A Theory of Slack

How Economic Slack Shapes Markets, Business Cycles, and Policies

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CHAPTER 6.

Price norm

In a slackish market, there are infinitely many ways to split the bilateral surplus enjoyed by traders who have met, and therefore many possible ways to set prices. This property is what allows us to introduce the price norm that determines prices in the market as well as explore different price norms that split the bilateral surplus between buyers and sellers.

This is of course very different from using a Walrasian market where the price has to equalize supply and demand, and is a unique feature of slackish models. But assuming a price norm is not as strange as it might seem at first. In the real world, there are also many ways in which prices are formed—a lot of it is cultural or institutional.

In this chapter, we first review evidence on prices and wages in the United States. This review will show that prices and wages are somewhat rigid: they adjust slowly to shocks that disturb the market. Fairness appears to be a key reason behind price and wage rigidity. We then plug into our slackish market model a price norm that mimics the real world: a price that is neither fixed nor flexible but somewhat rigid. Finally, we derive the implications of that realistic price norm.

6.1. What are price norms?

A price norm is just how buyers or sellers set prices in a market. There is no such thing in a Walrasian market because there the price is set to equalize supply and demand. Sellers have no choice but to adhere to the market price. If they set the price 1 cent above the market price they lose all customers; and there is no reason for anyone to set the price below the market price since they already sell whatever they want at that price.

In the service industry in the United States, prices are actually jointly determined by buyers and sellers. Sellers set a floor price, and then buyers add a tip on top, at their discretion. A tremendous amount of goods and services are transacted that way, where cultural norms determine the price. Basker, Foster, and Stinson (2024) report that between 2008 and 2018 in the United States, tips declared on W-2 forms amount to about $30 billion per year. Furthermore tips are widely underreported: only between 45% and 60% of tips are reported. Assuming 50% of tips are reported, the W-2 numbers imply yearly tips of $60 billion—offered entirely voluntarily by buyers after consumption.

Tips are an example of how culture influences prices. The minimum wage and other price controls show how institutions might influence prices. Huet-Vaughn and Piqueras (2023) provide fascinating evidence from a minimum wage reform in Iowa in 2015, which affected wages paid by firms for many years although the reform itself only lasted a bit more than a year. In 2015–2016 in a county in Iowa, the minimum wage was raised from $7.25 an hour to $10.10 an hour. The reform obviously raised the wages of minimum-wage workers. But the minimum-wage reform was abolished after 17 months by the state of Iowa, bringing the minimum wage in the county back down to $7.25. Despite the abolition, wages remained elevated for minimum-wage workers at least until 2022. Firms voluntarily chose to pay workers better for many years, influenced by a temporary policy intervention.

6.2. Evidence of price rigidity

In this section, we look at evidence on how prices are set in the real world. We will use the evidence to design price norms that are as realistic as possible. What do we mean when we say that prices are rigid? By that we mean that prices do not fully respond to underlying shocks. An extreme case of this is when prices don't move at all—in that case the price is fixed. This is the opposite of a flexible price, which fully responds to shocks and absorbs them. In slackish markets, where sellers and buyers must match before trading, the central empirical question is how prices respond to shifts in demand—in how buyers value the good. Let us now look at evidence that prices are, in fact, rigid and do not fully respond to shocks in the real world.

6.2.1. Frequency of price changes

A typical piece of evidence in favor of price rigidity is that prices stay at the same level for a number of months. Nakamura and Steinsson (2013, table 1) report the frequency of price changes and duration for which prices stayed the same in the United States across many different products. The statistics come from the Consumer Price Index microdata, collected by the BLS between 1988 and 2005.

For regular prices, which exclude sales prices, the median durations are about 7–10 months, while the mean durations are a bit higher, around 9–12 months. The mean is bigger than the median because some products have prices that stay stable for a very long time. A classic example is the bottle of Coca-Cola, which remained priced at a nickel (5 cents) for more than 70 years, from 1886 until 1959 (Levy and Young 2004).

The noticeable difference between median and mean durations of price spells tells us that there is quite a lot of heterogeneity in the frequency of price changes across items. We see this clearly on the histogram reported by Nakamura and Steinsson (2013, figure 3). Many items have a frequency of regular-price changes that is very close to 0, meaning that prices are fixed over years. The biggest mass is for products that have a price-change frequency of 5% per month. These products' prices are fixed on average for 1/0.05 = 20 months, so about a year and a half. For most of the products, the probability of a price change is below 10% per month; these products' prices are fixed on average for at least 1/0.1 = 10 months, so close to a year. The rest of the products are scattered all over the frequency range. There is clearly a lot of heterogeneity in how prices change, which might not be very surprising, because both pricing norms and the variability of demand and production costs are very heterogeneous across products.

6.2.2. Prevalence of rigid prices

The literature focuses so much on the frequency of price changes because it is a critical parameter in the New Keynesian model: it corresponds to the frequency at which the Calvo (1983) fairy operates. However, the evidence we have looked at doesn't tell us how prices respond to shocks. If the demand for a good or its production cost is not changing, there is no reason for its price to change.

In slackish markets, goods are traded only once buyers and sellers have matched. As we saw in chapter 5, the price is determined in a situation of bilateral monopoly, in which both buyer and seller derive a surplus from trading. Critically, the total surplus is determined by the buyer's valuation for the good. As a result, the key question is how prices respond to shifts in buyers' demand for the good.

In effect, we are interested in the passthrough of demand shocks into prices. The idea would be to determine how much the price of a good or service would increase if customers suddenly valued it 10% more. A flexible price would adjust one-for-one, so it would increase by 10%. Unfortunately, quantitative evidence on the passthrough of marginal valuation into prices is not readily available; but there's plenty of qualitative evidence that firms are reluctant to adjust prices in response to demand shocks. 64% of the 200 US firms interviewed by Blinder et al. (1998, pp. 153–157) report that customers do not tolerate price increases after demand increases. Okun (1975, p. 362) also observes in discussions with business people that "empirically, the typical standard of fairness involves cost-oriented pricing with a markup," implying that firms would not think about responding to a shift in demand.

