Although households see and use several economic variables, they may underappreciate the extent to which these variables convey information about firms' hidden nominal marginal costs in equilibrium. Indeed, the equilibrium relationship between these variables and marginal costs is not transparent. In this section, we analyze the economy when households make this kind of erroneous inference, which we call *cursed inference*. We find that introducing cursed inference has important implications in the presence of fairness concerns, notably causing the nonneutrality of money.[12]

4.1. Definition of Cursed Inference

Household j seeks to maximize the utility u_j, given by (2), subject to its known budget constraint, given by (3). In this constrained optimization problem, the household knows everything except for the MC_i^p terms that enter the fairness factors, $\psi_i = 1 - (\phi/\mu^p) \cdot \left(P_i/MC_i^p - \mu_i^f \right)$. Each MC_i^p is the household's perception about firm i's nominal marginal cost.

Cursed households perceive firm i's nominal marginal cost to be

$$MC_i^p = \overline{MC}_i^\chi \cdot MC_i^{1-\chi}, \tag{18}$$

where $\overline{MC}_i$ denotes households' prior belief of firm i's nominal marginal cost, and MC_i denotes

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[12]Without fairness concerns, inference about marginal costs plays no role, so the equilibrium with cursed inference coincides with the one with rational inference; we do not discuss this equilibrium here.

firm i's true nominal marginal cost. The cursedness parameter $\chi \in [0,1]$ characterizes the sophistication of households' inferences. When $\chi = 0$, households are rational, as in Section 3: based upon a perfect understanding of firms' and households' behavior, as well as their observations of economic variables, they correctly infer firms' true nominal marginal costs. Because households' perceived marginal costs agree with firms' true marginal costs, their prior beliefs about marginal costs play no role. When $\chi = 1$, households entirely fail to update their beliefs about firms' nominal marginal costs; they neglect all the information that observable variables convey about marginal costs. Hence, households' beliefs about marginal costs do not depart from their prior beliefs. When $\chi \in (0,1)$, households adjust their beliefs about nominal marginal costs in the direction of the true nominal marginal costs, but the adjustment is only partial. Households commit an inference error by not adjusting they prior beliefs sufficiently upon observing equilibrium variables.

Our formula for partial inference (18) nearly coincides with the "χ-cursed inference" formula of Eyster and Rabin [2005], the only difference being that they use the χ-weighted arithmetic rather than geometric average of prior beliefs and correct beliefs; we employ a geometric average solely because it proves more tractable.[13] This form of underinference also resembles inference in the analogy-based expectation equilibrium by Jehiel [2005] and Jehiel and Koessler [2008].[14]

In a symmetric equilibrium, firms' true nominal marginal cost is given by (17) and the nominal marginal cost perceived by households is given by (18), so the markup perceived by households is

$$\mu^p(n,P) \equiv \frac{P}{MC^p} = \overline{MC}^{-\chi} \cdot \left[\frac{\alpha \cdot (\nu - 1)}{\nu} \right]^{1-\chi} \cdot n^{-(1+\xi)\cdot(1-\chi)} \cdot P^{\chi}. \tag{19}$$

When $\chi \in (0,1)$, households appreciate that higher prices reflect higher nominal marginal costs, but they do not raise sufficiently their estimate of the nominal marginal cost. Thus, the perceived markup is an increasing function of the price level. Since cursed households partially misattribute higher prices to higher markups, they see higher prices as less fair. Although households correctly perceive markup as a real variable, cursed inference ties their estimates to the nominal variable $\overline{MC}$. In this way, cursed inference induces a specific form of money illusion.

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[13]We strongly suspect that all of our results would carry through under the arithmetic variant.

[14]We cannot apply any of these concepts exactly because we study a market equilibrium, whereas cursed equilibrium and analogy-based-expectations equilibrium are game-theoretic concepts.

4.2. Motivation for our Model of Cursed Inference

Although each household sees the price set and the labor hired by each firm, (18) indicates that they underappreciate the extent to which changes in prices and employment convey information about changes in nominal marginal costs. Copious evidence suggests that people fail at precisely this type of inference. Indeed, numerous experimental studies find that people underinfer other people's information from their actions in various contexts. Samuelson and Bazerman [1985], Holt and Sherman [1994], and Carillo and Palfrey [2011], among others, provide evidence in the context of bilateral bargaining with asymmetric information that bargainers underappreciate adverse selection in trade. The papers collected in Kagel and Levin [2002] present evidence that bidders underattend to the winner's curse in common-value auctions. In a metastudy of social-learning experiments, Weizsäcker [2010] finds evidence that subjects behave as if they underinfer their predecessors' private information from their actions. Last, in a voting experiment, Esponda and Vespa [2014] show that subjects underinfer others' private information from their votes.

Furthermore, the mistake that households make in (19) is akin to the money illusion documented by Shafir, Diamond and Tversky [1997]. Households evaluate the markup charged by firms to assess the fairness of a transaction. The markup represents the real value of the economic transaction going to the firm. As (19) indicates, the evaluation of the markup is contaminated by the nominal value of the transaction going to the firm: when the price is higher, households believe that firms capture a larger markup; when the price is lower, households believe that firms capture a smaller markup. It is because households' real evaluation of the transaction is contaminated by their nominal evaluation of it that their behavior exhibits money illusion. In fact, Shafir, Diamond, and Tversky report evidence that directly supports our assumption. They present the following situation: "Changes in the economy often have an effect on people's financial decisions. Imagine that the US experienced unusually high inflation which affected all sectors of the economy. Imagine that within a six-month period all benefits and salaries, as well as the prices of all goods and services, went up by approximately 25%. You now earn and spend 25% more than before. Six months ago, you were planning to buy a leather armchair whose price during the 6-month period went up from $400 to $500. Would you be more or less likely to buy the armchair now?" The higher prices were distinctly aversive to buying: while 55% of respondents were as likely to buy
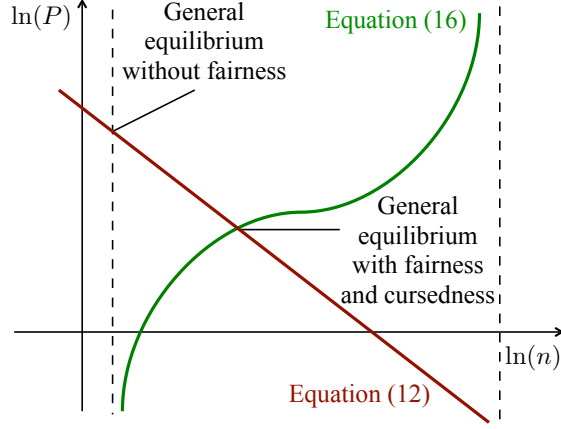
Figure 3: The General Equilibrium with Fairness Concern and Cursed Inference

as before and 7% were more likely to buy as before, 38% of respondents were less likely to buy as before. Our model of cursed inference exactly makes this prediction because some households perceive markups to be higher when prices are higher, as in (19), which reduces the value of the fairness-adjusted consumption of the chair and thus households' willingness to pay for it.

4.3. Cursed General Equilibrium

With cursed inference, the markup on the goods market is no longer independent of the price level. A higher price causes households to perceive a higher markup, which in turn increases the elasticity of the demand for goods and reduces the markup charged by firms. Specifically, firms charge a markup $\mu\left(\mu^p(n,P)\right)$, where the function $\mu^p(n,P)$, given by (19), increases with P, and the function $\mu(\mu^p)$, given by (15), decreases with μ^p. Hence, the general equilibrium has the following structure:

PROPOSITION 2. *Consider an economy in which households care about fairness ($\phi > 0$) and make cursed inferences ($\chi > 0$). Equation (12) defines employment as a function, $n^H(P,a,M_0)$, of price, technology, and money supply. The function n^H is continuous, strictly decreasing in P and a, strictly increasing in M_0, with $\lim_{\ln(P)\to-\infty}\ln(n^H) = +\infty$ and $\lim_{\ln(P)\to+\infty}\ln(n^H) = -\infty$. Equation (16), with μ^p given by (19), defines employment as a function, $n^F(P)$, of price. The function n^H is continuous, strictly increasing in P, with two asymptotes: $\lim_{\ln(P)\to-\infty}(1+\xi)\cdot \ln\left(n^F\right) = \ln(\alpha\cdot(v-1)/v)-\ln(\varepsilon/(\varepsilon-1))$ and $\lim_{\ln(P)\to+\infty}(1+\xi)\cdot\ln\left(n^F\right) = \ln(\alpha\cdot(v-1)/v)-$*

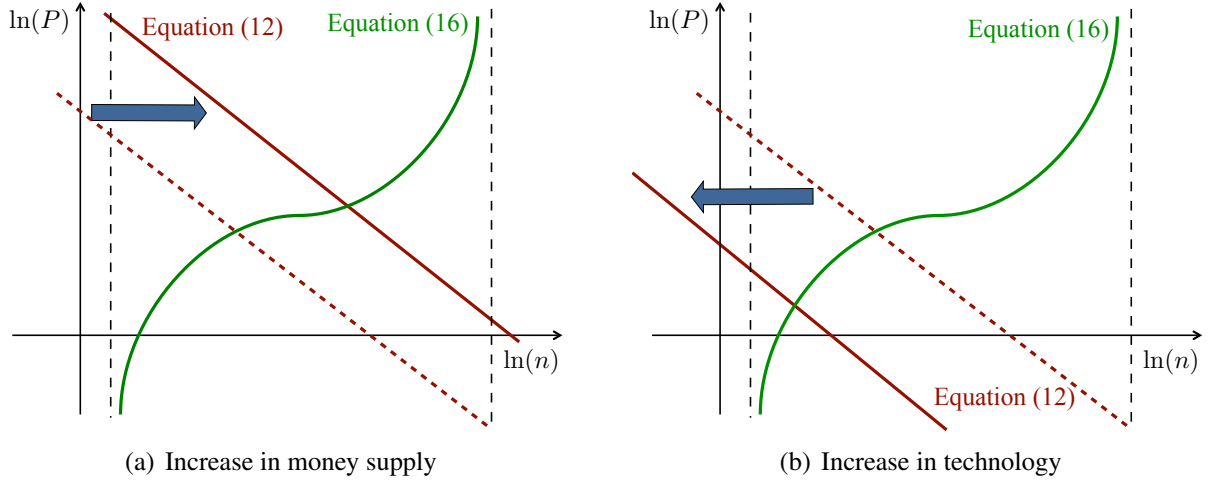(a) Increase in money supply   (b) Increase in technology

Figure 4: Comparative Statics with Fairness Concern and Cursed Inference

$\ln\left((\varepsilon - \phi)/(\varepsilon - 1)\right)$. *In general equilibrium, the price satisfies $n^H(P, a, M_0) = n^F(P)$. The general equilibrium always exists and is unique.*

The general equilibrium is represented in Figure 3. The downward-sloping curve represents the function n^H and the upward-sloping curve represents the function n^F. Because money-supply and technology shocks shift only the downward-sloping curve, it is straightforward to use the figure to analyze how the equilibrium changes with the shocks, which we do in the following subsections.

