The Macroeconomic Consequences of Reciprocity in Labor Relations: Appendix

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1 Reciprocity and rent sharing: a survey of the evidence

One of the most provocative findings in experimental economics is that many individuals seem to be willing to spend considerable resources to reward (punish) fair (unfair) behavior by others even though no direct material gain derives from such action. In Fehr and Falk (1999), individuals are either assigned the role of a worker or a firm manager.[1] Even though competitive bidding should push the equilibrium remuneration down to the worker's reservation wage, results show that if effort cannot be contracted in advance, the average wage chosen by the firm is considerably higher than the reservation wage of the worker. Workers often try to underbid in order to obtain a job, but managers consistently refuse. This choice turns out to be rational because hired workers on average reciprocate the favor of a high wage with high effort (even though providing effort is costly), thus increasing the firm's profit relative to a low-wage / low-effort policy.

The hypothesis that reciprocity is an important element in labor relations also receives support from field studies such as Levine (1993), Campbell and Kamlani (1997) and Bewley (1999) who survey U.S. company managers and labor leaders about wage policy.[2] Most respondents in these studies report favoring layoffs over wage cuts dur-

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[1]Other experiments that simulate similar worker-employer relationships are Fehr, Kirchsteiger and Riedl [1993] or Gächter and Falk [2002]. See Fehr and Gächter [2000] for a general survey.

[2]See Bewley (2002) for a summary.

ing downturns because the negative effect of wage cuts on work morale, and thus on productivity, would outweigh the associated cost savings.

Interestingly, managers in Bewley's survey generally dismiss the shirking theory of efficiency wages. Rather than promoting a high effort level, the threat of punishment if caught shirking (in the form of firing or of a wage penalty) creates a negative workplace atmosphere that is counterproductive. Bewley thus concludes from his inquiry that Akerlof's (1982) partial gift exchange hypothesis of efficiency wages is most consistent with his empirical evidence. This view conforms with the results of another experiment by Fehr and Gächter (2002). Their setup is similar to the one of Fehr and Falk discussed above, but with the addition that firm managers can make workers pay a fine if the latter are caught shirking (which occurs with a fixed probability). Except for very low wage offers, workers in this setting provide much lower effort than in the original experiment where no verification of shirking is allowed.

As will be stressed below, the import of reciprocity in labor relations crucially depends on the relevant references considered by workers when deciding on effort. In a famous study, Kahneman, Knetsch and Thaler (1986) shed light on this issue by interviewing a randomly selected sample of individuals on their perception of fairness of alternative firm actions in different profit situations. They report that a substantial proportion of individuals consider the principle of dual entitlement to be an important standard of fairness: workers are entitled to a reference salary, while firms are entitled to a reference profit. Accordingly, a wage reduction is more likely to be judged unfair if it results in a gain for the firm than if it permits averting a loss.[3]

The importance of rent-sharing considerations in the management of effort finds further support in an experiment by Fehr, Gächter and Kirchsteiger (1997). Firms in this experiment are assigned different levels of profitability and make (costly) wage offers to workers. Workers are then given the choice in a randomly determined order to accept wage offers. Once workers accept an offer, they observe the profitability of their firm and decide on the level of (costly) effort they want to provide. The results are striking: workers consistently offer high effort in return for a high wage. Firms, in turn, seem to understand the negative (suboptimal) effect of inadequate rent sharing on effort and offer wages that are increasing in the level of profitability assigned; i.e. they pay pure job rents.

[3]The idea of dual entitlement is closely related to Adam's (1963) theory of equity and Blau -Homans (1955, 1961) theory of social exchange. Both theories hypothesize that the rewards of an exchange (here between firms and workers) should be proportional to the perceived value of the different parties' inputs. Numerous studies in psychology and sociology have attempted to test these theories and report overall strongly supportive results. See Akerlof and Yellen (1990) for a review of this evidence.

By construction, these studies on rent sharing focus on very specific references and may therefore miss other elements considered by workers in their evaluation of fairness. In particular, employees may pay attention to outside references such as wages paid for similar jobs at other firms or local unemployment rates. The aforementioned survey studies (Levine (1993), Campbell and Kamlani (1997) and Bewley (1999)) suggest that this is not the case: workers' morale rather depends on firm-internal references such as established pay traditions, the firm's ability to pay, the difference between current and past wages, and the compensation of peer workers in the same firm. Importantly, according to the surveyed managers, even in cases of high unemployment, substantial reductions in pay are possible only in situations of great financial distress when wage reductions are the only way to prevent the firm from going bankrupt or laying off a large fraction of its workforce. Bewley (2002, page 7) goes even further and argues that *"...employees usually have little notion of a fair or market value for their services and quickly come to believe that they are entitled to their existing pay, no matter how high it may be....workers do not use pay rates at other firms as reference wages, for they know too little about them. Exceptions to this statement may occur when workers are represented by an active union that keeps them informed about what other firms pay."*[4] Furthermore, most managers in Bewley's survey responded that they do not take into consideration underbidding by job applicants, thus closing off an indirect channel through which external references could possibly affect average firm pay.