6.2.3. Possible reasons for price rigidity

We now briefly try to explain why prices might be rigid: why might sellers not fully respond to demand shocks? In a Walrasian market, the price goes up whenever demand goes up, so why are sellers reluctant to charge a higher price for their goods if buyers value them more?

The main reason for price rigidity is that people care about the fairness of prices and react negatively when they perceive prices as unfair. As a result, sellers avoid charging prices that customers might consider unfair. In a famous survey, Kahneman, Knetsch, and Thaler (1986, p. 729) document that buyers find it unfair for sellers to raise prices when the demand for their good is high. 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." Among 107 respondents, only 18% regard this pricing as acceptable, whereas 82% regard it as unfair.

We saw in chapter 5 that if demand for a good is higher but the market price does not respond, market tightness rises, making it more difficult for buyers to buy the good. One might wonder whether, in this situation, it would become acceptable for sellers to raise prices. Kahneman, Knetsch, and Thaler (1986, p. 732) actually inquire about this situation: "A shortage has developed for a popular model of automobile, and customers must now wait two months for delivery. A dealer has been selling these cars at list price. Now the dealer prices this model at $200 above list price." Among 130 respondents, only 29% regard this pricing as acceptable, whereas 71% regard it as unfair. So buyers also find it unfair for sellers to raise prices when the market for their good is tight.

We also saw in chapter 5 that market tightness rises if supply of a good is lower and the market price does not respond. One might wonder in this situation too whether it would become acceptable for sellers to raise prices. Kahneman, Knetsch, and Thaler (1986, p. 734) inquire about this question by describing the following vignette: "A severe shortage of Red Delicious apples has developed in a community and none of the grocery stores or produce markets have any of this type of apple on their shelves. Other varieties of apples are plentiful in all of the stores. One grocer receives a single shipment of Red Delicious apples at the regular wholesale cost and raises the retail price of these Red Delicious apples by 25% over the regular price." Among 102 respondents, only 37% view this pricing as acceptable, whereas 63% view it as unfair. This vignette confirms that buyers find it unfair for sellers to raise prices when market tightness is high.

Kahneman, Knetsch, and Thaler conducted their survey in Toronto and Vancouver, but subsequent studies have confirmed their results in the United States. For instance, Shiller, Boycko, and Korobov (1991) obtained similar results from a survey conducted in the greater New York area in 1990.

A natural question is: why should firms care about what is fair and what is not fair? This question has a simple answer: customers appear to reduce purchases when they feel unfairly treated (Piron and Fernandez 1995). More generally, unfair prices seem to make customers angry, which of course firms would like to avoid (Rotemberg 2009).

Moreover, firms do identify fairness as a major concern in price setting. Blinder et al. (1998, tables 5.1 and 5.2) finds that it is in part because of "implicit contracts" with customers that firms do not respond to shocks more: "firms tacitly agree to stabilize prices, perhaps out of fairness to customers." In fact, US firms report that the main reason why they do not change prices more often is that "it would antagonize or cause difficulties for our customers" Blinder (1994, table 4.5).

6.3. Evidence of wage rigidity

In this section, we turn from prices to wages. We review evidence on how wages are set in the real world, both for workers in established relationships with firms and for new hires. The main takeaway is that wages are somewhat rigid in the real world.

6.3.1. Frequency of wage changes for job stayers

Just as we have done with prices, we begin by looking at the frequency of wage changes in the United States. Dickens et al. (2007, figure 1) report the distribution of percentage changes of wages received by workers who stayed in the same job in the United States in 1987. The data come from the Panel Study of Income Dynamics (PSID), a large-scale household survey run by the University of Michigan.

The first interesting observation is that there is a substantial spike at 0: more than 15% of workers do not have a wage change between 1986 and 1987; they have a wage freeze or a fixed nominal wage. This is surprising since the United States was experiencing inflation during that time. Therefore, real wages for these workers actually fell during that time.

Another interesting point is that a significant mass of wage changes is around 4%. In that period, US inflation was around 4%, so this is evidence of real wages being fixed: nominal wages adjusted exactly by the amount of inflation.

The presence of nominal and real wage freezes are typical in the PSID and other household surveys. These freezes imply that for many workers, their nominal or real wage does not change from year to year: it remains fixed for several years. Kahn (1997) finds such patterns in the PSID between 1970 and 1988. Card and Hyslop (1997) find the same patterns in CPS microdata for 1979–1993.

Interestingly, there are a significant number of workers whose nominal wages decrease. Since Keynes (1936), macroeconomic models often assume that nominal wages are downwardly rigid—that nominal wages cannot be reduced. However, in the PSID distribution, nominal wage reductions do exist; Kahn (1997, table 1) reports that among workers in the PSID, a nominal wage cut from one year to the next occurs 18% of the time. In CPS data, 15%–20% of job stayers report nominal wage cuts in any year (p. 75 Card and Hyslop 1997). Hence, nominal wages do fall, but there seems to be a cost of cutting nominal wages that makes such cuts less prevalent than they would otherwise be. This cost can be seen in the asymmetry of the wage changes: a mass of negative wage changes seems to be missing and reallocated to no changes—as Kahn (1997) and Card and Hyslop (1997) formally document.

One possible issue with the household data such as the PSID and CPS, however, is measurement error, which might explain the nominal wage cuts that we see in the data (Akerlof, Dickens, and Perry 1996). Lebow, Saks, and Wilson (2003, figure 3) address the measurement-error problem by using the BLS Employment Cost Index microdata for 1981–1999. These data are based on establishment records, so they are less prone to measurement error than household data. Overall, the data show the same patterns: nominal and real wage freezes are common, but nominal wage cuts do occur. Elsby and Solon (2019, table 1) report an even more convincing piece of evidence on the frequency of downward nominal wage rigidity: in administrative data covering all workers from the US state of Washington, 2005–2015, between 20% and 33% of workers receive year-to-year nominal wage cuts, depending on the year.