4.4. The Effects of Money-Supply Shocks

The following proposition describes the effects of money-supply shocks.

PROPOSITION 3. *Consider an economy in which households care about fairness ($\phi > 0$) and make cursed inferences ($\chi > 0$). Money is not neutral. An increase in money supply has the following effects: the goods-market markup decreases; employment, output, and real wage increase; real profits decrease when $\mu < 1 + \alpha$; the price level increases less than proportionally to the money supply; on the goods market, the perceived markup increases and transactions are perceived as less fair.*

Under the joint assumptions of fairness concerns and cursed inference, money is no longer neutral. Instead, we find that an increase in money supply reduces the markup on the goods market

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and thus stimulates the economy. After an increase in money supply, cursed households underappreciate the increase in nominal marginal costs, so they attribute the higher prices partly to higher nominal marginal costs and partly to higher markups, which they find unfair. Since the perceived fairness of the transactions on the goods market decreases, the elasticity of the demand for goods increases. In response, firms reduce their markups. We have showed that the markup is the inverse of the real marginal cost and the real marginal cost is an increasing function of employment. Therefore, a lower markup implies higher real marginal cost and thus higher employment, which in turn implies higher output. Here, households mistakenly believe that transactions on the goods market are less fair although firms suffer lower per-unit real profits as well as lower total real profits. The nonneutrality result is illustrated in Figure 4(a). An increase in money supply raises the downward-sloping curve and therefore raises employment. The price level is also raised.

Of course, a decrease in money supply has exactly opposite effects. It lowers the markup perceived by households, leading them to believe that transactions on the goods market have become fairer. Thus, it raises the markup set by firms, which lowers employment and output.

Importantly, our nonneutrality result only requires an infinitesimal deviation from the standard model. Any amount of fairness concern, however small, combined with any amount of cursedness, short of fully rational inference, lead to the nonneutrality of money. This can be seen in Proposition 3 because money is nonneutral for any $\phi > 0$ and any $\chi > 0$. Our result does not require households to care immensely about fairness or to make large inference errors.

With fairness concerns and cursed inference, the economy exhibits a form of price rigidity in that the price level moves less than proportionally with the money supply. To understand why, suppose that starting from equilibrium the money supply M_0 and the price level P double. In this hypothetical equilibrium with price flexibility, M_0/P remains the same. Output and employment remain the same so that households' indifference between consumption and money holdings, and firms' production function, remain satisfied. Accordingly, firms' real marginal cost, which is an increasing function of employment, and the goods-market markup, which is the inverse of the real marginal cost, do not change. Since the real marginal cost is the same but P has doubled, the nominal marginal cost has doubled. But households are cursed, so they underappreciate the increase in the underlying nominal marginal costs and mistakenly perceive higher markups. They find these higher markups unfair, which raises the elasticity of the demand for goods, leading firms

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to set lower markups. Hence, the economy cannot be in equilibrium. The same logic shows that P cannot increase more than proportionally with M_0. Thus, P rises less than proportionally with M_0.

In traditional monetary models, the nonneutrality of money arises because firms face constraints which prevent them from setting the optimal price given the demand they face. These constraints take different forms: long-term nominal contracts in Akerlof [1969], Fischer [1977], and Taylor [1979], a quadratic price-adjustment cost in Rotemberg [1982], infrequent pricing as in Calvo [1983], and a menu cost in Mankiw [1985] and Akerlof and Yellen [1985]. Firms always desire to charge the same markup, but the price-setting constraints prevent them from doing so, inducing fluctuations in the goods-market markup in response to money-supply shocks. These fluctuations explain the nonneutrality of money.

While the nonneutrality of money also arises from fluctuations in the goods-market markup in our model, our mechanism differs because these fluctuations are not forced by price-setting constraints. Instead, the fluctuations arise from firms' optimal response to money-supply shocks when households are concerned about fairness and make cursed inferences. Firms tailor their markups to the money supply in such a way that money-supply shocks have real effects. In that respect, our model is closer to models of business-cycle fluctuations based on endogenous markups [Stiglitz, 1984]. The closest ones generate cyclical markups from cyclical variations in the elasticity of demand faced by firms, an idea that dates back to Robinson [1932]. She predicts greater elasticity of demand for durables in expansions than in recessions, leading to countercylical markups. Galí [1994] gives a related model in which demand for consumption and investment goods have different elasticities; since their relative shares of output vary systematically over the business cycle, aggregate markups exhibit cyclical fluctuations. Other models generate cyclical markups through alternative mechanisms. For example, Rotemberg and Saloner [1986] predict lower markups in good times due to price wars among oligopolists when demand is high. Bils [1989] predicts low markups in good times because firms find it most profitable to expand their customer base when demand is high.

Although Proposition 3 only describes the effects of money-supply shocks, we can show that aggregate-demand shocks parametrized by changes in the preference parameter η have exactly the same effects. An increase in η lowers the marginal utility of money balances, pushing households to consume more goods; it can therefore be interpreted as a positive aggregate-demand shock.

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Since M_0 and η enter similarly in all the equilibrium conditions, increasing η has exactly the same effects as increasing M_0. Therefore, if households care about fairness and make cursed inferences, aggregate demand is nonneutral, and aggregate-demand shocks can generate business cycles.

4.5. The Money-Supply Elasticities of Price Level, Output, Employment, and Real Wage

The tractability of our model allows for closed-form expressions describing how prices and quantities respond to money-supply shocks, and how the responses depend on fairness concerns and cursedness. We derive these expressions below.

PROPOSITION 4. *The pass-through of money-supply shocks is the elasticity of the price level with respect to the money supply:* $\sigma \equiv d\ln(P)/d\ln(M_0)$. *When households do not care about fairness* ($\phi = 0$) *or do not make cursed inferences* ($\chi = 0$), *the pass-through equals* 1. *When households care about fairness* ($\phi > 0$) *and make cursed inferences* ($\chi > 0$), *the pass-through is below* 1 *but above* $(\varepsilon - 1)/\varepsilon$, *and it satisfies*

$$\frac{\sigma}{1 - \sigma} = \frac{1 + \xi}{\alpha \cdot \chi} \cdot \left[\left(\varepsilon \cdot \frac{\psi + \phi}{\phi} - 1 \right) \cdot \left(\frac{\psi + \phi}{\psi + \phi - 1} \right) + 1 - \chi \right].$$

The elasticities of output, employment, and real wage with respect to the money supply can be expressed as a function of the pass-through: $d\ln(c)/d\ln(M_0) = 1 - \sigma$, $d\ln(n)/d\ln(M_0) = (1 - \sigma)/\alpha$, *and* $d\ln(W/P)/d\ln(M_0) = (1 + \xi/\alpha) \cdot (1 - \sigma)$. *These elasticities are positive if and only if the pass-through is below 1.*

When households care about fairness and make cursed inferences, the pass-through is less than 1. Hence, prices exhibit a mild form of rigidity by moving less than proportionally to the money supply. The amount of price rigidity determines the amplitude of the increase in output, employment, and real wage after a money-supply shock: more rigid prices yield larger increases.

Since the pass-through is between $(\varepsilon - 1)/\varepsilon$ and 1, the pass-through converges to 1 when the economy becomes perfectly competitive ($\varepsilon \to \infty$). In that case, the elasticities of output and employment with respect to the money supply are zero. These results imply that money becomes neutral and prices become perfectly flexible when the economy becomes perfectly competitive.

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They also imply that fairness and cursedness do not matter in a perfectly competitive economy.

In an equilibrium where households appraise the markups they face as fair, which through acclimation they may be particularly apt to do in steady state, the pass-through admits a simpler form. To obtain comparative statics for the pass-through, we consider such equilibria.

COROLLARY 1. *Let σ^n be the pass-through of money-supply shocks evaluated at an equilibrium where the perceived and fair markups coincide. When households care about fairness ($\phi > 0$) and make cursed inferences ($\chi > 0$), the pass-through σ^n satisfies*

$$\frac{\sigma^n}{1-\sigma^n} = \frac{1+\xi}{\alpha \cdot \chi} \cdot \left[\left(\frac{1+\phi}{\phi} \right)^2 \cdot \left(\varepsilon - \frac{\phi}{1+\phi} \right) + 1 - \chi \right].$$

The pass-through increases with the competitiveness of the economy, ε, but decreases with fairness concerns, ϕ, and cursedness, χ. Therefore, the elasticities of output, employment, and real wage with respect to the money supply decrease with the competitiveness of the economy but increase with fairness concerns and cursedness.

Although any amount of concern for fairness, however small, combined with any amount of cursedness, short of fully rational inference, lead to the nonneutrality of money, Corollary 1 shows that more concern for fairness and more cursedness lead to a lower pass-through—that is, more price rigidity—and stronger responses of output and employment to a money-supply shock.

4.6. The Effects of Technology Shocks

Our model allows us to study the effects of shocks other than demand shocks. Current macroeconomic models are commonly used to study the effects of technology shocks, and we can also use our model to do that. The following proposition describes these effects.

PROPOSITION 5. *Consider an economy in which households care about fairness ($\phi > 0$) and make cursed inferences ($\chi > 0$). An increase in technology has the following effects: the goods-market markup increases; employment decreases; output increases less than proportionally to technology; the real wage increases less than proportionally to technology and might decrease; real profits increase, more than proportionally to technology when $\mu < 1 + \alpha$; the price decreases*

less than inversely proportionally to technology; on the goods market, the perceived markup decreases and transactions are perceived as fairer.

The main result from the proposition is that enhanced technology leads to higher output but lower employment. Its logic mirrors that following a money-supply shock. When technology improves, prices and nominal marginal costs fall. Cursed households underestimate the drop in firms' nominal marginal costs and partially misattribute the fall in prices to reduced markups. These households perceive lower markups and fairer transactions, decreasing the elasticity of the demand for goods. Firms best respond by raising their markups. The higher goods-market markup implies a lower real marginal cost and thus lower employment. Relative to the case without fairness concerns, the positive effect of the increase in technology on output is diminished. Here, households mistakenly believe that transactions on the goods market are fairer although firms enjoy higher per-unit real profits as well as higher total real profits. The result that employment falls after an increase in technology is illustrated in Figure 4(b). An increase in technology lowers the downward-sloping curve and thus employment. The price level is also lower.