The reported evidence does not imply that references external to the firm are completely irrelevant to the worker's effort decision. In fact, Bewley's conclusion simply suggests that workers often have only incomplete information on their earnings potential outside of the firm. But the evidence strongly suggest that the firm's ability to pay and established rent-sharing traditions are non-negligible references in workers' perception of fairness. While incomplete information (e.g., about the firm's revenues) may be relevant here as well, this conclusion should be robust provided some learning about the relevant

[4]Bewley's observation that unions act as an information source accords with studies by Agell and Lundborg [1995, 1999] and Agell and Bennmarker [2004] who survey managers of Swedish companies about wage determination. In line with Bewley, many of their respondents indicate that wage claims are affected by profits and the firm's ability to pay. However, and in contrast to the responses of U.S. companies, Swedish managers gave larger support to the view that firm-external information such as unemployment and wages at other firms also matter for wage determination. Agell and Bennmarker try to assess whether this difference can be explained by the greater importance of labor unions in Sweden compared to the U.S. They find a significant positive correlation between union density and the appreciation of the external reference perspective, thus lending further support to the view that incomplete information is part of the explanation for why workers focus on internal rather than external wage references.

variable is taking place.

Interestingly, the reciprocity perspective on labor relations may provide the rationale for empirical results obtained on the sources of wage dispersion. Starting with Slichter (1950), a rich set of microeconometric studies – from Dickens and Katz (1987), Krueger and Summers (1988) for the U.S.; Blanchflower, Oswald and Garrett (1990), Nickell and Wadhwani (1990), Holmlund and Zetterberg (1991) or Hildreth and Oswald (1997) for European labor markets; and Christofides and Oswald (1992) or Abowd and Lemieux (1993) for Canada – document that wages for apparently identical jobs differ significantly across industries, and that these differences are remarkably robust over time and across countries. Based on the evidence, these authors argue that these wage differentials cannot be attributed entirely to differences in skill or working conditions. Rather, differences in compensation depend to a substantial part on the firm's ability to pay, even in sectors where unions do not play an important role.

A dissenting view is expressed by Murphy and Topel (1987) who argue instead that high-wage individuals get sorted into high-performance firms because of *unobserved* abilities. The recent availability of large firm-worker matched panel data makes it possible to assess the relevance of rent-sharing versus the sorting argument. Abowd and Kramarz (2000) thus decompose wage data for France and Washington State, respectively, into observed worker characteristics plus unobserved worker and unobserved firm effects. Their estimates show that the two effects are about equally important in explaining wage disparity. Abowd, Creecy and Kramarz (2002) further report that the correlation between the two effects is slightly negative, a result that appears to contradict the sorting argument. Finally, Abowd, Kramarz, Margolis and Troske (2001) find that the unobserved firm effect is strongly and positively correlated with different firm productivity measures.[5]

While complementary explanations for rent sharing cannot be ruled out, the reciprocity view of labor relations figures prominently among the potential organizing principles for the reported evidence. In particular it proposes (i) that reciprocal behavior by individuals is central to the firm's management of work effort; and (ii) that the firm's ability to pay is an important factor in workers' perception of a given wage offer (and thus of their effort decision). The model presented in the paper is predicated on these two hypotheses.

[5]The latter finding is confirmed by Arai (2003) who uses firm-worker matched data from Sweden. Arai's estimates of the wage-profit relation are sizable and stable across unionized vs. non-unionized workers, blue-collar vs. white-collar workers, and for manufacturing and non-manufacturing sectors. Interestingly, Arai also introduces controls for worker supervision but finds no significant change in the wage-profit relation, thus providing further evidence against the shirking hypothesis.

2 Robustness Analysis

In this section, we assess the robustness of our model along two dimensions. First, we report how the comparative statics change for different calibrations of the parameter ν. Second, we examine how the results change for different degrees of consumer risk aversion.

2.1 Robustness to alternative calibrations of ν

The parameter ν determines the fraction of y/n that workers consider as the maximum wage; i.e. $w_{\max} = (y/n)^{\nu}$. Everything else constant, a higher value of ν makes the wage reference more responsive to changes in y/n. A higher ν should therefore induce firms to adjust their optimal wage more in line with changes in y/n. Tables 4a and 4b report the results for $\nu = 0.5$ and $\nu = 0.9$ with all other parameters left at their benchmark calibration values. Our intuition is confirmed but so is the robustness of the message developed in the previous section. The importance of the weight parameter in the wage reference is clearly noticeable with strong shock amplification (in terms of employment and output when relevant) for high enough values of φ. The differential responses to demand and technology shocks is fully present for all values of ν. And the response of effort is largely unaffected.