As Altonji and Devereux (2000) write:

> The data overwhelmingly rejects a model of flexible wage changes and provides some evidence against a model of perfect downward rigidity in favor of a more general model.

Based on the evidence, and unlike in Keynesian models, this book will not rely on downward nominal wage rigidity to generate unemployment and unemployment fluctuations. Instead, we will use real wages that are somewhat rigid both upward and downward.

We have seen that many job stayers keep the same wage from one year to the next. So what is the expected duration of wages in jobs? Barattieri, Basu, and Gottschalk (2014, table 6) look at the Survey of Income and Program Participation, which is administered by the US Census Bureau, and which they correct for measurement error. They find that between 1996 and 2000, the probability of a within-job nominal wage change is between 15% and 22% per quarter. The implied duration of the nominal wage is between $1/0.22 = 4.5$ quarters and $1/0.15 = 6.7$ quarters, so between one year and one year and a half.

6.3.2. Frequency of wage changes for new hires

We have seen that within a firm-worker relationship, wages are not moving freely. However, when we consider dynamic labor market models, the key decision that the firm makes is whether they hire a worker or not, and what matters to them at the time of making that decision is how they expect to pay the worker during the entire duration of their relationship. Thus, when a worker is hired, the fact that their wages are going to be fixed over time is not sufficient information for the firm. What the firm needs to know is the total wage bill expected over the entire relationship. And what affects the firm's decision to post vacancies and hire workers is whether the overall wage payments are rigid or not.

This is not to say that the wages of existing workers are irrelevant, but they are only one piece of the puzzle. We need to know what happens to the wages of new hires. Once we combine these two bits of information, we will have the full picture of the wage that's paid during the entire relationship. And we will then build a model around that.

To know what happens to wages of new hires, we need to look at wages that are attached to vacancies that are posted. This will tell us what happens when a new worker comes into a firm. Hazell and Taska (2025, table 3) do exactly this; they use data from Burning Glass (a company that collects vacancies of many online job portals) to look at how the wage associated with each job vacancy in a given firm and location varies over time. They find significant rigidities in wages that are posted with vacancies.

They report the quarterly probability of nominal posted wage change at the job level, for one job within a specific firm in a specific location. We can see that the probability of a wage change is only 14% per quarter, and the expected duration for which the wage remained at the same level is 6.4 quarters—about a year and a half. This is in line with what we saw earlier for job stayers: many workers do not get a change in nominal wage from year to year.

When wages do change, Hazell and Taska also look at whether they go up or down. They find that there is a 3% chance of wages decreasing, and an 11% chance of them increasing. This means that 3/14 = 21% of wage changes are decreases, and 79% are increases. It is not surprising that increases are more common, because many forces push wages up, such as technological progress and inflation. The 21% of nominal wage decreases is also in line with the fraction of job stayers experiencing cuts in nominal wages.

Hazell and Taska (2025, figure 3) then look at the distribution of wage changes. It is only for non-zero wage growth, meaning it eliminates the mass of vacancies for which wages do not change from quarter to quarter. We can see that there are some nominal wage decreases, and many more wage increases. A lot of the nominal wage change seems to be around an increase of 3% every wage change, so every six quarters. The peak of the distribution therefore implies that the typical wage posted for vacancies grows at 2%

per year, which is roughly the level of inflation in the United States during that time. This shows that fixed real wages are common for new hires.

Last, Hazell and Taska (2025, figure 4) find no significant difference in wage rigidity between new and existing workers. In particular, it is not the case that wages for new hires are flexible.

6.3.3. Prevalence of rigid wages

We have seen that nominal and real wages move sluggishly, both in existing employment relationships and new employment relationships. However, this is not sufficient to conclude that wages are rigid. When we talk about wage rigidity, we are thinking about how wages respond to shocks to labor productivity. Real wages are rigid if they do not respond fully to a change in productivity, and flexible if they respond one-for-one to a change in productivity.

In fact, wage rigidity to productivity shocks is isomorphic to price rigidity to demand shocks. In a slackish market, wages and prices are not set to clear markets but to split the bilateral surplus generated by a match. A change in labor productivity shifts the marginal value of a match to the firm, just as a change in preferences shifts the marginal value of a match to the buyer in the goods market. In both cases, the price paid in the relationship would adjust one-for-one to the underlying shock under flexible prices or wages, and less than one-for-one under rigid prices or wages.

Haefke, Sonntag, and van Rens (2013, table 4) look at how the real wage paid to US workers changes when there is a change in that worker's productivity, combining several BLS datasets. They look at what happens to wages in both new and existing relationships, which will allow us to have a complete picture of what happens to real wages over the entire relationship. They specifically estimate the response of wages to productivity. We can see that the elasticity of real wages with respect to productivity is always less than 1. The elasticity is 0.24–0.37 for all workers and 0.79–0.83 for new hires. These elasticities below 1 are clear evidence of rigidity, in the same way that the passthrough of marginal costs being less than 1 is evidence of price rigidity.[1] At the same time, wages of job stayers and new hires respond to changes in productivity, and therefore real wages are not completely fixed.

Overall, Haefke, Sonntag, and van Rens find that the elasticity of real wages for new hires with respect to productivity is about 0.8. They also find that wages in ongoing contracts are close to a random walk, meaning that in expectation the wage in an entire relationship will be determined by the wage at the beginning of the relationship. The

[1]Haefke, Sonntag, and van Rens (2013) conclude that because the elasticity of 0.8 is quite close to 1, "wage rigidity is not likely to be the sole reason for employment volatility." However, as we will see in chapter 10, an elasticity as high as 0.8 is sufficient to generate realistic unemployment fluctuations.

elasticity of the present value of wages is close to the elasticity of the wages of newly hired workers because once you set the wage, its fluctuations will roughly be a random walk, so in expectation there would be no drift. This is why 0.8 is a good estimate of the real wage in the entire relationship.