Our model allows for closed-form expressions for the pass-through of technology shocks, defined as $\sigma^a \equiv -d\ln(P)/d\ln(a)$ and normalized to be positive (prices decline after an increase in technology). Because of the normalization and the fact that $\ln(a)$ and $-\ln(M_0)$ enter symmetrically into (12) and (16), the pass-throughs for technology shocks and money-supply shocks coincide. The elasticity of output, employment, and real wage with respect to technology relate directly to the pass-through: $d\ln(c)/d\ln(a) = \sigma^a$, $d\ln(n)/d\ln(a) = -(1-\sigma^a)/\alpha$, and $d\ln(W/P)/d\ln(a) = 1 - (1 + \xi/\alpha) \cdot (1 - \sigma^a)$.

4.7. Evaluating the Comparative-Statics Predictions of the Model

Identifying the cause of money nonneutrality is important to guide monetary policy. Here we review available empirical evidence to evaluate the comparative-statics predictions of our model with fairness concerns and cursed inference. We start with the macroevidence, based on aggregate data, before turning to the microevidence, mostly based on survey data.

Macroevidence. Proposition 3 predicts that in business cycles generated by money-supply shocks, markups are countercyclical: higher money supply leads to lower markups and higher output, and

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conversely, lower money supply leads to higher markups and lower output. Despite the large volume of empirical work measuring the cyclical variation of markups, no consensus on cyclicality has emerged. Rotemberg and Woodford [1999] provide an exhaustive survey of the empirical evidence. The evidence suggests that the labor share—the ratio of the real wage bill $(W/P) \cdot n$ to output $a \cdot n^{\alpha}$—is countercyclical. In our model, the marginal and the average cost are proportional; thus, the empirical evidence implies that the marginal cost is countercyclical and hence the markup is procyclical (recall that the markup is the inverse of the marginal cost in equilibrium). However, Rotemberg and Woodford [1999] list several reasons why marginal cost may be more procyclical than average cost. For instance, in good times workers earn overtime pay in excess of normal earnings [Bils, 1987]. Adjusting the fluctuations of the labor share for such corrections, they conclude that the markup is countercyclical. Using the cyclical behavior of inventories, Bils and Kahn [2000] also estimate a countercyclical markup. But recent work by Nekarda and Ramey [2013] using updated methods and data do not find a significant response of the markup to aggregate-demand shocks—if anything, they find a slightly procyclical markup.

Proposition 5 predicts that an increase in technology leads to higher output but lower employment. The prediction is consistent with the empirical findings of several influential papers.[15] Using a structural vector autoregression, Galí [1999] shows that higher technology lead to higher output but lower employment. Using a measure of technological change that they have constructed, Basu, Fernald and Kimball [2006] also find that higher technology leads to slightly higher output but lower employment. Addressing some econometric issues that affected earlier work, Francis and Ramey [2009] confirm Gali's findings. Proposition 5 also predicts that in business cycles generated by technology shocks, markups are procyclical: higher technology leads to higher markups and higher output, and conversely, lower technology leads to lower markups and lower output. Nekarda and Ramey [2013] report empirical evidence consistent with this prediction.

Corollary 1 predicts that the pass-through is smaller in less-competitive economies, and Proposition 4 shows that it even goes to one as the economy becomes perfectly competitive.[16] This property echoes the finding of Carlton [1986] that prices are more rigid in industries that are more concentrated. Corollary 1 also shows that the pass-through is smaller in economies in which house-

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[15]These findings are not universally accepted; Galí and Rabanal [2004] summarize the debate in the literature.

[16]Corollary 1 describes the pass-through of money-supply shocks to prices, but the results also apply to the pass-through of technology shocks to prices.

holds care more about fairness. This result accords well with the results reported by Kackmeister [2007]. First, he finds that the fairness of transactions matters less today than it did in 1890 due to weaker current personal relationships between retailers and customers. Second, he shows that retail prices were much more rigid in 1889–1891 than in 1997–1999.

Overall, the macroevidence provides support for the nonneutrality mechanism proposed in our model. However, the evidence does not allow us to separate our mechanism from the mechanism proposed by some other monetary models—including the standard New Keynesian model of Galí [2008]—because our model predicts the same response of the markup to money-supply and technology shocks as these models. We therefore turn to the microevidence in an attempt to separate between different models of the nonneutrality of money.

Microevidence.   Although the actual goods-market markup responds similarly to money-supply shocks in our model and in other monetary models, the perceived markup responds very differently. In our model, as established by Proposition 3, cursed households believe that markups on the goods market are higher and transactions are less fair when they observe the higher prices generated by an increase in money supply. In contrast, in existing monetary models, households correctly infer markups from available information, so they understand that after an increase in money supply, although prices are higher, markups on the goods market are lower.

The prediction of our model accords well with the findings of Shiller [1997]. In Shiller's survey, 85% of respondents report that they dislike inflation because when they "go to the store and see that prices are higher", they "feel a little angry at someone", the most common culprits including "manufacturers", "store owners", and "businesses", and the most common causes including "greed" and "corporate profits". On the other hand, the prediction of existing monetary models seems at odds with the evidence provided by Shiller that people feel cheated by rising prices.

In our model as in most monetary models, prices are somewhat rigid in response to shocks. Indeed, as established by Proposition 4, the pass-through of money-supply shocks is strictly less than 1 in our model, so firms stabilize prices in response to money-supply shocks. However, the motive for stabilizing prices is very different in our model and in other monetary models. In our model, it is households' concern for fairness that causes firms to stabilize prices in response to shocks. In other monetary models, firms stabilize prices because they are constrained by long-term

Table 1: The Prevalence of Implicit Contracts with Customers ("Firms tacitly agree to stabilize prices, perhaps out of fairness to customers")

Study	Country	Period	Sample	Ranking of implicit contracts
Blinder et al. [1998]	US	1990–92	200	4/12
Hall, Walsh and Yates [2000]	UK	1995	654	5/11
Amirault, Kwan and Wilkinson [2006]	Canada	2002–03	170	2/11
Apel, Friberg and Hallsten [2005]	Sweden	2000	626	1/13
Kwapil, Baumgartner and Scharler [2005]	Austria	2004	873	1/10
Aucremanne and Druant [2005]	Belgium	2004	1,979	1/15
Loupias and Ricart [2004]	France	2004	1,662	4/10
Lunnemann and Matha [2006]	Luxembourg	2004	367	1/15
Hoeberichts and Stokman [2006]	Netherlands	2004	1,246	1/8
Martins [2005]	Portugal	2004	1,370	1/12
Alvarez and Hernando [2005]	Spain	2004	2,008	1/9

Notes: Respondents to the surveys rated the relevance of several price-setting theories to explain price rigidity in their own firms. The table shows how the theory of implicit contracts ranks amongst the alternatives: a rank of 4/12 means that it was the 4th most popular of 12 proposed theories.

nominal contracts, price-adjustment costs, or information-collection costs.

The description of firms in our model accords well with survey responses collected by researchers studying firms' pricing strategies. Following Blinder et al. [1998], researchers have presented firm managers with economic theories of price setting and asked them to rate the importance of each as a cause of price rigidity in their firm. The surveys include three leading macroeconomic theories of price rigidity—menu costs, nominal contracts, and informational frictions.[17] The surveys do not explicitly include our theory of fairness, but they include a closely related theory called "implicit contracts" and described as follows: "firms tacitly agree to stabilize prices, perhaps out of fairness to customers". Such a fairness theory receives abundant support from firms, as shown in Table 1: while no theory clearly dominates the surveys, the fairness theory always finishes amongst the most relevant ones. Firms appear to take fairness into account when they set their prices.

Last, our assumption that buyers care not only about consumption but also about firms' markups implies that firms may wish to transmit some cost information to households. In particular, firms

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[17]Table 5.1 in Blinder et al. [1998] summarizes the twelve commonly proposed theories. While a useful modeling device, the infrequent pricing of Calvo [1983] does not provide a theory of price rigidity and could therefore not be evaluated. Besides macroeconomic theories, industrial-organization theories of price rigidity, such as coordination failure and quality signaling, are also typically included.

(a) A sandwich shop in Columbus, OH, 2008 (photo: S. Petrov)

(b) A taqueria in Kona, HI, 2008 (photo: P. Michaillat)

Figure 5: Examples of Firms Justifying Price Increases by Cost Increases

with high marginal costs may wish to reveal them to households whose estimates are too low.[18] Empirical evidence suggests that firms indeed try to justify price increases caused by cost increases. Zbaracki et al. [2004] study the pricing process of a large firm and find that the firm expends substantial resources communicating and justifying price increases to customers. The observation that firms attempt to rationalize price increases dates at least back to Okun [1975], who noted that firms aim to "justify cost-oriented price increases—a desire evident in the dedicated, if fuzzy, statements that firms issue, insisting that higher costs force them to raise prices". Our own observations suggest that these statements are indeed prevalent, as showed in Figure 5. The picture in Panel (a) is interesting because the shop explicitly states that it "strives" to serve food "at a fair price". The picture in Panel (b) is interesting because it was taken on an island without competing taquerias; hence, the firm did not post its sign to signal higher competitor prices, something that firms may do when consumers face search costs. Appendix B provides additional statements of this kind.

5. The Effect of Money-Supply Shocks on Welfare

We now turn to the welfare implications of money-supply shocks. We define two notions of welfare, one that includes an emotional, fairness-based component, and one that does not. Since a

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[18]In this paper firms have no ability to signal marginal costs, but we could extend the model to allow for signaling.

household's utility is given by (2), we define *overall welfare* to be

$$u = \ln(c) - \frac{1}{1+\xi} \cdot n^{1+\xi} + \frac{1}{\eta} \cdot \ln\left(\frac{M_0}{P}\right) + \left(1 + \frac{1}{\eta}\right) \cdot \ln(\psi).$$

We distinguish this from the notion of *unemotional welfare* that omits fairness considerations. Unemotional welfare is obtained by setting $\psi = 1$ in overall welfare:

$$\hat{u} = \ln(c) - \frac{1}{1+\xi} \cdot n^{1+\xi} + \frac{1}{\eta} \cdot \ln\left(\frac{M_0}{P}\right).$$

Unemotional welfare corresponds to a conventional measure of welfare, accounting for consumption, leisure, and real money balances, but abstracting from the psychological cost of buying goods at prices perceived as unfair.

First, we characterize the response of unemotional welfare to an increase in money supply.

PROPOSITION 6. *When households care about fairness ($\phi > 0$) and make cursed inferences ($\chi > 0$), an increase in money supply increases unemotional welfare.*

When evaluating welfare as if households' well-being did not depend upon their concern for fairness, an increase in money supply always improves welfare. Intuitively, monopolistic distortions on the goods and labor markets entail that any policy that reduces the markup on either market, including increased money supply, leads to higher $\ln(c) - n^{1+\xi}/(1+\xi)$.[19] In addition, an increase in money supply M_0 increases the utility from real money, $(1/\eta) \cdot \ln(M_0/P)$, because the price level P responds less than proportionally to the increase in M_0. Consequently, unemotional welfare rises with money supply.