Table 4a: Robustness to different ν for -1% technology shock

	$\nu = 0.5$				$\nu = 0.9$			
Value of φ	y	n	w	e	y	n	w	e
0.25	-1.60	-0.79	-0.81	-0.12	-1.49	-0.61	-0.88	-0.12
0.5	-1.82	-1.14	-0.68	-0.10	-1.55	-0.71	-0.84	-0.12
0.75	-2.19	-1.74	-0.46	-0.07	-1.70	-0.95	-0.76	-0.11

Table 4b: Robustness to different ν for -1% demand shock

	$\nu = 0.5$				$\nu = 0.9$			
Value of φ	y	n	w	e	y	n	w	e
0.25	-1.00	-1.58	-1.03	0.08	-1.00	-1.58	-0.91	0.08
0.5	-1.00	-1.58	-0.36	0.08	-1.00	-1.58	-0.18	0.08
0.75	-1.00	-1.58	0.03	0.08	-1.00	-1.58	0.25	0.08

2.2 Robustness to alternative consumption risk aversion

In our benchmark model, the firm finds it optimal to set wages such that its gift to the worker remains constant. As we noted in Section 2 of the paper, this result is a consequence of the assumption of log preferences for consumption. Here we examine whether our results are robust to more general preferences under the assumption of constant relative risk aversion in consumption. Workers' utility function takes the form: $u(c,e) = \frac{1}{\chi}c^{\chi} - e^{\theta}$, with $\chi \leq 1$. The logarithmic case corresponds to $\chi = 0$.

The effort function for this specification of preferences is

$$Qe^{\theta} = \frac{y}{n}g(w,\cdot) = \frac{y}{n}\left[\frac{1}{\chi}(\tau w)^{\chi} - \frac{\varphi}{\chi}\left[\tau(y/n)^{\nu}\right]^{\chi} - \frac{(1-\varphi)}{\chi}[\tau\bar{w}^{\bar{n}}b^{1-\bar{n}}]^{\chi}\right]. \tag{1}$$

It results in the following optimal wage setting equation (see Section 3 of this Appendix for details of the derivation)

$$w^{\chi} = \varphi\bar{\theta}[(y/n)^{\nu}]^{\chi} + (1-\varphi)\tilde{\theta}[\bar{w}^{\bar{n}}b^{1-\bar{n}}]^{\chi}, \tag{2}$$

with $\bar{\theta} \equiv (\theta - 1 - \chi\nu)/(\theta - 1 - \chi) > 0$ and $\tilde{\theta} \equiv (\theta - 1)/(\theta - 1 - \chi) > 0$; while the labor demand can be represented by

$$w^{\chi} = \frac{\theta - 1}{\theta - \alpha}\psi\alpha\left(\frac{y}{n}\right)w^{\chi-1} + \frac{\theta(1-\alpha)}{\theta-\alpha}\varphi\nu\left(\frac{y}{n}\right)^{\nu\chi} \tag{3}$$

Using the optimal wage setting equation to substitute for w in the definition of the firm's gift, we obtain the following expression for effort

$$Qe^{\theta} = \frac{y}{n}\left[\frac{(\bar{\theta}-1)}{\chi}\varphi\left[\tau(y/n)^{\nu}\right]^{\chi} + \frac{(\tilde{\theta}-1)}{\chi}(1-\varphi)[\tau\bar{w}^{\bar{n}}b^{1-\bar{n}}]^{\chi}\right]. \tag{4}$$

As before, the y/n term outside the square brackets is the result of the specification of the gift of the worker discussed in Section 3: workers volunteer effort more willingly in situations where firms are highly productive because the same level of effort translates into a larger gift (measured in terms of output increment).

Noting that $\frac{(\bar{\theta}-1)}{\chi}$ and $\frac{(\tilde{\theta}-1)}{\chi}$ are positive numbers independently of the sign of χ, it is apparent from (4) that the optimal gift of the firm (which is the expression inside the square brackets) is no longer constant. Optimal effort varies with y/n - which affects both the gift of the worker and the gift of the firm - and the outside option $\bar{w}^{\bar{n}}b^{1-\bar{n}}$. In particular, for $\chi > 0$, firms find it optimal to increase their gift to the worker when y/n and $\bar{w}^{\bar{n}}b^{1-\bar{n}}$ increase. Since the gift of the worker also increases with y/n, the impact of the comparative static analysis will be unambiguous. Conversely, for $\chi < 0$, firms find it optimal to decrease their gift as y/n and $\bar{w}^{\bar{n}}b^{1-\bar{n}}$ increase. The effect of an increase in y/n on effort is a priori ambiguous here as the gift of the firm and the gift of the worker move in opposite directions.