However, these estimates might be overly high, and that the true elasticity might be less than 0.8. Indeed, Gertler, Huckfeldt, and Trigari (2020) find that the wage cyclicality of new hires in excess of that of job stayers "is driven by new hires from employment, raising the possibility that this excess cyclicality is an artifact of cyclical movements in match quality via the job ladder, as opposed to true wage flexibility". If the higher cyclicality observed with new hires comes from workers moving to better jobs in booms, then the wage for a given job is more rigid than the 0.8 figure suggests.

6.3.4. Possible reasons for wage rigidity

We have seen that wages are quite rigid and do not adjust like flexible wages would. We now briefly explain why that might be the case.

To understand wage rigidity, it helps to look at the history of the US labor market. In the early 20th century, American firms shifted from a spot-market system—where workers were hired and paid on a daily basis—to a system of internal labor markets that produced rigid wages (Jacoby 1984). Internal labor markets were more bureaucratic, rule-based, and rigid than spot markets. Wages were tied to job descriptions rather than to how productive an individual worker happened to be on a given day or how bad the labor market was that year. The motivation for the organization of firms around internal labor markets was to provide a more equitable remuneration to workers, to make them more satisfied with their job and eventually more productive and loyal to the firm. Internal labor markets are prevalent today, and they make wages insensitive to marginal productivity or labor market slack (Doeringer and Piore 1971). Having access to 20 years of personnel data from a large US firm, Baker, Gibbs, and Holmstrom (1994) find evidence of an internal labor market: the firm "seems to be shielding its employees from some of the market-induced variations in marginal product."

Internal labor markets also impose the internal equity constraint: new hires and existing hires are treated in fairly similar manner. So these institutions ensure that wage rigidity is roughly the same whether you look at continuing workers or new workers, as Gertler, Huckfeldt, and Trigari (2020) and Hazell and Taska (2025) find.

Managers themselves have now completely internalized the ideas that led to the adoption of internal labor markets. They are convinced that cutting pay is a bad idea. Detailed interviews of compensation managers by Bewley (1999) in hundreds of US firms show that they avoid wage cuts at all costs, even in recessions, because they think wage cuts will antagonize workers and damage morale. Low morale in turn has a range of negative consequences for firms: workers get demotivated or angry, they stop trying as hard, turnover goes up, hiring gets harder, and eventually profitability drops. These findings are confirmed by other interviews and surveys of US firms (Blinder and Choi 1990; Campbell and Kamlani 1997).

And experimental evidence supports managers' views. In a natural experiment involving New Jersey police departments, (Mas 2006) finds that when police officers are paid less than what they think is a fair wage, their effort drops—leading to lower arrest rates, lower sentence length, and more numerous crime reports. And in numerous laboratory experiments, researchers have found that people do not just work for money; they very much care about fairness, and when they feel shortchanged by firms, performance suffers (Fehr, Goette, and Zehnder 2009). By running experiments in firms, organizational psychologists have also found that fair pay leads to better morale and loyalty to the firm (Bewley 2005).

Labor market institutions can play a role, too, in explaining wage rigidity. During the Great Depression, for example, the National Industrial Recovery Act is often blamed for keeping wages higher than they otherwise would have been, even while the economy was collapsing (Temin 1990). Another institution that plays an important role in explaining wage rigidity in more recent times, at least for low-wage workers, is the minimum wage. Indeed, the minimum wage compresses the bottom of the wage distribution, especially for female workers, which necessarily generates rigidities DiNardo, Fortin, and Lemieux (1996, figure 1).

Overall, internal labor markets, managerial norms, and labor market institutions all form barriers that prevent wages from adjusting flexibly to product market or labor market conditions. Firms don't tie wages tightly to productivity and treat new and existing workers alike within their internal labor market, and managers believe cuts are poison for morale.

6.4. Model with rigid prices

We have looked at empirical evidence showing that prices and wages are quite rigid. We now go back to our slackish market model and assume a price norm that captures how prices move: they don't fully respond to underlying shocks and move in a sluggish fashion.

6.4.1. Expression of rigid prices

We will now look at what happens when we have a rigid price: a price that moves in the direction of the flexible price, but less than it. To impose this, our rigid price norm will be

$$p^n = \rho \cdot \left(\frac{a}{k^\alpha}\right)^{1-\gamma}, \tag{6.1}$$

where $\gamma \in (0, 1]$ determines the amount of rigidity of the price norm and $\rho > 0$ determines the level of the price norm. At $\gamma = 1$, the price is fixed and $p^n = \rho$. At $\gamma = 0$, the price would be flexible. We do not consider $\gamma = 0$ below because we focus on somewhat-rigid prices.

6.4.2. Solution with rigid prices

Next, we solve the model with rigid prices. The tightness that solves the model is given by the supply-equals-demand condition, (5.21), where the price norm is (6.1). Because the price norm is just a function of the parameters, and not of tightness, we can show that the model admits a unique solution, just like we did in the case with a fixed price, and as illustrated in figure 5.3. Indeed, the argument that we presented was valid for any price, so it is valid in particular if the price takes the value given by (6.1).

The solution of the model also continues to be represented graphically by figure 5.3A. What is different is the response to shocks, which we examine next.