Next, we turn to the response of overall welfare to an increase in money supply.

PROPOSITION 7. *When households care about fairness ($\phi > 0$) and make cursed inferences ($\chi > 0$), an increase in money supply decreases overall welfare.*

Although an increase in money supply increases unemotional welfare, it reduces overall welfare. The discrepancy arises because an increase in money supply increases perceived markups

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[19]The proof of Proposition 6 in Appendix A shows that if there were no monopolistic distortions (that is, if markups were one on the goods and labor markets), the effect on $\ln(c) - n^{1+\xi}/(1+\xi)$ would be zero. The proof also shows that the more distorted is the economy (that is, the higher are the markups), the larger is the positive effect of an increase in money supply on $\ln(c) - n^{1+\xi}/(1+\xi)$.

and, thus, decreases the perceived fairness of prices. Although our model may be too simple to draw detailed implications for optimal monetary policy, it suggests that increased money supply imposes a first-order cost on welfare through people's emotional response to higher prices. The welfare cost is psychological and thus very different from the welfare cost of inflation in existing monetary models. For instance, in the New Keynesian model, the welfare cost of inflation arises from the price dispersion it creates when firms are subject to staggered pricing.

Proposition 7 also suggests that expansionary monetary policy may prove unpopular by upsetting people with higher prices more than it gratifies them with higher consumption. This accords well with the survey responses in Shiller [1997], in which 85% of respondents report disliking inflation. The proposition also sheds light on the evidence provided by Di Tella, MacCulloch and Oswald [2001] that social well-being is strongly reduced by inflation. Their data comes from the Euro-Barometer survey, which records happiness and life-satisfaction information for nearly 265,000 people in 12 European countries during the 1975–1991 period. They study how the residual macroeconomic well-being (the level of well-being not explained by individual characteristics) depends on inflation. They find that increasing the inflation rate by 1 percentage point has a large well-being cost, similar to the cost of increasing the unemployment rate by 0.6 percentage point.

The decrease in overall welfare after an increase in money supply results from households' misperception that higher prices reflect higher markups. If we kept the equilibrium as it is but evaluated overall welfare with correct beliefs about goods-market markups (instead of cursed beliefs), we would find that welfare increases in money supply. Equivalently, if we added a measure zero of fairness-minded rational households to the model—being in measure zero, these households would not affect equilibrium—the fairness-minded rational households would see their overall welfare rise with money supply. Indeed, their unemotional welfare would rise and their overall welfare would rise even more because they would understand that goods-market markups have fallen so that transactions have become fairer.

To simplify the analysis, we have assumed throughout that the psychological fairness factor is a linear function of the perceived markup given by (1). To explore the extent to which our welfare results rely on linearity, we now allow the fairness factor to be a nonlinear function of the perceived

markup given by

$$\psi_i^\beta = \left[1 - \frac{\phi}{\mu^p} \cdot \left(\mu_i^p - \mu_i^f \right) \right]^\beta, \tag{20}$$

where $\beta > 0$. When $\beta > 1$, the higher households perceive markups, the less they dislike a marginal increase in markup: households have diminishing sensitivity to markups. When $\beta > 1$, households' sensitivity to markups rises with perceived markups.

PROPOSITION 8. *Consider an economy in which households care about fairness ($\phi > 0$), have the generalized fairness factor (20), and make cursed inferences ($\chi > 0$). First, an increase in money supply increases unemotional welfare. Second, for any $\beta \geq 1$, an increase in money supply decreases overall welfare. Third, for any equilibrium markup $\mu \in ((\varepsilon - \phi)/(\varepsilon - 1), \varepsilon/(\varepsilon - 1))$, there is $\beta(\mu) < 1$ such that for any $\beta < \beta(\mu)$, an increase in money supply increases overall welfare.*

When households have diminishing sensitivity to markups ($\beta > 1$), an increase in money supply necessarily reduces overall welfare, even though it raises unemotional welfare. However, for any level of the equilibrium markup, it is always possible to find a parameter β sufficiently smaller than 1 such that an increase in money supply raises overall welfare.[20]

6. Conclusion

This paper presents a macroeconomic model in which fairness matters on the goods market. Consumers dislike paying more than a fair markup over marginal costs. These preferences for fair prices lower the markups that firms set, but alone they cannot explain money nonneutrality. However, when consumers only partially update their beliefs about marginal costs from available information, an increase in money supply makes consumers partially misattribute higher prices to higher markups, discouraging firms from fully passing along the increase in nominal marginal costs. In this case money has real effects. Although greater money supply stimulates output, it

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[20]As can be seen in Appendix A, the curvature of the fairness factor, parameterized by β, plays two roles in the analysis. First, β influences the price elasticity of the fairness factor, which then influences the goods-market markup and the pass-through. This first effect enters the emotional and unemotional components of welfare. Second, lowering β reduces the marginal disutility from unfair prices (the disutility from unfair prices is the term $(1 + 1/\eta) \cdot \beta \cdot \ln(\psi)$ in equation (A18)). This second effect is preeminent. Consequently, lowering β can reverse the welfare results obtained in the linear case ($\beta = 1$) such that increasing money supply raises overall welfare.

lowers the perceived fairness of transactions, inflicting a psychological cost on consumers that can offset the economic benefit. Hence, our model helps bridge the gap between people's attitudes toward inflation in the real world and in macroeconomic models.[21]

Abundant evidence shows that consumers care about the fairness of prices, and there is a view that incorporating fairness into macroeconomic models would allow us to better understand many phenomena [Akerlof, 2002]. However, many models of social preferences, such as the those of Rabin [1993], Fehr and Schmidt [1999], and Charness and Rabin [2002], have the property that fairness considerations do not affect people's marginal rates of substitution amongst different goods or between labor and leisure.[22] Consequently, people behave in general competitive equilibrium as if they did not care about fairness [Dufwenberg et al., 2011].

Our formulation of fairness has the advantage that it affects the general equilibrium, even under perfect competition.[23] Consumers who feel mistreated by firms withhold demand not to punish firms, as in models of social preferences, but instead because they derive less joy from consuming unfairly priced goods. Fairness perceptions affect marginal rates of substitution between goods, influencing the general equilibrium even with perfect competition, which explains why our preferences exert large effects on the general equilibrium with monopolistic competition. We view our approach and the other models of social preference approach as complementary: while we fully agree with Schmidt [2011] that these other models of social preferences offer important insights on agency problems in organizational settings, we also believe that our preferences may play an important role in macroeconomic settings.

In our model, because households supply labor monopolistically, no one experiences involuntary unemployment, nor are nominal wages rigid. Extending the model to include involuntary unemployment and nominal-wage rigidity would alter the effect of increasing money supply on welfare in at least three ways. First, as Akerlof, Dickens and Perry [1996] proposed, an increase in money supply would erode real wages in the presence of nominal-wage rigidity, thus reducing unemployment and improving economic efficiency beyond the improvement on the goods mar-

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[21]See for instance Romer [2001, p.519]: "Inflation's costs are not well understood. There is a wide gap between the popular view of inflation and the costs of inflation that economist can identify. Inflation is intensely disliked."

[22]Rotemberg [2005] employs such preferences.

[23]Because we focus on a symmetric equilibrium with a common fair markup across goods, fairness plays no role in the competitive limit of our model ($\varepsilon \to \infty$). But with different fair markups for different goods, fairness would matter even in the competitive limit.

ket studied in this paper. Second, our analysis suggests that an increase in money supply may leave an average worker with a stable job—who looks like the representative household in our model—worse-off because the anger from higher perceived markups dominates the added utility from higher consumption. However, an increase in money supply might benefit an unemployed worker immensely by improving employment prospects through increased labor demand. If people find unemployment very costly, either due to decreased consumption or psychological costs, then reducing unemployment would improve welfare in substantial ways neglected by our model. Third, people seem to fear that rising prices outpace wages, and that inflation impoverishes them. This fear features preeminently in Shiller [1997] and could add to the cost of increased money supply when nominal wages sluggishly adjust to shocks.

By virtue of being static, our model can only represent the short-term and not the long-term response to monetary shocks. Of course, the effects of monetary shocks diminish over time, and money is usually thought to be neutral in the long term. We suspect, however, that a dynamic extension of our model in which consumers gradually adjust their perceptions of marginal costs would predict nonneutral money in the short term and neutral money in the long term.

References

Akerlof, George A. 1969. "Relative Wages and the Rate of Inflation." *Quarterly Journal of Economics*, 83(3): 353–374.

Akerlof, George A. 2002. "Behavioral Macroeconomics and Macroeconomic Behavior." *American Economic Review*, 92(3): 411–433.

Akerlof, George A., and Janet L. Yellen. 1985. "A Near-Rational Model of the Business Cycle, With Wage and Price Inertia." *Quarterly Journal of Economics*, 100: 823–838.

Akerlof, George A., William T. Dickens, and George L. Perry. 1996. "The Macroeconomics of Low Inflation." *Brookings Papers on Economic Activity*, 1996(1): 1–76.

Alvarez, Luis J., and Ignacio Hernando. 2005. "Price Setting Behaviour of Spanish Firms: Evidence from Survey Data." European Central Bank Working Paper 538.

Amirault, David, Carolyn Kwan, and Gordon Wilkinson. 2006. "Survey of Price-Setting Behaviour of Canadian Companies." Bank of Canada Working Paper 06-35.

Apel, Mikael, Richard Friberg, and Kerstin Hallsten. 2005. "Microfoundations of Macroeconomic Price Adjustment: Survey Evidence from Swedish Firms." *Journal of Money, Credit and Banking*, 37(2): 313–338.

Aucremanne, Luc, and Martine Druant. 2005. "Price-Setting Behaviour in Belgium: What Can Be Learned from an Ad Hoc Survey?" European Central Bank Working Paper 448.

Basu, Susanto, John G. Fernald, and Miles S. Kimball. 2006. "Are Technology Improvements Contractionary?" *American Economic Review*, 96(5): 1418–1448.

Bewley, Truman F. 1999. *Why Wages Don't Fall During a Recession.* Cambridge, MA:Harvard University Press.

Bils, Mark. 1987. "The Cyclical Behavior of Marginal Cost and Price." *American Economic Review*, 77(5): 838–855.

Bils, Mark. 1989. "Pricing in a Customer Market." *Quarterly Journal of Economics*, 104(4): 699–718.

Bils, Mark, and James A. Kahn. 2000. "What Inventory Behavior Tells Us about Business Cycles." *American Economic Review*, 90(3): 458–481.

Blanchard, Olivier J. 1990. "Why Does Money Affect Output? A Survey." In *Handbook of Monetary Economics*. Vol. 2, , ed. Benjamin M. Friedman and Frank H. Hahn, 779–835. Amsterdam:Elsevier.

