

Online Appendix

The importance of intangible capital for the transmission of financial shocks

Jose Ignacio Lopez¹

Universidad de Los Andes

Virginia Olivella

Banque de France

1. Intra-Firm Bargaining

In this online appendix we describe the model when firms internalize the effect of hiring decisions on wages. Wages are functions of all inputs of the production function. We focus on the problem of the firm as the consumer side remains unchanged. This version of the model follows closely the work by [Cahuc and Wasmer \(2001\)](#). We find that after re-calibrating the steady-state of the model, this specification delivers business cycle statistics for aggregate variables almost identical to our benchmark. This result is in line with the findings by [Krause and Lubik \(2007\)](#).

1.1. Entrepreneurs

The optimization problem of an entrepreneur is thus summarized as:

$$\max_{c_t^E, K_{T,t+1}, K_{I,t+1}, v_t, B_{t+1}} E_0 \sum_{t=0}^{\infty} \gamma^t \log(c_t^E) \quad (1)$$

subject to the budget (2) and borrowing constraints (3), and the law of motion for employment (4):

$$c_t^E + (1+r_t)B_t + K_{T,t+1} - (1-\delta_T)K_{T,t} + K_{I,t+1} - (1-\delta_I)K_{I,t} + W_t(n_t, K_{T,t}, K_{I,t})n_t + qv_t = Y_t + B_{t+1} \quad (2)$$

¹Corresponding author. Address: Carrera 1 No 18A-70, oficina W803, Bogota, Colombia. Tel: 57-13394949

Email addresses: ji.lopezg@uniandes.edu.co (Jose Ignacio Lopez),
Virginia.OlivellaMoppett@banque-france.fr (Virginia Olivella)

$$B_{t+1}(1 + r_{t+1}) \leq \chi_t K_{T,t+1} \quad (3)$$

$$n_{t+1} = (1 - x) n_t + \omega(\theta_t) v_t \quad (4)$$

The only difference with the benchmark version of the model is that wages are in the intra-firm bargaining model a function of the size of the firm (the number of workers and the stock to tangible and intangible capital). The First-Order Optimal Conditions of this problem are:

$$1 - \mu_t \chi_t = \gamma E_t \left[\left(c_t^E / c_{t+1}^E \right) (r_{T,t+1} + (1 - \delta_T)) - \frac{\partial W_{t+1}}{\partial K_{T,t+1}} n_{t+1} \right] \quad (5)$$

$$1 = \gamma E_t \left[\left(c_t^E / c_{t+1}^E \right) (r_{I,t+1} + (1 - \delta_I)) - \frac{\partial W_{t+1}}{\partial K_{I,t+1}} n_{t+1} \right] \quad (6)$$

$$\mu_t = 1/(1 + r_{t+1}) - \gamma E_t \left(c_t^E / c_{t+1}^E \right). \quad (7)$$

$$q/\omega(\theta_t) = \gamma E_t \left[\left(c_t^E / c_{t+1}^E \right) \left(MPL_{t+1} + q(1 - x)/\omega(\theta_{t+1}) - W_{t+1} - \frac{\partial W_{t+1}}{\partial n_{t+1}} n_{t+1} \right) \right] \quad (8)$$

Following [Cahuc and Wasmer \(2001\)](#), one can show that the system of differential equations that determine the Nash Bargaining process can be solved using generalized spherical coordinates. The resulting wages take the following form:

$$W = \frac{\eta \Theta_S}{1 - \eta(1 - \alpha_{K_T} - \alpha_{K_I})} MPL + q \theta \frac{\beta}{\gamma} + \frac{1 - x}{\omega(\theta)} q \left(1 - \frac{\beta}{\gamma} \right) + (1 - \phi) \varphi c \quad (9)$$

where,

$$\eta = \frac{\beta \phi}{(\phi \beta + (1 - \phi) \gamma)} \quad (10)$$

As shown by [Krause and Lubik \(2007\)](#) this version of the model requires a recalibration of the steady-state, with new depreciation rates for tangible and intangible capital in order to match the same capital-to-output ratios, but has almost identical business cycle statistics.

References

- Cahuc, P. and E. Wasmer (2001). Does intrafirm bargaining matter in the large firm's matching model? *Macroeconomic Dynamics* 5(05), 742–747. [1](#), [1.1](#)
- Krause, M. and T. A. Lubik (2007). Does intra-firm bargaining matter for business cycle dynamics? *Working Paper Deutschen Bundesbank*. [1](#), [1.1](#)