6.4.3. Comparative statics with rigid prices

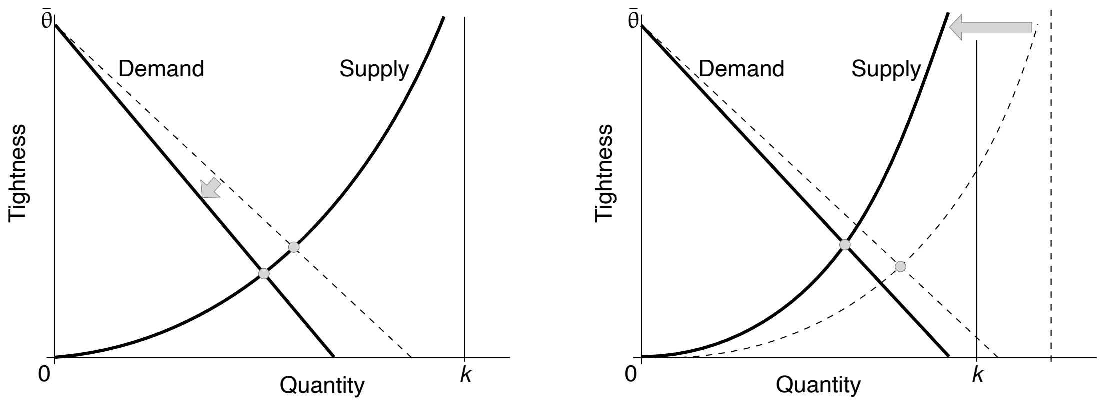
Let us look at a negative demand shock with rigid prices, represented by a reduction in the demand parameter a. We know that for a given price, the market demand is reduced when a falls. But the price also drops with a, which tends to push market demand back up. To determine the combined effect of a, we incorporate the rigid price (6.1) into the market demand (5.15):

$$y^d(\theta) = \left[\frac{(1-\alpha)a^{\gamma}}{\rho}\right]^{1/\alpha} \frac{k^{1-\gamma}}{[1+\tau(\theta)]^{1/\alpha-1}}. \tag{6.2}$$

This is a similar equation to the one with fixed prices, except that the parameters appear in a slightly different fashion. In particular, the demand parameter a enters with an exponent γ. Since γ is strictly positive, because of price rigidity, the demand parameter has the exact same effect as with fixed prices, except that the impact of shocks to a will be attenuated by the exponent γ.

So after a negative demand shock, the market demand curve moves inward while the market supply curve remains unmoved, as shown in figure 6.1A. Hence, the comparative statics under demand shocks are the same as with a fixed price. The only difference is quantitative: the size of the effects is slightly attenuated, especially when prices are becoming more flexible (γ closer to 0). Formally, the elasticities of all the variables with respect to a shrink by a factor $\gamma \leq 1$.

Next, let us look at a negative supply shock with rigid prices, represented by a reduction in the market capacity k. The market supply is reduced when k falls. In addition, prices rise, since k appears in the denominator of the price norm (6.1). This increase captures the



A. Negative demand shock — B. Negative supply shock

FIGURE 6.1. Comparative statics in the slackish market model with rigid prices

The market supply is given by (5.5). The market demand is given by (6.2). The price norm is given by (6.1). A negative demand shock is a reduction in the preference for goods a. A negative supply shock is a reduction in market capacity k.

fact that goods are scarcer so more valuable. That rise in prices will depress the market demand, as illustrated in figure 6.1B.

To perform the comparative statics, we have to determine what happens to tightness, so we have to determine which of the inward movements dominates: the reduction in supply (pushing tightness up) or the reduction in demand (pushing tightness down). To do that, we rewrite the supply-equals-demand condition with the expression (6.2) and separate the terms that depend on tightness from the terms that depend on the supply parameter:

$$\left[\frac{(1-\alpha)a^{\gamma}}{\rho}\right]^{1/\alpha} k^{-\gamma} = f(\theta)\left[1+\tau(\theta)\right]^{1/\alpha-1}. \tag{6.3}$$

Now, when the capacity k drops, the left-hand side rises, since $-\gamma < 0$. So the right-hand side must rise as well, to maintain the equality. We know that both f and $1+\tau$ are increasing functions of θ, and $1/\alpha > 1$, so the right-hand side is an increasing function of θ. This tells us that θ must rise when k falls. So just as with fixed prices, tightness goes up after a negative supply shock. As with demand shocks, the response of tightness is attenuated when prices are less rigid (lower γ). All the other variables respond as in the case with fixed prices, except of course the market price which rises here instead of remaining fixed.

6.4.4. Comparing fixed, rigid, and flexible prices

Overall, we find that even if we assume the price is not completely fixed but simply rigid, all the comparative statics remain the same (table 6.1). It is only when prices are flexible that comparative statics completely change.

This can be seen in (6.3): for any $\gamma \in (0, 1]$, including the case of fixed prices ($\gamma = 1$), tightness responds the same to demand and supply shocks. But for flexible prices ($\gamma = 0$), the terms a^{γ} and $k^{-\gamma}$ drop out, so tightness does not respond to either demand or supply shocks. In that case the shocks are entirely absorbed by prices (as can be seen from (6.1)), so tightness does not change.

An implication is that demand shocks are entirely neutral under flexible prices. Because tightness remains the same, the other quantities (output, consumption, rate of slack, visits) also remain the same.

Additionally, supply shocks do not affect tightness under flexible prices, although they do affect some quantities. Because tightness does not change, the rate of slack $u(\theta)$ does not change. However, because capacity has decreased, output $y = f(\theta)k$ decreases, consumption $c = y/[1 + \tau(\theta)]$ decreases, and visits $v = y/q(\theta)$ decrease too. As (6.7) shows, the flexible price rises when capacity k drops. This is because consumption drops, so the marginal consumption utility rises, which pushes prices up in a commensurate manner.