Blanchard, Olivier J., and Nobuhiro Kiyotaki. 1987. "Monopolistic Competition and the Effects of Aggregate Demand." *American Economic Review*, 77(4): 647–666.

Blinder, Alan S., Elie R. D. Canetti, David E. Lebow, and Jeremy B. Rudd. 1998. *Asking about Prices.* New York, NY:Russell Sage Foundation.

Calvo, Guillermo A. 1983. "Staggered Prices in a Utility-Maximizing Framework." *Journal of Monetary Economics*, 12(3): 383–398.

Carillo, Juan, and Thomas Palfrey. 2011. "No Trade." *Games and Economic Behavior*, 71(1): 66–87.

Carlton, Dennis W. 1986. "The Rigidity of Prices." *American Economic Review*, 76(4): 637–658.

Charness, Gary, and Matthew Rabin. 2002. "Understanding Social Preferences with Simple Tests." *Quarterly Journal of Economics*, 117(3): 817–869.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans. 1999. "Monetary Policy Shocks: What Have We Learned And To What End?" In *Handbook of Macroeconomics*. Vol. 1A, , ed. John B. Taylor and Michael Woodford, 65–148. Amsterdam:Elsevier.

Di Tella, Rafael, Robert J. MacCulloch, and Andrew J. Oswald. 2001. "Preferences over Inflation and Unemployment: Evidence from Surveys of Happiness." *American Economic Review*, 91(1): 335–341.

Dufwenberg, Martin, Paul Heidhues, Georg Kirchsteiger, Frank Riedel, and Joel Sobel. 2011. "Other-Regarding Preferences in General Equilibrium." *Review of Economic Studies*, 78(2): 613–639.

Esponda, Ignacio, and Emanuel Vespa. 2014. "Hypothetical Thinking and Information Extraction in the Laboratory." *American Economic Journal: Microeconomics*, 6(4): 180–202.

Eyster, Erik, and Matthew Rabin. 2005. "Cursed Equilibrium." *Econometrica*, 73(5): 1623–1672.

Fehr, Ernst, and Klaus M. Schmidt. 1999. "A Theory of Fairness, Competition, and Cooperation." *Quarterly Journal of Economics*, 114(3): 817–868.

Fischer, Stanley. 1977. "Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule." *Journal of Political Economy*, 85(1): 191–205.

Fraichard, Julien. 2006. "Le Commerce en 2005." http://www.insee.fr/fr/ffc/docs_ffc/ref/comfra06bb.pdf.

Francis, Neville, and Valerie A. Ramey. 2009. "Measures of per Capita Hours and Their Implications for the Technology-Hours Debate." *Journal of Money, Credit and Banking*, 41(6): 1071–1097.

Friedman, Milton, and Anna J. Schwartz. 1963. *A Monetary History of the United States, 1867-1960 .* Princeton, NJ:Princeton University Press.

Galí, Jordi. 1994. "Monopolistic Competition, Business Cycles, and the Composition of Aggregate Demand." *Journal of Economic Theory*, 63(1): 73–96.

Galí, Jordi. 1999. "Technology, Employment, and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?" *American Economic Review*, 89(1): 249–271.

Galí, Jordi. 2008. *Monetary Policy, Inflation, and the Business Cycle.* Princeton, NJ:Princeton University Press.

Galí, Jordi, and Pau Rabanal. 2004. "Technology Shocks and Aggregate Fluctuations: How Well Does the Real Business Cycle Model Fit Postwar U.S. Data?" *NBER Macroeconomics Annual*, 19: 225–288.

Hall, R. L., and C. J. Hitch. 1939. "Price Theory and Business Behaviour." *Oxford Economic Papers*, 2: 12–45.

Hall, Simon, Mark Walsh, and Anthony Yates. 2000. "Are UK Companies' Prices Sticky?" *Oxford Economic Papers*, 52(3): 425–446.

Hoeberichts, Marco, and Ad Stokman. 2006. "Pricing Behaviour of Dutch Companies: Main Results from a Survey." European Central Bank Working Paper 607.

Holt, Charles A., and Roger Sherman. 1994. "The Loser's Curse." *American Economic Review*, 84(3): 642–652.

Jehiel, Philippe. 2005. "Analogy-Based Expectation Equilibrium." *Journal of Economic Theory*, 123(2): 81–104.

Jehiel, Philippe, and Frédéric Koessler. 2008. "Revisiting Games of Incomplete Information with Analogy-Based Expectations." *Games and Economic Behavior*, 62(2): 533–557.

Kackmeister, Alan. 2007. "Yesterday's Bad Times Are Today's Good Old Times: Retail Price Changes Are More Frequent Today Than in the 1890s." *Journal of Money, Credit and Banking*, 39(8): 1987–2020.

Kagel, John, and Dan Levin. 2002. *Common Value Auctions and the Winner's Curse.* Princeton, NJ:Princeton University Press.

Kahneman, Daniel, Jack L. Knetsch, and Richard Thaler. 1986. "Fairness as a Constraint on Profit Seeking: Entitlements in the Market." *American Economic Review*, 76(4): 728–41.

Kaplan, Steven Laurence. 1996. *The Bakers of Paris and the Bread Question: 1700-1755.* Durham, NC:Duke University Press.

Kwapil, Claudia, Joseph Baumgartner, and Johann Scharler. 2005. "The Price-Setting Behaviour of Austrian Firms: Some Survey Evidence." European Central Bank Working Paper 464.

Loupias, Claire, and Roland Ricart. 2004. "Price Setting in France: New Evidence from Survey Data." European Central Bank Working Paper 448.

Lucas, Robert E. 1972. "Expectations and the Neutrality of Money." *Journal of Economic Theory*, 4(2): 103–124.

Lunnemann, Patrick, and Thomas Y. Matha. 2006. "New Survey Evidence on the Pricing Behavior of Luxembourg Firms." European Central Bank Working Paper 617.

Mankiw, N. Gregory. 1985. "Small Menu Costs and Large Business Cycles: A Macroeconomic Model." *Quarterly Journal of Economics*, 100(2): 529–537.

Mankiw, N. Gregory, and Ricardo Reis. 2010. "Imperfect Information and Aggregate Supply." In *Handbook of Monetary Economics*. Vol. 3, , ed. Benjamin M. Friedman and Michael Woodford, 183–229. Amsterdam:Elsevier.

Martins, Fernando. 2005. "The Price Setting Behaviour of Portuguese Firms: Evidence From Survey Data." European Central Bank Working Paper 562.

Miller, Judith A. 1999. *Mastering the Market. The State and the Grain Trade in Northern France, 1700-1860.* Cambridge:Cambridge University Press.

Nekarda, Christopher J., and Valerie A. Ramey. 2013. "The Cyclical Behavior of the Price-Cost Markup." National Bureau of Economic Research (NBER) Working Paper 19099.

Okun, Arthur M. 1975. "Inflation: Its Mechanics and Welfare Costs." *Brookings Papers on Economic Activity*, 6(2): 351–402.

Okun, Arthur M. 1981. *Prices and Quantities: A Macroeconomic Analysis.* Washington, DC:Brookings Institution.

Rabin, Matthew. 1993. "Incorporating Fairness into Game Theory and Economics." *American Economic Review*, 83(5): 1281–1302.

Robinson, Joan. 1932. *The Economics of Imperfect Competition.* London:Macmillan.

Romer, Christina D., and David Romer. 2004. "A New Measure of Monetary Policy Shocks: Derivation and Implications. ." *American Economic Review*, 94(4): 1055–1084.

Romer, David. 2001. *Advanced Macroeconomics. .* 2nd ed., New York, NY:McGraw-Hill.

Rotemberg, Julio J. 1982. "Monopolistic Price Adjustment and Aggregate Output." *Review of Economic Studies*, 49(4): 517–531.

Rotemberg, Julio J. 2005. "Customer Anger at Price Increases, Changes in the Frequency of Price Adjustment and Monetary Policy." *Journal of Monetary Economics*, 52(4): 829–852.

Rotemberg, Julio J. 2009. "Behavioral Aspects of Price Setting, and Their Policy Implications." In *Policymaking Insights from Behavioral Economics.* , ed. Christopher L. Foote, Lorenz Goette and Stephan Meier, 51–92. Boston, MA:Federal Reserve Bank of Boston.

Rotemberg, Julio J., and Garth Saloner. 1986. "A Supergame-Theoretic Model of Price Wars during Booms." *American Economic Review*, 76(3): 390–407.

Rotemberg, Julio J., and Michael Woodford. 1999. "The Cyclical Behavior of Prices and Costs." In *Handbook of Macroeconomics.* Vol. 1B, , ed. John B. Taylor and Michael Woodford, 1051–1135. Amsterdam:Elsevier.

Samuelson, William F., and Max H. Bazerman. 1985. "The Winner's Curse in Bilateral Negotiations." In *Research in Experimental Economics.* Vol. 3, , ed. Vernon L. Smith, 105–137. Greenwich, CT:JAI Press.

Schmidt, Klaus M. 2011. "Social Preferences and Competition." *Journal of Money, Credit and Banking*, 43(5): 207–231.

Shafir, Eldar, Peter Diamond, and Amos Tversky. 1997. "Money Illusion." *Quarterly Journal of Economics*, 112(2): 341–374.

Shiller, Robert J. 1997. "Why Do People Dislike Inflation?" In *Reducing Inflation: Motivation and Strategy.* , ed. Christina D. Romer and David H. Romer, 13–70. Chicago, IL:University of Chicago Press.

Sims, Christopher A. 2010. "Rational Inattention and Monetary Economics." In *Handbook of Monetary Economics.* Vol. 3, , ed. Benjamin M. Friedman and Michael Woodford, 155–181. Amsterdam:Elsevier.

Stiglitz, Joseph E. 1984. "Price Rigidities and Market Structure." *American Economic Review*, 74(2): 350–355.

Taylor, John B. 1979. "Staggered Wage Setting in a Macro Model." *American Economic Review*, 69(2): 108–113.

Weizsäcker, Georg. 2010. "Do We Follow Others when We Should? A Simple Test of Rational Expectations." *American Economic Review*, 100(5): 2340–2360.

Zbaracki, Mark J., Mark Ritson, Daniel Levy, Shantanu Dutta, and Mark Bergen. 2004. "Managerial and Customer Costs of Price Adjustment: Direct Evidence from Industrial Markets." *Review of Economics and Statistics*, 86(2): 514–533.

Appendices For Online Publication

Appendix A: Derivations and Proofs

Solving the Households' Utility-Maximization and Firms' Profit-Maximization Problems.
Taking as given $\{P_i\}$, M_{0j}, and Π_j, household j chooses $\{c_{ij}\}$, M_j, n_j, and W_j to maximize (2) subject to the constraint (3) (Lagrange multiplier $\mathscr{A}_j$) and to the constraint $n_j = n_j^d(W_j)$ (Lagrange multiplier $\mathscr{B}_j$). The labor demand $n_j^d(W_j)$ gives the quantity of labor that firms would hire from household j at a nominal wage W_j. The labor demand is a decreasing function of W_j determined below.