Tables 5a and 5b confirm this analysis for the same comparative statics exercises as before; i.e. a -1% technology shock under flexible prices and a -1% demand shock

Table 5a: Robustness to different χ for -1% technology shock

	$\chi=-2$				$\chi=1$			
Value of φ	y	n	w	e	y	n	w	e
0.25	-1.29	-0.55	-0.76	0.12	-1.67	-0.74	-0.91	-0.27
0.5	-1.43	-0.80	-0.71	0.14	-1.78	-0.93	-0.82	-0.25
0.75	-1.84	-1.44	-0.52	0.17	-2.02	-1.33	-0.67	-0.22

Table 5b: Robustness to different χ for -1% demand shock

	$\chi=-2$				$\chi=1$			
Value of φ	y	n	w	e	y	n	w	e
0.25	-1.00	-2.36	-2.02	0.88	-1.00	-1.40	-0.82	-0.10
0.5	-1.00	-1.88	-0.40	0.39	-1.00	-1.48	-0.24	-0.02
0.75	-1.00	-1.67	0.16	0.18	-1.00	-1.56	0.17	0.06

given fixed prices under different degrees of consumption risk aversion. The case $\chi = 1$ corresponds to preferences that are linear in consumption; the results for $\chi = 0$ are those of our benchmark logarithmic specification and are found in Tables 3a and 3b; the case $\chi = -2$ exemplifies the results obtained for risk aversion higher than log. All other parameters are left at their original calibration values.

Focusing on effort, one indeed observes that under a negative technology shock (when both y/n and $\bar{w}^{\bar{n}}b^{1-\bar{n}}$ decrease) effort falls for $\chi = 1$ and increases for $\chi = -2$ as predicted by the impact of the change on the gift of the firm. In the $\chi = -2$ case the change in the gift of the firm clearly swamps the direct impact of the fall on y/n on the gift of the worker.

In the case of a negative demand shock, the consequent increase in y/n tends to increase the gift of the worker while the two components of the gift of the firm exert conflicting influences. When $\chi = 1$, one sees that for low values of φ the negative impact of the drop in the outside option $\bar{w}^{\bar{n}}b^{1-\bar{n}}$ dominates and effort decreases (modestly). When more weight is placed on the internal reference, a small increase in effort results as the increase in y/n on the gift of the firm reinforces its effect on the gift of the worker. For $\chi = -2$, the fall in $\bar{w}^{\bar{n}}b^{1-\bar{n}}$ tends to increase the gift of the firm reinforcing the positive change in the worker's gift and yielding an increase in effort. This effect is seen to dominate for all values of φ although in conformity with intuition the larger the weight on the internal reference the smaller is the increase in effort as the negative effect of the increase in y/n on the gift of the firm takes increasing importance.

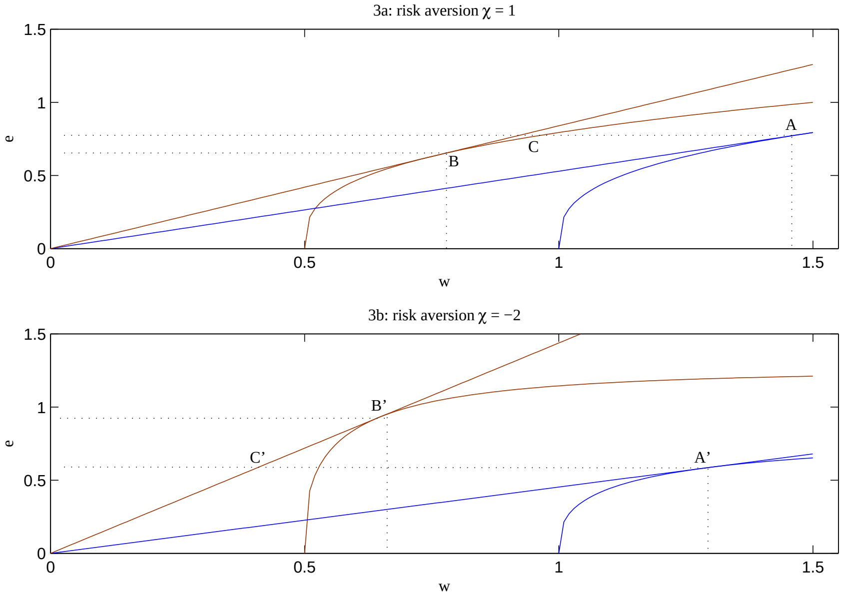
Beyond detailing these interesting reactions of effort, Table 4 confirms our main messages from the previous section. For the case of linear utility, all of the qualitative properties remain the same except that the change in effort depends on the value of φ even in the demand shock case. In particular, the larger the weight on the internal element of the wage reference, the larger the changes in quantities (employment and output under a technology shock, employment in the case of a demand shock) and the smaller the changes in wages. The differential responses to both shock types is apparent here as well with a demand shock eliciting stronger employment responses and smaller wage responses.

When $\chi = -2$, the differential responses to the two shock remains, as well as the impact of φ on the wage reaction to the two shocks. The wage response is very muted for φ equal to or larger than 1/2. This case however introduces a new dimension to our results insofar as the reaction of effort in the case of a demand shock is so strongly positive for low values of φ that the response of employment has to be even more strongly negative (since the output response is fixed at -1%) for lower than for higher values of this parameter. This is the only case where the reaction of employment becomes smaller when φ increases. It is entirely due to the very strong reaction of effort yielding an extreme reaction of employment. Yet the reaction of employment in the absolute, and in relation to wages, remain very large (larger than for the corresponding values of φ in the log case) even for the higher values of φ.