Why is the response so different under flexible prices, compared to rigid prices? Consider a negative demand shock, represented by a fall in demand parameter a. Under a flexible price, the price norm moves proportionally with a, leaving the market demand curve unchanged and therefore leaving tightness unchanged. This is because the flexible price decreases enough to exactly offset the fall in marginal utility and keep the market demand curve in the same position. We can see this in the expression for the flexible price, by setting $\gamma = 0$ in the price norm (6.1). The demand parameter a is in the numerator, so the price drops in proportion to a after the shock. Hence the price drops as much as the marginal consumption utility, which neutralizes that drop and brings back the market demand to its original position. After incorporating the drop in price, the market demand is unchanged, so tightness is unchanged.

A similar logic explains why flexible prices also neutralize shocks to market capacity. Consider a negative supply shock, represented by a fall in market capacity k. For a given tightness, lower capacity reduces output and consumption. Under flexible prices, this reduction in consumption raises the marginal utility of consumption. Because the flexible price is proportional to marginal consumption utility, the price increases exactly enough to reflect the increased scarcity of goods. This increase in the price shifts the market demand curve inward just enough to offset the inward shift of the market supply curve. The two effects cancel out, leaving market tightness unchanged. Formally, this can be seen by setting $\gamma = 0$ in the price norm (6.1), which implies that the price rises proportionally

TABLE 6.1. Comparative statics in the slackish market model with fixed, rigid, and flexible prices

	Sales y	Tightness θ	Price p	Slack rate u	Consumption c	Visits v
A. Fixed prices: $\gamma = 1$						
Decrease in demand a	–	–	0	+	?	–
Decrease in supply k	–	+	0	–	–	?
B. Rigid prices: $\gamma \in (0,1)$						
Decrease in demand a	–	–	–	+	?	–
Decrease in supply k	–	+	+	–	–	?
C. Flexible prices: $\gamma = 0$						
Decrease in demand a	0	0	–	0	0	0
Decrease in supply k	–	0	+	0	–	–

The comparative statics are obtained from equation (6.3) and are illustrated in figures 5.4A, 5.4B, 6.1A, and 6.1B.

when k falls. Under flexible prices, supply shocks are therefore fully absorbed by prices, so tightness does not respond.

6.5. A possible source of price flexibility: bargaining

We have looked at how the model of slack behaves when prices are fixed. Now, let us assume the polar opposite price norm: prices are bargained between the seller and buyer in any trade. Following Diamond (1982), we assume that the outcome of bargaining is that the buyer and seller agree to share the surplus of their trade. This means that the seller keeps a fraction χ of the surplus and the buyer gets a fraction $1 - \chi$ of the surplus, where $\chi \in [0, 1]$ is the bargaining power of the seller.[2]

6.5.1. Expression of bargained prices

We begin by determining the bargained price. In a trade at price p, we know that the buyer receives surplus $\mathcal{B}$, the seller receives surplus $\mathcal{S}$, and the total surplus is $\mathcal{T} = \mathcal{B} + \mathcal{S}$. The surplus-sharing solution to the bargaining problem requires that $\mathcal{B} = (1 - \chi) \cdot \mathcal{T}$ and $\mathcal{S} = \chi \cdot \mathcal{T}$.

At the same time, our analysis of the trade surplus in chapter 5 shows that for a trade at price p, the seller's surplus is just the price: $\mathcal{S} = p$. Moreover, the total surplus is just the marginal utility from consumption: $\mathcal{T} = \partial \mathcal{U} / \partial c$. Since the surplus-sharing solution

[2] Although the surplus-sharing solution to the bargaining problem is not as popular as the Nash bargaining solution, it is simpler, which is why we use it here. And if the buyer and seller have linear preferences, the surplus-sharing and Nash bargaining solutions are equivalent.

requires that $\mathcal{S} = \chi \cdot \mathcal{T}$, the surplus-sharing price must be

$$p = \chi \cdot \frac{\partial \mathcal{U}}{\partial c}.$$

That is, through bargaining, sellers keep a share χ of the surplus of the trade, which is just the marginal utility from the good enjoyed by buyers. Buyers are left with a fraction $1 - \chi$ of the surplus. They enjoy the full marginal utility by consuming the good but must pay a share χ of the marginal utility to sellers; so they are left with $1 - \chi$ of the marginal utility in the end. If sellers have all the bargaining power ($\chi = 1$), the price is just the marginal consumption utility. If buyers have all the bargaining power ($\chi = 0$), the price is 0.

The most natural expression for the bargained price norm is

$$p^n(c) = \chi \cdot (1 - \alpha) a c^{-\alpha}. \tag{6.4}$$

It simply uses the expression for the marginal consumption utility and therefore links the price in each trade to the consumption level of each buyer.

When we studied the model in chapter 5, we noted that all price norms reduced to functions of market tightness. This is true here too. When we solve the model, we know that consumption and output are related by $c = y/[1 + \tau(\theta)]$. And output is related to tightness by $y = f(\theta)k$. So consumption can be written a function of tightness too:

$$c = \frac{f(\theta)}{1 + \tau(\theta)} \cdot k.$$

By plugging the right-hand side of the expression into (6.4), we would write the price norm as a function of tightness.

6.5.2. Solution with bargained prices

Solving the model with a bargained price is a bit different because the market demand takes a very special form once it is combined with the bargained price. When we derived the market demand in chapter 5, we obtained it by equalizing the marginal utility of consumption to the marginal cost of consumption: $\partial \mathcal{U}/\partial c = [1 + \tau(\theta)]p$. And we have just seen that the surplus-sharing price satisfies $p = \chi \partial \mathcal{U}/\partial c$. Combining both, we see that once we incorporate the price norm into the market demand, the market demand becomes degenerate. It pins down a unique tightness irrespective of quantities traded:

$$1 = [1 + \tau(\theta)]\chi.$$

This condition on tightness can be rewritten as a condition on the matching wedge:

$$\tau(\theta) = \frac{1-\chi}{\chi}. \tag{6.5}$$

In the tightness-quantity diagram, the market demand is therefore horizontal and given by:

$$\theta = \tau^{-1}\left(\frac{1-\chi}{\chi}\right), \tag{6.6}$$

where τ^{-1} is the inverse of the matching wedge. The inverse is well defined because τ is strictly increasing from $(0, \bar{\theta}) \to (0, \infty)$. The inverse itself is defined on $(0, \infty)$ and is strictly increasing. So the market tightness is well defined.