The first-order conditions with respect to c_{ij} for all i are $(\psi_i/z_j) \cdot (z_{ij}/z_j)^{-1/\varepsilon} = \mathscr{A}_j \cdot P_i$, where we used the fact that $\partial z_j/\partial z_{ij} = (z_{ij}/z_j)^{-1/\varepsilon} di$. Manipulating these first-order conditions yields

$$\mathscr{A}_j = \frac{1}{\hat{P} \cdot z_j}. \tag{A1}$$

Combining these two results, we obtain the optimal consumption of good i for household j:

$$c_{ij} = \frac{z_j}{\psi_i} \cdot \left(\frac{P_i/\psi_i}{\hat{P}} \right)^{-\varepsilon}.$$

Integrating the consumption of good i over all households yields the demand (6) for good i. Next, the first-order condition with respect to M_j is $1/(\eta \cdot M_j) = \mathscr{A}_j$. Combining this condition with (A1) yields (7).

Given household j's demand for good i, the fairness-adjusted price index has the property that the total cost of purchasing goods equals the fairness-adjusted price index times the fairness-adjusted consumption index:

$$\int_0^1 P_i \cdot c_{ij}\, di = \hat{P} \cdot z_j.$$

This property can be verified by substituting in the expressions for the optimal c_{ij}:

$$\int_0^1 P_i \cdot c_{ij} di = \hat{P} \cdot \int_0^1 \frac{P_i}{\hat{P}} \cdot c_{ij} di = \hat{P} \cdot z_j \cdot \int_0^1 \left(\frac{P_i/\psi_i}{\hat{P}} \right)^{1-\varepsilon} di = \hat{P} \cdot z_j \cdot \frac{\hat{P}^{1-\varepsilon}}{\hat{P}^{1-\varepsilon}} = \hat{P} \cdot z_j.$$

Hence, $\hat{P}$ is the price index used by households to deflate nominal money balances in their utility function.

Because the quantity of labor supplied by household j depends on firms' demand for its labor, we turn to the firm's profit maximization problem before returning to the household. The firm maximizes profits (5) subject to the constraint $c_i = c_i^d(P_i)$ (with Lagrange multiplier $\mathscr{C}_i$) and the constraint (4) (with Lagrange multiplier $\mathscr{D}_i$). The demand curve $c_i^d(P_i)$ is given by (6).

The first-order conditions with respect to n_{ij} for all j are $W_j = \mathscr{D}_i \cdot a_i \cdot \alpha \cdot n_i^{\alpha-1} \cdot (n_{ij}/n_i)^{-1/\nu}$, where we used the fact that $\partial n_i/\partial n_{ij} = (n_{ij}/n_i)^{-1/\nu} dj$. Manipulating these first-order conditions

yields

$$\mathscr{D}_i = \frac{W}{a_i \cdot \alpha \cdot n_i^{\alpha-1}}, \tag{A2}$$

where $W \equiv \left(\int_0^1 W_j^{1-v} dj\right)^{\frac{1}{1-v}}$ is the nominal wage index. Combining these two results, we obtain the quantity of labor that firm i hires from household j:

$$n_{ij} = n_i \cdot \left(\frac{W_j}{W}\right)^{-v}.$$

Integrating the quantities n_{ij} over all firms i yields the labor demand (8) faced by household j.

Next, the first-order conditions with respect to c_i and P_i are $P_i = \mathscr{C}_i + \mathscr{D}_i$ and $c_i = -\mathscr{C}_i \cdot dc_i^d/dP_i$. Combining these conditions with (A2) yields (10).

Having determined the labor demands faced by households, we come back to household j and determine the wage W_j that it sets. The first-order conditions with respect to n_j and W_j are $n_j^{\xi} = \mathscr{A}_j \cdot W_j + \mathscr{B}_j$ and $\mathscr{A}_j \cdot n_j = \mathscr{B}_j \cdot dn_j^d/dW_j$. Combining these conditions with (A1) and (7), and using the fact that $-(W_j/n_j) \cdot (dn_j^d/dW_j) = v$, we find that household j sets its wage as in (9).

Proof of Proposition 1. Firms understand that households are rational and able to infer their marginal cost and thus their markup by observing the price level and employment. Hence, the markup μ^* charged by firms facing rational households satisfies $\mu^* = \mu(\mu^*)$, where $\mu(\mu^p)$ is given by (15).

Since $\mu = \mu^*$, equation (16) implies that employment is independent of money supply and technology. Equation (13) implies that the real wage is independent of money supply but proportional to technology. In a symmetric equilibrium, equation (4) becomes

$$c = a \cdot n^{\alpha}. \tag{A3}$$

It implies that output is independent of money supply but proportional to technology. Equation (12) implies that the price is proportional to money supply and inversely proportional to technology.

By combining equations (5), (10), and (A3), we obtain an expression for real profits

$$\frac{\Pi}{P} = c \cdot \left(1 - \frac{\alpha}{\mu}\right) \tag{A4}$$

that is independent of money supply but proportional to technology. The only remaining part of the proof is to compare profits in the equilibria with and without fairness concerns. To do so, we compute the elasticity of real profits with respect to the markup. Equation (A3) implies that $d\ln(c)/d\ln(n) = \alpha$ and equation (16) implies that $d\ln(n)/d\ln(\mu) = -1/(1+\xi)$ so $d\ln(c)/d\ln(\mu) = -\alpha/(1+\xi)$. The definition of real profits implies that $d\ln(\Pi/P)/d\ln(\mu) = d\ln(c)/d\ln(\mu) + \alpha/(\mu-\alpha)$. Combining these results, we obtain

$$\frac{d\ln(\Pi/P)}{d\ln(\mu)} = \alpha \cdot \left(\frac{1}{\mu-\alpha} - \frac{1}{1+\xi}\right). \tag{A5}$$

Since $1/(1+\xi) < 1$, the elasticity is positive as long as $\mu < 1+\alpha$.

Proof of Proposition 2. First, we show that for any $P > 0$, there is a unique n that solves equation (16) when μ^p is given by (19). The equation can be written as

$$(1+\xi) \cdot \ln(n) = \ln(\alpha) - \ln\left(\mu\left(\gamma \cdot n^{-(1+\xi)\cdot(1-\chi)} \cdot P^{\chi}\right)\right) - \ln\left(\frac{v}{v-1}\right), \tag{A6}$$

where the function $\mu(\mu^p)$ is given by (15) and

$$\gamma \equiv \overline{MC}^{-\chi} \cdot \left[\frac{\alpha \cdot (v-1)}{v}\right]^{1-\chi} > 0.$$

Using Lemma 1, it is clear that the right-hand side of (A6) is a continuous and strictly decreasing function of n on $(0,+\infty)$. Furthermore, since $P > 0$ and $\gamma > 0$, the right-hand side of (A6) converges to

$$\ln(\alpha) - \ln\left(\frac{\varepsilon - \phi}{\varepsilon - 1}\right) - \ln\left(\frac{v}{v-1}\right) \tag{A7}$$

when $n \to 0$ and to

$$\ln(\alpha) - \ln\left(\frac{\varepsilon}{\varepsilon - 1}\right) - \ln\left(\frac{v}{v-1}\right) \tag{A8}$$

when $n \to +\infty$. We obtain these asymptotes from the limits of the function $\mu(\mu^p)$ obtained in Lemma 1. In addition, the left-hand side of (A6) is a continuous and strictly increasing function of n on $(0,+\infty)$ that converges to $-\infty$ when $n \to 0$ and to $+\infty$ when $n \to +\infty$. The intermediate-value theorem implies that there is a unique $n \in (0,+\infty)$ that solves equation (A6) for any $P > 0$. We conclude that the function n^F is well-defined.

Second, since the right-hand side of (A6) is strictly increasing with P, the implicit-function theorem implies that the function n^F is continuously differentiable and is strictly increasing in P. Given that the function $\mu(\mu^p)$ is bounded, we infer that the function n^F admits a positive lower bound and an upper bound. From this and from the logic used above, we infer that $n^F(P)$ converges to (A8) when $P \to 0$ and to (A7) when $P \to +\infty$.

The properties of the function n^H are obvious. From the properties of n^H and n^F, the intermediate-value theorem implies that there exists a unique $P > 0$ that solves the equation $n^H(P,a,M_0) = n^F(P)$. Hence, the general equilibrium always exists and is unique.

Proof of Proposition 3. Equation (12) implies that a high realization of M_0 shifts the downward-sloping curve upward in Figure 4(a). Hence, P and n are higher in equilibrium. Equations (13) and (A3) imply that W/P and c are higher. Since n is higher, equation (16) implies that μ is lower. Since μ is lower, Lemma 1 implies that μ^p is higher. Since μ^p is higher, $\psi = 1 - \phi + \phi \cdot \mu^f/\mu^p$ is higher. The response of μ determines that of real profits, Π/P. The elasticity (A5) of Π/P with respect to μ remains valid. The elasticity is positive when $\mu < 1+\alpha$; in this case, Π/P is lower.

Proof of Proposition 4.   Differentiating equation (16) yields

$$(1+\xi)\cdot\frac{d\ln(n)}{d\ln(M_0)} = -\frac{d\ln(\mu)}{d\ln(\mu^p)}\cdot\left(\frac{\partial\ln(\mu^p)}{\partial\ln(n)}\cdot\frac{d\ln(n)}{d\ln(M_0)}+\frac{\partial\ln(\mu^p)}{\partial\ln(P)}\cdot\sigma\right).$$

Differentiating equation (12) yields

$$\frac{d\ln(n)}{d\ln(M_0)} = \frac{1-\sigma}{\alpha}.\tag{A9}$$

Equation (19) yields the following elasticities:

$$\frac{\partial\ln(\mu^p)}{\partial\ln(n)} = -(1+\xi)\cdot(1-\chi)$$

$$\frac{\partial\ln(\mu^p)}{\partial\ln(P)} = \chi.$$

The markup set by firms is given by equation (15), which can be rewritten as

$$\mu = \frac{1}{\varepsilon-1}\cdot\left(\varepsilon-\frac{\phi}{\psi+\phi}\right).\tag{A10}$$

Hence, the elasticity of the markup with respect to the perceived markup is

$$\frac{d\ln(\mu)}{d\ln(\mu^p)} = -\frac{1}{\varepsilon\cdot(\psi+\phi)/\phi-1}\cdot\frac{\psi}{\psi+\phi}\cdot\frac{d\ln(\psi)}{d\ln(\mu^p)}.$$

Given that $\psi = 1-\phi+\phi\cdot\mu^f/\mu^p$, we infer that

$$\frac{d\ln(\psi)}{d\ln(\mu^p)} = \frac{\psi+\phi-1}{\psi}.\tag{A11}$$

Arranging these results shows that

$$\frac{d\ln(\mu)}{d\ln(\mu^p)} = -\left(\frac{\psi+\phi-1}{\psi+\phi}\right)\cdot\left(\varepsilon\cdot\frac{\psi+\phi}{\phi}-1\right)^{-1} \equiv -\frac{1}{Z(\psi)}.\tag{A12}$$

The function Z has the following properties: $Z(\psi) \geq \varepsilon-1 > 0$, $\lim_{\psi\to1-\phi}Z(\psi) = +\infty$, and $\lim_{\psi\to+\infty}Z(\psi) = +\infty$. We obtain $Z(\psi) > \varepsilon-1$ because $\psi+\phi = 1+\phi\cdot(\mu^f/\mu^p) \geq 1$ and $\phi \leq 1$ so $\varepsilon\cdot(\psi+\phi)/\phi \geq \varepsilon$ and $1/[1-1/(\psi+\phi)] \geq 1$.