Figures 3a and 3b provide a deeper understanding of the reaction of effort to the two shocks under the alternative preference hypotheses and for $\varphi = 0$. The graphs depict the solution to the firm's optimal wage problem (the Solow condition) in the $e - w$ space for different degrees of risk aversion. The concave function represents the EC that firms take as their constraint when maximizing profits. At the optimum (w^*, e^*), denoted by point A, the marginal cost of an additional unit of effective labor $\partial w/\partial e$ equals its average cost w/e. Now, consider a decrease in the wage reference, which corresponds to a leftward translation of the EC. The firm's optimal wage response to this new situation depends on how the worker's perception of the firm's marginal gift (and thus the slope of the EC) changes with variations in w.

Assume first that individuals are risk neutral ($\chi = 1$). In this case, depicted in Figure 3a, the inverse of the slope of the EC, $\partial w/\partial e = [\partial(h_e/d_e)/\partial e]/[\partial g/\partial w]$, remains unchanged for any level of effort. This is because the numerator $\partial(h_e/d_e)/\partial e$ is a function of effort only and thus remains the same for any level of e, while the worker's perception of the firm's marginal gift in the denominator $\partial g/\partial w$ is a constant when preferences are linear. Concavity of the EC then implies that tangency with a ray from the origin of slope e/w must occur at a lower level of e than before the shock (point B rather than point C). Intuitively, in this situation a decrease in wages leaves the marginal cost of

Figure 3:
The differential reaction of effort to shocks for alternative values of χ



Note: Calibration as described in the text, in particular $A = 1; \alpha = .66; \psi = .9; n = .95; \nu = .75; \rho = .5; \varphi = 0$.

effective labor $\partial w/\partial e$ unchanged while average costs w/e fall. Firms therefore find it optimal to decrease wages and to let effort fall in order for the Solow condition to hold again.

In Figure 3b, by contrast, we assume that individuals exhibit higher than logarithmic risk aversion ($\chi < 0$). The leftward shift of the EC therefore implies that for any given level of effort, the slope of the EC becomes steeper. As in the risk-neutral case, the numerator of $\partial w/\partial e$ is unaffected by e. But higher than logarithmic risk aversion now implies that the marginal gift of the firm decreases more than linearly and thus, $\partial w/\partial e$ increases more than linearly. Concavity of the EC then implies that tangency with a ray from the origin of slope e/w must occur at a higher level of e than before (point B' rather than point C'). Economically, firms in this situation take advantage of the relatively lower marginal cost of effective labor and decrease wages less than proportionally so as to obtain more effort.

Finally, let us return to logarithmic risk aversion in consumption ($\chi = 0$). In this case, $\partial w/\partial e$ increases linearly in w and thus, the cost of effective labor remains exactly the same. Firms in this situation change wages so as to keep their gift to the worker and thus effort at the same level.

While we cannot claim that the cyclical properties of effort would remain the same for any change in our functional forms, it is more robust than the graphical argument here would suggest. First, the comparative statics in Table 5a and 5b show that the same results obtain when firms take into account the effect of their employment decision on effort; i.e. when firms' optimality condition is the MSC, $\varepsilon_{e,w} - \varepsilon_{e,n} = 1$, rather than simply the SC, $\varepsilon_{e,w} = 1$ (which applies when $\varphi = 0$), as implied by the above graphical illustration. Second, for the cyclical properties of effort to be substantially different, the elements of the EC that depend on effort (h_e and d_e) would have to be a function of wages. It is not obvious why this should be the case.

3 Derivation of the main equations

3.1 Derivation for logarithmic preference case (Section 2 of the paper)

For the case when preferences for consumption are logarithmic, we focus our derivation on the model variant with variable effort; i.e. when the gift of the worker depends on the firm's productivity. The derivations for the simpler model with constant effort are very much similar and therefore omitted. The Matlab code for the computations presented in this appendix as well as for the comparative statics is available from the authors upon request.

Consider the Effort Condition (EC) of the variable effort model in Section 3 (the second variant of equation 6 on page 12)

$$\begin{aligned} Qe^{\theta-\alpha} &= An^{\alpha-1}\{\log(\tau w) - \varphi \log\left[\tau (y/n)^{\nu}\right] - (1-\varphi)\log[\tau \bar{w}^{\bar{n}} b^{(1-\bar{n})}]\} \\ &= An^{\alpha-1} g, \end{aligned}$$

where $Q \equiv \theta/\lambda\alpha$ and $g \equiv \log(\tau w) - \varphi \log\left[\tau (y/n)^{\nu}\right] - (1-\varphi)\log[\tau \bar{w}^{\bar{n}} b^{(1-\bar{n})}]$. This equation can be rewritten as an implicit function