From the expression (6.6) for the tightness, and the expression (6.4), we can also express the bargained price as a function of the parameters of the model. The price norm that reflects surplus sharing is given by

$$p^n = \frac{a}{k^\alpha} \cdot (1-\alpha)\chi^{1-\alpha} f\left(\tau^{-1}\left(\frac{1-\chi}{\chi}\right)\right)^{-\alpha}. \tag{6.7}$$

We simplified the expression using the fact that when (6.6) holds, $1 + \tau(\theta) = 1/\chi$.

We now see that if we set $\gamma = 0$ and

$$\rho = (1-\alpha)\chi^{1-\alpha} f\left(\tau^{-1}\left(\frac{1-\chi}{\chi}\right)\right)^{-\alpha}$$

in (6.1), then p^n is the surplus-sharing price norm described by (6.7). Hence, bargaining provides a foundation for a flexible price.

Because bargained prices are flexible, they are not realistic: the rate of slack never changes—neither with demand nor supply shocks—which is not consistent with the real world, where the amount of slack in the markets varies considerably over the business cycle (chapter 3). Nevertheless, bargained prices provide an explanation for movements in prices in the direction of flexibility. If there is any amount of bargaining in markets, prices will not be completely fixed but rigid towards the bargaining price, as summarized by (6.1).

6.6. Quantifying the response of the model to shocks

Comparative statics tell us in which directions the model variables respond to demand and supply shocks (see for instance table 6.1). But it is also possible to determine the amplitude of the response of the variables. The key step is to compute the elasticity of market tightness with respect to the parameters at the source of the shocks (a and k). Given that tightness determines all other variables in the model, we can quantify the response of any variable from the response of tightness. From the elasticity of tightness, we will see in particular that the response of the model to shocks is determined critically by the rigidity of prices. Throughout the section, we use the properties of elasticities introduced in appendix B.

6.6.1. Response to demand shocks

We start with the elasticity of tightness with respect to the demand parameter a. This elasticity tells us how much the model responds to demand shocks. We start from the supply-equals-demand equation, which implicitly gives tightness: $y^d(\theta, a) = y^s(\theta)$, where the market demand is given by (6.2) and the market supply takes the usual form, (5.5). Using implicit differentiation with elasticities, we get

$$\epsilon_a^d + \epsilon_\theta^d \cdot \epsilon_a^\theta = \epsilon_\theta^s \cdot \epsilon_a^\theta,$$

where ϵ_a^d is the partial elasticity of market demand y^d with respect to the demand parameter a, ϵ_θ^d is the partial elasticity of market demand y^d with respect to tightness θ, ϵ_θ^s is the elasticity of market supply y^s with respect to tightness θ, and ϵ_a^θ is the elasticity of tightness θ with respect to the demand parameter a—which is the elasticity that we are aiming to compute.

Using results on elasticities as well as (4.6) and (4.7), we get

$$\epsilon_a^d = \frac{\gamma}{\alpha}, \quad \epsilon_\theta^d = -\frac{1-\alpha}{\alpha} \cdot \epsilon_\theta^{1+\tau}, \quad \epsilon_\theta^s = 1 - \eta,$$

where $\epsilon_\theta^{1+\tau}$ is the elasticity of $1+\tau$ with respect to tightness θ. Given (4.6) and (5.8), we infer that the elasticity of $1+\tau(\theta) = q(\theta)/[q(\theta)-\kappa]$ with respect to θ is

$$\epsilon_\theta^{1+\tau} = (-\eta) - (-\eta) \cdot \frac{q(\theta)}{q(\theta)-\kappa} = (-\eta) \cdot \frac{-\kappa}{q(\theta)-\kappa} = \eta\tau(\theta). \tag{6.8}$$

Combining all these results, we obtain first that

$$\epsilon_a^\theta = \frac{\epsilon_a^d}{\epsilon_\theta^s - \epsilon_\theta^d}, \tag{6.9}$$

which shows that the response of tightness to a demand shock depends of course on the response of demand to the shock (ϵ_a^d), and critically on the slopes of the demand and supply curves ($\epsilon_\theta^s - \epsilon_\theta^d$). Next, we can plug in this abstract expression the various values of the elasticities and we obtain:

$$\epsilon_a^\theta = \frac{\gamma}{(1-\eta)\alpha + (1-\alpha)\eta\tau(\theta)}. \tag{6.10}$$

From (6.10) we see several properties of the response of the market to demand shocks. First of all, tightness goes up when demand is stronger ($\epsilon_a^\theta > 0$). Second, if prices are flexible ($\gamma = 0$), then tightness does not respond demand shocks ($\epsilon_a^\theta = 0$), which means that the market does not respond to demand shocks—in line with what we saw when we looked at bargained prices (table 6.1). Third, the more rigid prices are (higher γ), the stronger is the response of tightness, and thus of the other variables, to demand shocks.