Bringing all these results together yields

$$\frac{1-\sigma}{\alpha}\cdot(1+\xi) = \frac{1}{Z(\psi)}\cdot\left[-(1+\xi)\cdot(1-\chi)\cdot\frac{1-\sigma}{\alpha}+\chi\cdot\alpha\right].$$

Rearranging the equation yields

$$\frac{\sigma}{1-\sigma} = \frac{1+\xi}{\alpha \cdot \chi} \cdot (Z(\psi)+1-\chi). \tag{A13}$$

Obviously, $\sigma/(\sigma-1) > 0$ so $\sigma \in (0,1)$. Furthermore, $Z \geq \varepsilon-1$ and $1-\chi \geq 0$ and $(1+\xi)/(\alpha \cdot \chi) \geq 1$ so $\sigma/(\sigma-1) > \varepsilon-1$ and $\sigma \geq (\varepsilon-1)/\varepsilon$.

Finally, we turn to the elasticities of output, employment, and real wage with respect to the money supply. In a symmetric equilibrium, equation (7) becomes

$$\frac{c}{\eta} = \frac{M_0}{P}. \tag{A14}$$

The elasticity $d\ln(c)/d\ln(M_0)$ is obtained from (A14). The elasticity $d\ln(n)/d\ln(M_0)$ is obtained from (12). Last, the elasticity $d\ln(W/P)/d\ln(M_0)$ is obtained from (13).

Proof of Corollary 1. If $\mu^p = \mu^f$, households find transactions just fair and $\psi = 1$. All the results follow using the results of Proposition 4.

Proof of Proposition 5. Equation (12) implies that a high realization of a shifts the downward-sloping curve downward in Figure 4(b). Hence, P and n are lower in equilibrium. Equation (13) implies that W/P increases less than proportionally to technology. In fact, the elasticity of W/P with respect to a is $d\ln(W/P)/d\ln(a) = 1 - (1-\sigma^a) \cdot (1+\xi/\alpha)$ where $\sigma^a \equiv -d\ln(P)/d\ln(a)$ is the pass-through of technology shocks, normalized to be positive. The analysis of the pass-through that we conduct in the text shows that $\sigma^a \in (0,1)$. Hence, $d\ln(W/P)/d\ln(a)$ is strictly less than 1 and it could be negative. Equation (16) also implies that $P \cdot a$ increases; in other words, P does not decrease as much as $1/a$. Since $P \cdot a$ increases but P decreases, (A14) implies that c increases but c/a decreases. Since n is lower, (16) implies that μ is higher. Since μ is higher, Lemma 1 implies that μ^p is lower. Since μ^p is lower, ψ is higher. Since c increases and μ increases, (A4) implies that real profits increase. In fact, (A4) implies that

$$\frac{d\ln(\Pi/P)}{d\ln(a)} = \frac{\partial \ln(\Pi/P)}{\partial \ln(a)}\bigg|_{\mu} + \frac{\partial \ln(\Pi/P)}{\partial \ln(\mu)}\bigg|_a \cdot \frac{d\ln(\mu)}{d\ln(a)}.$$

Since $\partial \ln(c)/\partial \ln(a)\big|_{\mu} = 1$, (A4) implies that $\partial \ln(\Pi/P)/\partial \ln(a)\big|_{\mu} = 1$. Since $\partial \ln(\Pi/P)/\partial \ln(\mu)\big|_a$ is given by (A5), it is positive if $\mu < 1+\alpha$. We have also showed earlier that $d\ln(\mu)/d\ln(a) > 0$. We conclude that $d\ln(\Pi/P)/d\ln(a) > 1$ if $\mu < 1+\alpha$.

Proof of Propositions 8. The proofs of Propositions 6 and 7 are special cases of this proof for $\beta = 1$.

We begin with some preliminary results. With a nonlinear fairness factor

$$\psi_i^{\beta} = \left[1 - \frac{\phi}{\mu^p} \cdot \left(\mu_i^p - \mu_i^f\right)\right]^{\beta},$$

the elasticity of the fairness factor with respect to P_i is $d\ln(\psi_i^\beta)/d\ln(P_i) = \beta \cdot (\phi/\psi_i) \cdot (\mu_i^p/\mu^p)$. In a symmetric equilibrium, the elasticity becomes $\beta \cdot \phi/\psi$, which is the same as with the linear fairness factor, but for the factor β. Following the logic used to obtain (A10), we find that the markup set by firms is

$$\mu(\mu^p) = \frac{1}{\varepsilon - 1} \cdot \left(\varepsilon - \frac{\beta \cdot \phi}{\psi + \beta \cdot \phi} \right). \tag{A15}$$

The expression for the pass-through is modified since the fairness factor is nonlinear. Following the logic of the proof of Proposition 4, we find that the pass-through remains given by equation (A13), except that the function Z is now given by

$$Z(\psi) \equiv \frac{-1}{d\mu/d\mu^p} = \left(\varepsilon \cdot \frac{\psi + \beta \cdot \phi}{\beta \cdot \phi} - 1 \right) \cdot \left(\frac{\psi + \beta \cdot \phi}{\psi + \phi - 1} \right). \tag{A16}$$

When $\beta = 1$, the expression reduces to our previous expression for Z, given by (A12).

Next, we study the effect of a money-supply shock on unemotional welfare. We start by studying the effect on $\ln(c) - n^{1+\xi}/(1+\xi)$. Equation (A14) yields $d\ln(c)/d\ln(M_0) = 1 - \sigma$. Equation (12) yields $d\ln(n)/d\ln(M_0) = (1-\sigma)/\alpha$ so $d\left[n^{1+\xi}/(1+\xi)\right]/d\ln(M_0) = n^{1+\xi} \cdot (1-\sigma)/\alpha$. Equation (16) shows that $n^{1+\xi} = \alpha \cdot (v-1)/(\mu \cdot v)$. Thus, we have

$$\frac{d\left[\ln(c) - n^{1+\xi}/(1+\xi)\right]}{d\ln(M_0)} = (1-\sigma) \cdot \left(1 - \frac{v-1}{\mu \cdot v} \right).$$

We have $d\left[\ln(c) - n^{1+\xi}/(1+\xi)\right]/d\ln(M_0) > 0$ because $\sigma \in (0,1)$, $\mu > 1$, and $v/(v-1) > 1$.

To obtain the effect of a money-supply shock on unemotional welfare, we add the effect on the utility from holding money, $(1/\eta) \cdot \ln(M_0/P)$, to the effect on the utility $\ln(c) - n^{1+\xi}/(1+\xi)$. Since $d\ln(P)/d\ln(M_0) = \sigma$, we have $d\left[(1/\eta) \cdot \ln(M_0/P)\right]/d\ln(M_0) = (1/\eta) \cdot (1-\sigma)$. Since $\sigma \in (0,1)$, we have $d\left[(1/\eta) \cdot \ln(M_0/P)\right]/d\ln(M_0) > 0$.

Collecting these results, we obtain the effect of a money-supply shock on unemotional welfare:

$$\frac{d\hat{u}}{d\ln(M_0)} = (1-\sigma) \cdot \left(1 + \frac{1}{\eta} - \frac{v-1}{\mu \cdot v} \right). \tag{A17}$$

We find that $d\hat{u}/d\ln(M_0) > 0$ because $\sigma \in (0,1)$, $\mu > 1$, $v > 1$, and $\eta > 0$.

Next, we study the effect of a money-supply shock on overall welfare. Overall welfare is related to unemotional welfare by

$$u = \hat{u} + \left(1 + \frac{1}{\eta} \right) \cdot \beta \cdot \ln(\psi). \tag{A18}$$

We can therefore obtain the effect of a money-supply shock on overall welfare from its effects on

unemotional welfare and ψ. Differentiating equation (16) yields

$$(1+\xi)\cdot\frac{d\ln(n)}{d\ln(M_0)}=-\frac{d\ln(\mu)}{d\ln(\psi)}\cdot\frac{d\ln(\psi)}{d\ln(M_0)}.$$

Equation (A9) gives $d\ln(n)/d\ln(M_0)=(1-\sigma)/\alpha$. Using equations (A11) and (A16), we obtain

$$\frac{d\ln(\mu)}{d\ln(\psi)}=\frac{d\ln(\mu)/d\ln(\mu^p)}{d\ln(\psi)/d\ln(\mu^p)}=-\frac{1}{Z(\psi)}\cdot\frac{\psi}{\psi+\phi-1}.$$

Given the expression for Z in (A16), we find

$$\frac{1}{Z(\psi)}\cdot\frac{\psi}{\psi+\phi-1}=\left(\varepsilon\cdot\frac{\psi+\beta\cdot\phi}{\beta\cdot\phi}-1\right)^{-1}\cdot\frac{\psi}{\psi+\beta\cdot\phi}.$$

Equation (A15) implies that $\psi/(\psi+\beta\cdot\phi)=(\varepsilon-1)\cdot(\mu-1)$ and $\beta\cdot\phi/(\psi+\beta\cdot\phi)=\varepsilon-(\varepsilon-1)\cdot\mu$. Therefore,

$$\frac{1}{Z(\psi)}\cdot\frac{\psi}{\psi+\phi-1}=(\varepsilon-1)\cdot(\mu-1)\cdot\left(\frac{\varepsilon}{\varepsilon-1}\cdot\frac{1}{\mu}-1\right).$$

Bringing these results together, we infer that

$$\frac{d\ln(\psi)}{d\ln(M_0)}=\frac{1+\xi}{\alpha\cdot(\varepsilon-1)}\cdot(1-\sigma)\cdot(\mu-1)^{-1}\cdot\left(\frac{\varepsilon}{\varepsilon-1}\cdot\frac{1}{\mu}-1\right)^{-1}. \qquad (A19)$$

Combining the results from equations (A17) and (A19), we obtain

$$\frac{du}{d\ln(M_0)}=(1-\sigma)\cdot\left(1+\frac{1}{\eta}-\frac{v-1}{\mu\cdot v}\right)-\left(1+\frac{1}{\eta}\right)\cdot\beta\cdot\frac{1+\xi}{\alpha\cdot(\varepsilon-1)}\cdot(1-\sigma)\cdot(\mu-1)^{-1}\cdot\left(\frac{\varepsilon}{\varepsilon-1}\cdot\frac{1}{\mu}-1\right)^{-1}.$$

As long as $\sigma<1$, we find that $du/d\ln(M_0)$ has the same sign as

$$\left(\frac{\varepsilon}{\varepsilon-1}-\mu\right)\cdot(\mu-1)\cdot\left(\mu-\frac{\eta}{1+\eta}\cdot\frac{v-1}{v}\right)-\beta\cdot\frac{(1+\xi)}{\alpha\cdot(\varepsilon-1)}\cdot\mu^2\equiv Q(\mu).$$

Using the polynomial Q, we establish two results, depending on whether $\beta<1$ or $\beta\geq1$.