$$\Gamma = An^{\alpha-1}\{\log(\tau w) - \varphi \log\left[\tau (An^{\alpha-1}e^{\alpha})^{\nu}\right] - (1-\varphi)\log[\tau \bar{w}^{\bar{n}} b^{(1-\bar{n})}]\} - Qe^{\theta-\alpha} = 0,$$

where y/n has been replaced using the production function

$$y = A(en)^{\alpha}. \tag{5}$$

To compute the labor demand and the Modified Solow Condition (MSC), we apply the implicit function theorem to derive the elasticities

$$\begin{aligned}\varepsilon_{e,w} &= \frac{\partial e}{\partial w}\frac{w}{e} = -\frac{\Gamma_w}{\Gamma_e}\frac{w}{e} \\ &= \frac{An^{\alpha-1}}{Q(\theta-\alpha)e^{\theta-\alpha}+An^{\alpha-1}\varphi\alpha\nu},\end{aligned}$$

and

$$\begin{aligned}\varepsilon_{e,n} &= \frac{\partial e}{\partial n}\frac{n}{e} = -\frac{\Gamma_n}{\Gamma_e}\frac{n}{e} \\ &= \frac{(\alpha-1)An^{\alpha-1}g - An^{\alpha-1}\varphi(\alpha-1)\nu}{Q(\theta-\alpha)e^{\theta-\alpha}+An^{\alpha-1}\varphi\alpha\nu}.\end{aligned}$$

Plugging these two expressions into the MSC $1 = \varepsilon_{e,w} - \varepsilon_{e,n}$, we obtain

$$\begin{aligned}& Q(\theta-\alpha)e^{\theta-\alpha} + An^{\alpha-1}\varphi\alpha\nu \\ =\ & An^{\alpha-1} + (1-\alpha)An^{\alpha-1}g - An^{\alpha-1}\varphi(1-\alpha)\nu,\end{aligned}$$

which can be simplified to

$$Q(\theta-\alpha)e^{\theta} = \frac{y}{n}[1+(1-\alpha)g-\varphi\nu]. \tag{6}$$

Combining this expression with the EC, we obtain

$$\begin{aligned}(\theta-\alpha)\frac{y}{n}g &= \frac{y}{n}[1+(1-\alpha)g-\varphi\nu] \\ (\theta-1)g &= 1-\varphi\nu;\end{aligned}$$

and using the definition of the firm's gift g, we arrive at the wage setting curve (equation 11 on page 15)[6]

$$\begin{aligned}(\theta-1)\log w &= 1-\varphi\nu+\varphi\nu(\theta-1)\log\left(\frac{y}{n}\right)+(1-\varphi)(\theta-1)\log[\bar{w}^{\bar{n}}b^{(1-\bar{n})}] \\ \log w &= \frac{1-\varphi\nu}{\theta-1}+\varphi\nu\log\left(\frac{y}{n}\right)+(1-\varphi)\log[\bar{w}^{\bar{n}}b^{(1-\bar{n})}]. \end{aligned} \tag{7}$$

The wage setting curve can now be used to derive the optimal gift of the firm as $g^* = \frac{1-\varphi\nu}{\theta-1}$ and thus, the EC becomes (second variant of equation 12 on page 15)

$$Qe^{\theta} = \frac{y}{n}g^*. \tag{8}$$

[6]Note that with logarithmic preferences, the constant τ in the definition of the gift of the firm cancels out.

Finally, to derive an explicit expression for the labor demand $w = \psi\alpha\frac{y}{n}[1+\varepsilon_{e,n}]$, we first use the MSC in (6) to simplify $\varepsilon_{e,n}$ to

$$\begin{aligned}\varepsilon_{e,n} &= \frac{(\alpha-1)\left(\frac{y}{n}\right)g - \varphi(\alpha-1)\nu\left(\frac{y}{n}\right)}{\frac{y}{n}[1+(1-\alpha)g-\varphi\nu] + \left(\frac{y}{n}\right)\varphi\alpha\nu} \\ &= \frac{(\alpha-1)g - \varphi(\alpha-1)\nu}{1+(1-\alpha)g-\varphi(1-\alpha)\nu}.\end{aligned}$$

Then plugging this expression into the labor demand and replacing g with its optimal value $g^* = \frac{1-\varphi\nu}{\theta-1}$, we obtain

$$\begin{aligned}w &= \psi\alpha\frac{y}{n}\left[1+\frac{(\alpha-1)g-\varphi(\alpha-1)\nu}{1+(1-\alpha)g-\varphi(1-\alpha)\nu}\right] \\ &= \frac{y}{n}\left[\frac{\psi\alpha}{1+(1-\alpha)g^*-\varphi(1-\alpha)\nu}\right].\end{aligned}$$

By definition, $\frac{\psi\alpha}{1+(1-\alpha)g^*-\varphi(1-\alpha)\nu} = \frac{\psi\alpha}{\mu}$ equals the labor share. Furthermore, we can reformulate this expression in logarithms to recover the equation for labor demand in the text (equation 13 on page 15)

$$\log n = \log\left(\frac{\psi\alpha}{\mu}\right) + \log\left(\frac{y}{w}\right). \tag{9}$$