6.6.2. Response to supply shocks

Next we move to the elasticity of tightness with respect to the market capacity k, which determines the market supply. This elasticity tells us how much the model responds to supply shocks. We start again from the supply-equals-demand equation, which implicitly gives tightness: $y^d(\theta, k) = y^s(\theta, k)$, where the market demand is given by (6.2) and the market supply takes the usual form, (5.5). Using implicit differentiation with elasticities, we get

$$\epsilon_\theta^d \cdot \epsilon_k^\theta + \epsilon_k^d = \epsilon_\theta^s \cdot \epsilon_k^\theta + \epsilon_k^s,$$

where ϵ_k^s is the partial elasticity of market supply y^s with respect to the market capacity k and ϵ_k^θ is the elasticity of tightness θ with respect to the market capacity k—which is the elasticity that we are aiming to compute here. Besides the elasticity above, we also have

$$\epsilon_k^d = 1 - \gamma, \quad \epsilon_k^s = 1.$$

Combining these results, we obtain first that

$$\epsilon_k^\theta = \frac{\epsilon_k^d - \epsilon_k^s}{\epsilon_\theta^s - \epsilon_\theta^d}, \tag{6.11}$$

which shows that the response of tightness to a supply shock depends on the response of demand and supply to the shock (ϵ_k^s and ϵ_k^d), and critically on the slopes of the demand and supply curves ($\epsilon_\theta^s - \epsilon_\theta^d$). Next, we can plug in this abstract expression the various values of the elasticities and we obtain:

$$\epsilon_k^\theta = \frac{-\gamma}{1 - \eta + \frac{1-\alpha}{\alpha} \cdot \eta\tau(\theta)}. \tag{6.12}$$

From (6.12) we see several properties of the response of the market to supply shocks. First, tightness goes down when supply is higher ($\epsilon_k^\theta < 0$). Second, if prices are flexible

($\gamma = 0$), then tightness does not respond supply shocks ($\epsilon^{\theta}_{k} = 0$). Third, the more rigid prices are (higher γ), the stronger is the response of tightness to supply shocks.

6.6.3. State dependence

A critical property of the slackish model emerges from the elasticity formulas: the model exhibits state dependence. This means that the model behaves differently when the market is slack or tight. To display such state dependence, we now compute the response of output to demand and supply shocks.

We begin by picking a relationship that relates output to tightness. A convenient choice is the market supply: $y = y^{s}(\theta, k)$. From this relationship, we then obtain $\epsilon^{y}_{a} = \epsilon^{s}_{\theta} \cdot \epsilon^{\theta}_{a}$ so

$$\epsilon^{y}_{a} = \frac{\gamma}{\alpha + \frac{\eta(\theta)}{1-\eta(\theta)} \cdot (1-\alpha)\tau(\theta)}.$$

So the response of output to demand shocks has broadly the same properties as the response of tightness.

In addition, we see here that the response of output to demand shocks is stronger in a slacker market. Indeed, the matching wedge $\tau(\theta)$ is highly procyclical. Moreover, for the three main matching functions that we have considered in chapter 4, the ratio $\eta(\theta)/[1-\eta(\theta)]$ is weakly increasing in tightness. In the case of the Cobb-Douglas function, the elasticity η is constant so the ratio is constant. In the cases of the urn-ball and CES function, the elasticity $\eta(\theta)$ is strictly increasing in tightness, so the ratio is strictly increasing in tightness. In all cases, the term $\eta(\theta)\tau(\theta)/[1-\eta(\theta)]$ is strictly increasing in tightness. This implies that, since all other terms in the elasticity are constant, the elasticity ϵ^{y}_{a} is decreasing in tightness. This means that when the market is slack, the elasticity is high: output responds sharply to changes in market demand. By contrast, when the market is tight, the elasticity is low: output does not respond much to changes in market demand.

For supply shocks, we have $\epsilon^{y}_{k} = \epsilon^{s}_{k} + \epsilon^{s}_{\theta} \cdot \epsilon^{\theta}_{k}$ so

$$\epsilon^{y}_{k} = 1 - \frac{\gamma}{1 + \frac{\eta(\theta)}{1-\eta(\theta)} \cdot \frac{1-\alpha}{\alpha} \cdot \tau(\theta)}.$$

Since $\gamma \leq 1$, the elasticity is positive ($\epsilon^{y}_{k} > 0$). So unlike tightness, which falls after an increase in supply, output rises after an increase in supply. Furthermore, output rises more when prices are less rigid. With a flexible price ($\gamma = 0$), output moves one-for-one with capacity ($\epsilon^{y}_{k} = 1$); when prices are rigid, the move is less than one-for-one ($\epsilon^{y}_{k} < 1$).

We also see that the response of output to supply shocks is stronger in a tighter market. Following the same logic as above, we know that the term $\eta(\theta)\tau(\theta)/[1-\eta(\theta)]$ is strictly increasing in tightness for all the matching functions that we have considered. This result implies that the elasticity ϵ_k^y is increasing in tightness. This means that when the market is slack, the elasticity is low: output does not respond much to changes in market capacity. By contrast, when the market is tight, the elasticity is high: output responds significantly to changes in market capacity.

We have just established that the slackish model is state-dependent: the response of output to shocks depends on the state of the market. The reason behind state dependence is the nonlinearity of the slackish model. Because of the curvature of the market demand and supply curves, shocks have systematically different effects when tightness is high or low. We will come back to this result in the dynamic model, where state dependence is exacerbated by a stronger nonlinearity (chapter 8). State dependence has particularly important implications for policy design (part IV).

6.7. Summary

The evidence from US markets reveals a fundamental feature of price determination: prices and wages exhibit substantial rigidity. This rigidity stems primarily from fairness concerns. Customers find price increases due to a higher demand or a tighter market to be unfair, and firms avoid wage cuts when labor productivity is lower or the labor market is slacker to preserve worker morale.

When we incorporate price rigidity into our slackish market model—where prices respond partially to shocks with some rigidity parameter $\gamma \in (0, 1]$—the mechanism of adjustment to shocks is between the extremes of fixed and flexible prices. Both prices and tightness now adjust, with the elasticity of tightness to demand and supply shocks determined by γ. This price rigidity explains why slack varies over the business cycle—a central feature of real markets that models with flexible prices cannot capture.

Because of the curvature of the market supply, the slackish model is state dependent. Market output responds more to demand shocks in slack conditions than in tight conditions. Conversely, output responds more to supply shocks in tight conditions than in slack conditions.

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