The first result is that for any $\alpha\leq1$, any $\xi\geq0$, and any $\beta\geq1$, then $Q(\mu)<0$ for any $\mu\in((\varepsilon-\phi)/(\varepsilon-1),\varepsilon/(\varepsilon-1))$. Note that $Q(\mu)<0$ iff

$$\left(\frac{\varepsilon}{\varepsilon-1}-\mu\right)\cdot(\mu-1)\cdot\left(1-\frac{\eta}{1+\eta}\cdot\frac{v-1}{v}\cdot\frac{1}{\mu}\right)-\frac{(1+\xi)\cdot\beta}{\alpha\cdot(\varepsilon-1)}\cdot\mu<0.$$

Since $(1+\xi)\cdot\beta/\alpha>1$ and $\mu>0$, a sufficient condition for $Q(\mu)<0$ is

$$\left(\frac{\varepsilon}{\varepsilon-1}-\mu\right)\cdot(\mu-1)\cdot\left(1-\frac{\eta}{1+\eta}\cdot\frac{v-1}{v}\cdot\frac{1}{\mu}\right)-\frac{\mu}{\varepsilon-1}<0.$$

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Since $(\varepsilon/(\varepsilon-1)-\mu)\cdot(\mu-1)>0$ and $1-[\eta/(1+\eta)]\cdot[(v-1)/v]\cdot(1/\mu)\in(0,1)$, a sufficient condition for $Q(\mu)<0$ is

$$Z(\mu)\equiv(\varepsilon-(\varepsilon-1)\cdot\mu)\cdot(\mu-1)-\mu<0.$$

The polynomial Z is of degree 2 with a negative coefficient on μ^2 so it is strictly convex. Since $Z'(\mu)=2\cdot(\varepsilon-1)\cdot(1-\mu)$, $Z'(1)=0$ and the polynomial Z admits a global maximum at $\mu=1$. Since $Z(1)=-1<0$, we infer that $Z(\mu)<0$ for all μ. The implication is that $Q(\mu)<0$ for all $\mu\in(1,\varepsilon/(\varepsilon-1))$.

We now turn to the case with $\beta<1$. First, $Q(1)<0$ and $Q(\varepsilon/(\varepsilon-1))<0$. Second, for any $\mu\in(1,\varepsilon/(\varepsilon-1))$, there exists a $\beta(\mu)\in(0,1)$ such that for any $\beta<\beta(\mu)$, $Q(\mu)>0$. The upper bound on β is given by

$$\beta(\mu)=X(\mu)\cdot\frac{\alpha\cdot(\varepsilon-1)}{(1+\xi)\cdot\mu^2}<1$$

where for any $\mu\in(1,\varepsilon/(\varepsilon-1))$,

$$X(\mu)\equiv\left(\frac{\varepsilon}{\varepsilon-1}-\mu\right)\cdot(\mu-1)\cdot\left(\mu-\frac{\eta}{1+\eta}\cdot\frac{v-1}{v}\right)<\left(\frac{\varepsilon}{\varepsilon-1}-1\right)\cdot\mu^2=\frac{\mu^2}{\varepsilon-1}.$$

Using the fact that $X(\mu)<\mu^2/(\varepsilon-1)$ for any $\mu\in(1,\varepsilon/(\varepsilon-1))$, it is obvious that $\beta(\mu)<1$ for any $\alpha\le1$ and any $\xi\ge0$.

Appendix B: Evidence on Firms' Behavior after a Cost Increase

In this appendix, we provide some evidence on the response of firms to cost increases. This evidence complements the evidence provided in Figure 5.

Figure A1 is interesting because the coffee shop mentions that they increase their prices "for the first time in over 2 years". Presumably, keeping prices fixed for a long period of time make the announcement that costs have increased more credible.

In Figure A2, an Italian restaurant also explains that they have waited 8 months to pass the cost increase to customers. This note is particularly interesting because the restaurant provides a very detailed breakdown of the increase in cost: wheat (used to make pasta) increased by 70%, eggs (also used to make pasta) increased by 28%, and dairy products increased by 25%. Here again, the level of detail probably aims to make the announcement that costs have increased more credible.

Last, Figure A3 shows that producers go to great lengths to document cost increases. It comprises two displays posted side-by-side in a bakery in Ithaca, NY. The first reproduces several graphs from the New York Times to substantiate the claim. These graphs plot the price of wheat, soybeans, and corn over time. The second explains that the increase in the price of wheat price translated into an increase in the price of flour, a key ingredient for bagels. Interestingly, the bakery promises to "drop the surcharge" when wheat prices return to their normal level.

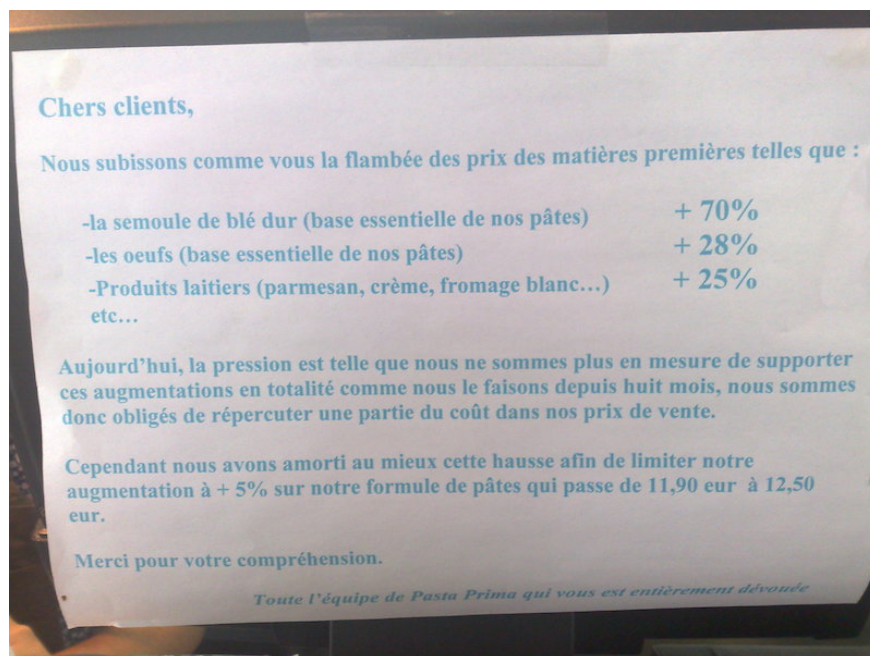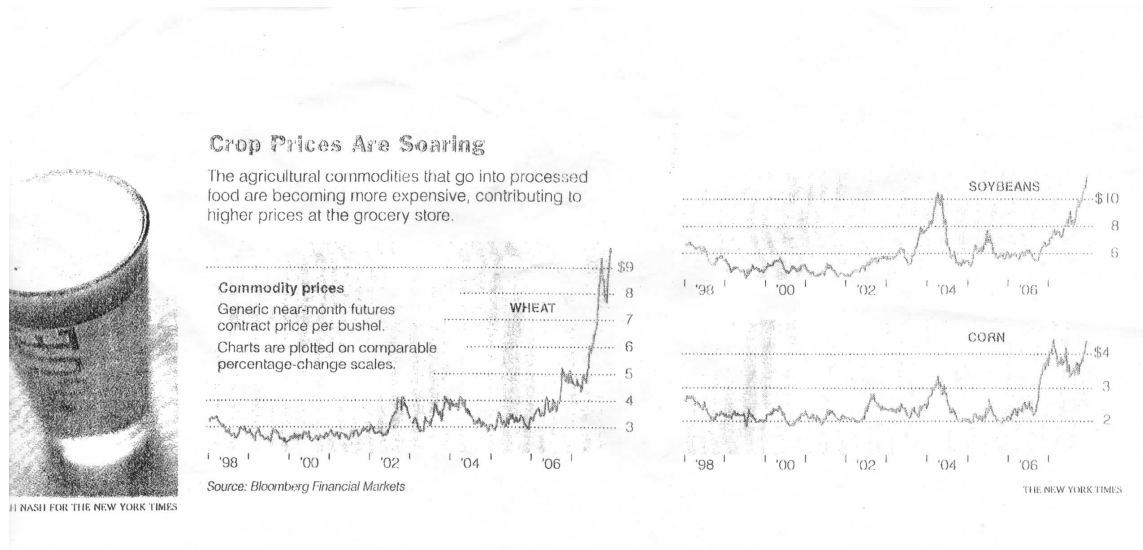Figure A1: A Coffee Shop in London, UK, 2014 (Photo: P. Michaillat)

Figure A2: An Italian Restaurant in Paris, France, 2008 (Photo: M. Franitch-Decaris)

(a) Evidence of higher costs

February 28, 2008

TO OUR VALUED CUSTOMERS
Wheat is continuing to hit record prices, vastly increasing our costs for flour. To cope with this, we are forced to impose a surcharge on bread and bagels, effective immediately. This will include sandwiches. Each week, we will recalculate the surcharge, according to the price of wheat. We hope that this will be temporary, but industry experts do not know when—or if—prices will stabilize.

• Our flour cost has more than tripled in the past month.

• On Monday (2/25/08) the price of March spring wheat on the Minneapolis Grain Exchange hit $24 a bushel, double its cost two months ago and the highest price ever for wheat.

• The high-quality wheat we use to make artisan breads and bagels is getting harder to find.

• U.S. stocks of wheat are now at their lowest level in 60 years.

We can direct customers to substantial references for information about the wheat situation, online and in print.

When prices return to normal, we will drop the surcharge. Please bear with us as we try to address this very serious situation.

Sincerely,
The Brous & Mehaffey Family

(b) Justification for higher prices

Figure A3: A Bakery in Ithaca, NY, 2008 (Photo: D. Benjamin)