3.2 Derivation for general CRRA preference case (Section 2 of this Appendix)

The derivation of the model with CRRA preferences for consumption proceeds in similar fashion. Consider the EC (equation 17 on page 24)

$$Qe^{\theta-\alpha} = An^{\alpha-1}\left[\frac{1}{\chi}(\tau w)^\chi - \frac{\varphi}{\chi}[\tau(y/n)^\nu]^\chi - \frac{(1-\varphi)}{\chi}[\tau\bar{w}^{\bar{n}}b^{1-\bar{n}}]^\chi\right],$$

or in implicit function form

$$\Gamma = An^{\alpha-1}\left[\frac{1}{\chi}(\tau w)^\chi - \frac{\varphi}{\chi}\left[\tau(An^{\alpha-1}e^\alpha)^\nu\right]^\chi - \frac{(1-\varphi)}{\chi}[\tau\bar{w}^{\bar{n}}b^{1-\bar{n}}]^\chi\right] - Qe^{\theta-\alpha} = 0.$$

The elasticities of effort with respect to the wage and to employment are

$$\begin{aligned}\varepsilon_{e,w} &= \frac{\partial e}{\partial w}\frac{w}{e} = -\frac{\Gamma_w}{\Gamma_e}\frac{w}{e} \\ &= \frac{An^{\alpha-1}(\tau w)^\chi}{Q(\theta-\alpha)e^{\theta-\alpha} + An^{\alpha-1}\varphi\nu\alpha[\tau(Ae^\alpha n^{\alpha-1})^\nu]^\chi}\end{aligned}$$

$$\begin{aligned}\varepsilon_{e,n} &= \frac{\partial e}{\partial n}\frac{n}{e} = -\frac{\Gamma_n}{\Gamma_e}\frac{n}{e} \\ &= \frac{(\alpha-1)An^{\alpha-1}g - An^{\alpha-1}\varphi\nu(\alpha-1)[\tau(Ae^\alpha n^{\alpha-1})^\nu]^\chi}{Q(\theta-\alpha)e^{\theta-\alpha} + An^{\alpha-1}\varphi\nu\alpha[\tau(Ae^\alpha n^{\alpha-1})^\nu]^\chi},\end{aligned}$$

where $g \equiv \frac{1}{\chi}(\tau w)^\chi - \frac{\varphi}{\chi}\left[\tau(An^{\alpha-1}e^\alpha)^\nu\right]^\chi - \frac{(1-\varphi)}{\chi}[\tau \bar{w}^{\bar{n}} b^{1-\bar{n}}]^\chi$. Plugging these two expressions into the MSC $1 = \varepsilon_{e,w} - \varepsilon_{e,n}$, we obtain

$$\begin{aligned} & Q(\theta-\alpha)e^{\theta-\alpha} + An^{\alpha-1}\varphi\nu\alpha[\tau(Ae^\alpha n^{\alpha-1})^\nu]^\chi \\ = \quad & An^{\alpha-1}(\tau w)^\chi + (1-\alpha)An^{\alpha-1}g - An^{\alpha-1}\varphi\nu(1-\alpha)[\tau(Ae^\alpha n^{\alpha-1})^\nu]^\chi, \end{aligned}$$

which can be simplified to

$$Q(\theta-\alpha)e^\theta = \frac{y}{n}[(\tau w)^\chi + (1-\alpha)g - \varphi\nu\left[\tau(y/n)^\nu\right]^\chi]. \tag{10}$$

Combining this expression with the EC, we get

$$\begin{aligned} (\theta-\alpha)\frac{y}{n}g &= \frac{y}{n}[(\tau w)^\chi + (1-\alpha)g - \varphi\nu\left[\tau(y/n)^\nu\right]^\chi] \\ (\theta-1)g &= (\tau w)^\chi - \varphi\nu\left[\tau(y/n)^\nu\right]^\chi. \end{aligned}$$

Then using the definition of g above, we obtain

$$\begin{aligned} & (\theta-1)\left[\frac{1}{\chi}(\tau w)^\chi - \frac{\varphi}{\chi}\left[\tau(y/n)^\nu\right]^\chi - \frac{(1-\varphi)}{\chi}[\tau\bar{w}^{\bar{n}}b^{1-\bar{n}}]^\chi\right] \\ = \quad & (\tau w)^\chi - \varphi\nu\left[\tau(y/n)^\nu\right]^\chi, \end{aligned}$$

and after some rearrangements

$$\begin{aligned} (\theta-1-\chi)(\tau w)^\chi &= \varphi(\theta-1-\chi\nu)\left[\tau(y/n)^\nu\right]^\chi + (1-\varphi)(\theta-1)[\tau\bar{w}^{\bar{n}}b^{1-\bar{n}}]^\nu \\ w^\chi &= \varphi\bar{\theta}\left[(y/n)^\nu\right]^\chi + (1-\varphi)\tilde{\theta}[\bar{w}^{\bar{n}}b^{(1-\bar{n})}]^\nu, \end{aligned} \tag{11}$$

with $\bar{\theta} \equiv (\theta-1-\chi\nu)/(\theta-1-\chi) > 0$ and $\tilde{\theta} \equiv (\theta-1)/(\theta-1-\chi) > 0$. This is the wage setting curve (equation 18 on page 24). It can be used to rewrite the EC as (equation 20 on page 25)

$$Qe^\theta = \frac{y}{n}\left[\frac{(\bar{\theta}-1)}{\chi}\varphi\left[\tau(y/n)^\nu\right]^\chi + \frac{(\tilde{\theta}-1)}{\chi}(1-\varphi)[\tau\bar{w}^{\bar{n}}b^{(1-\bar{n})}]^\nu\right]. \tag{12}$$

Finally, to derive an explicit expression for the labor demand, we use again the MSC to simplify $\varepsilon_{e,n}$

$$\begin{aligned} \varepsilon_{e,n} &= \frac{(\alpha-1)\frac{y}{n}g - \frac{y}{n}\varphi\nu(\alpha-1)[\tau(y/n)^\nu]^\chi}{\frac{y}{n}[(\tau w)^\chi + (1-\alpha)g - \varphi\nu\left[\tau(y/n)^\nu\right]^\chi] + \frac{y}{n}\varphi\nu\alpha[\tau(y/n)^\nu]^\chi} \\ &= \frac{(\alpha-1)g - \varphi\nu(\alpha-1)[\tau(y/n)^\nu]^\chi}{(\tau w)^\chi + (1-\alpha)g - \varphi\nu(1-\alpha)\left[\tau(y/n)^\nu\right]^\chi}. \end{aligned}$$

Plugging this expression into the definition of the labor demand, $w = \psi\alpha\frac{y}{n}[1+\varepsilon_{e,n}]$, we obtain

$$\begin{aligned} w &= \psi\alpha\frac{y}{n}\left[1 + \frac{(\alpha-1)g - \varphi\nu(\alpha-1)[\tau(y/n)^\nu]^\chi}{(\tau w)^\chi + (1-\alpha)g - \varphi\nu(1-\alpha)\left[\tau(y/n)^\nu\right]^\chi}\right] \\ & \psi\alpha\frac{y}{n}\left[\frac{(\tau w)^\chi}{(\tau w)^\chi + (1-\alpha)g - \varphi\nu(1-\alpha)\left[\tau(y/n)^\nu\right]^\chi}\right]; \end{aligned}$$

or equivalently, using the expression $(\theta-1)g = (\tau w)^{\chi} - \varphi\nu\,[\tau(y/n)^{\nu}]^{\chi}$ from the derivation of the wage setting equation above,

$$w^{\chi} + \frac{(1-\alpha)}{(\theta-1)}\left[w^{\chi} - \varphi\nu\,[(y/n)^{\nu}]^{\chi}\right] - \varphi\nu(1-\alpha)\,[(y/n)^{\nu}]^{\chi} = \psi\alpha\frac{y}{n}w^{\chi-1}.$$

After some rearrangement, we arrive at the expression of the labor demand in the text (equation 19 on page 24)

$$w^{\chi} = \frac{(\theta-1)}{(\theta-\alpha)}\psi\alpha\frac{y}{n}w^{\chi-1} + \frac{\theta(1-\alpha)}{(\theta-\alpha)}\varphi\nu\,[(y/n)^{\nu}]^{\chi}\,. \tag{13}$$

3.3 Equilibrium equations

In equilibrium, $w = \bar{w}$, $n = \bar{n}$ and $b = \rho w$. The equilibrium values of e, w, b, y and λ given calibrations for θ, ρ, n, ψ, α, φ and A are computed as follows. For the model in section 3, we first combine the wage setting curve (7), the labor demand (9), and $b = \rho w$ to derive the equilibrium expression for wages

$$\log w = \frac{g^{*} - \varphi\nu\log(\psi\alpha/\mu) + (1-\varphi)(1-n)\log\rho}{(1-\nu)\varphi}.$$

From there, we find the equilibrium value of y/n using the labor demand; the equilibrium values of effort and output using the the production function (5); and λ using the EC (8).

For the model in section 5, the equilibrium computations are somewhat more involved. First, we use the wage setting curve (11) and $b = \rho w$ to derive the following expression for y/n

$$\frac{y}{n} = \left[\frac{w^{\chi} - \tilde{\theta}(1-\varphi)(w\rho^{1-n})^{\chi}}{\bar{\theta}\varphi}\right]^{\frac{1}{\nu\chi}}.$$

Then, we numerically iterate over w so as to make the labor demand (13) hold. From there, we obtain the equilibrium value of y/n from the above equation; the equilibrium values of effort and output using the the production function (5); and λ using the EC (12).

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