

The Production Sector in EURACE

EURACE Winter School 2009

H. Dawid, S. Gemkow, P. Harting, and M. Neugart

13. November 2009

Introduction

The Consumption Goods Producer

The Investment Goods Producer

Malls and Consumers' Consumption decision

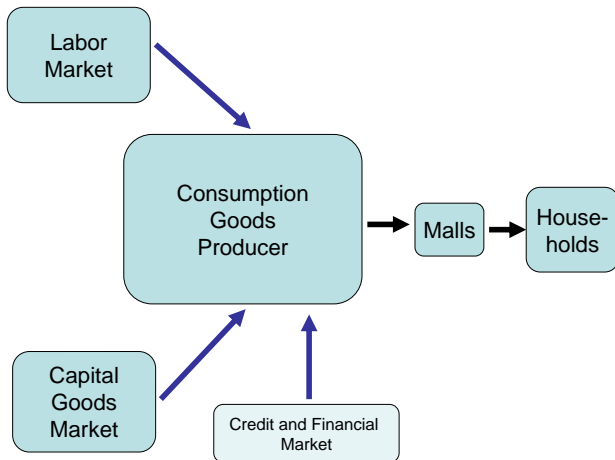
Summary

The real side of EURACE

- ▶ There are 3 real markets in EURACE:
 - ▶ Consumption Goods Market.
 - ▶ Production and selling of a homogeneous consumption good.
 - ▶ Semi local market.
 - ▶ Capital Goods Market.
 - ▶ Capital goods are vertically differentiated among their productivity.
 - ▶ Global market.
 - ▶ Labor Market.
 - ▶ Labor differentiated among general and specific skills.
 - ▶ Semi local market.
 - ▶ Labor and capital goods are input factors for the production of the consumption good.

Agents and their roles

- ▶ Consumption goods producer:
 - ▶ Producer and seller of consumption goods.
 - ▶ Buyer of labor and capital goods.
- ▶ Households:
 - ▶ Consumer on the Consumption Goods Market.
 - ▶ Supplier on the Labor Market.
- ▶ Investment Goods Producer:
 - ▶ Supplier on the Investment Goods Market.
- ▶ Malls:
 - ▶ Local market platforms where consumption goods producers store and offer their commodities.
 - ▶ Transfer of information and goods from producers to consumers.



General modeling philosophy

- ▶ Strong micro-foundation of decision rules: firms and households act rule-based using backward looking expectations.
- ▶ Operational decisions of firms are modeled using standard decision rules from the Operations Management literature:
 - ▶ Pricing (markup)
 - ▶ Inventory and production planning (newsboy problem)
- ▶ Savings/consumption decisions of HHs are simplified versions of empirically confirmed rules.

General features

- ▶ The firm uses capital and labor to produce consumption goods.
- ▶ Firms are located in regions.
 - ▶ The commodities are sold at geographically distributed outlet malls.
 - ▶ Goods can be frictionless transferred to all regions/malls.
 - ▶ Firms have access to the (global) Investment Goods Market.
 - ▶ There are barriers to hire workers from outside regions (commuting costs).
- ▶ The firm can finance the production internally and externally.

Technology

- ▶ The production technology of firm i is embedded in firm's capital stock $K_{i,t}$ and is characterized by its technical productivity $A_{i,t}$.
- ▶ Average productivity $A_{i,t}$ depends on past investments.
- ▶ $A_{i,t}$ is updated by depreciation and new physical investments.
- ▶ The firm depreciates its capital stock $K_{i,t}$ at a rate δ , it follows $K_{i,t} = (1 - \delta)K_{i,t-1} + I_{i,t}$.

The impact of Skills

- ▶ A worker w has two skill dimensions:
 - ▶ General skills: Education and general abilities measured in 5 discrete skill groups $b_w^{gen} = \{1, \dots, 5\}$.
 - ▶ Specific skills: $b_{w,t}$ are experiences and know how obtained on the job.
 - ▶ Specific skills of a worker w employed in firm i evolve through learning by doing etc. according to

$$b_{w,t} = b_{w,t-1} + \chi(b_w^{gen}) \cdot (A_{i,t} - b_{w,t-1}).$$

- ▶ Building up specific skills depends on educational level.
- ▶ Function χ increasing in the general skill level of worker w , $f'(b_w^{gen}) > 0$.

Interaction of Technology and Skills

- ▶ Complementarity between mean specific skills $B_{i,t}$ and technical productivity $A_{i,t}$.
- ▶ Effective productivity $A_{i,t}^{eff} = \min [A_{i,t}, B_{i,t}]$.
- ▶ Productivity of a given technology level is only fully exploited if workers in the firm have sufficiently high specific skills.

Production Function

- ▶ Production Function of a Consumption Goods Producer:
 - ▶ Cobb-Douglas production function

$$Q_{i,t} = \min [A_{i,t}, B_{i,t}] L_{i,t}^{\alpha} K_{i,t}^{\beta}.$$

- ▶ $L_{i,t}$ current labor stock, $K_{i,t}$ capital stock, α, β input factor intensity with constant returns to scale, $\alpha + \beta = 1$.

Sequence of activities

- ▶ The sequence of decisions and actions
 - ▶ Production planning.
 - ▶ Tentative input factor planning.
 - ▶ Financial planning.
 - ▶ Final production and input factor determination.
 - ▶ Labor and Capital Market transactions.
 - ▶ Production and delivery.
 - ▶ Periodic earnings statement.

Timing

- ▶ Timing of production
 - ▶ Length of the production cycle: 1 month.
 - ▶ At the monthly activation day (first day of the cycle):
Production planing, financing, production, and delivery to the malls.
 - ▶ Selling during the whole of the month.
 - ▶ Earnings statement at the last day of the production cycle.

Production planning

- ▶ Standard inventory rule with stochastic demand: The firms compute different delivery volumes for all served malls (newsboy problem).
- ▶ $Y_{i,r,t}$ is the critical stock of firm i in mall r , $SL_{i,r,t}$ is the current mall stock at the activation day.
- ▶ Desired replenishment quantity:

$$\tilde{D}_{i,r,t} = \begin{cases} 0 & SL_{i,r,t} \geq Y_{i,r,t}, \\ Y_{i,r,t} - SL_{i,r,t} & \text{else.} \end{cases}$$

Production planning

- ▶ Demand is estimated by computing a linear trend from the previous demands.
- ▶ Estimated demand of the last τ periods for mall r :
 $\{\hat{D}_{i,r,t-\tau}, \dots, \hat{D}_{i,r,t-1}\}.$
- ▶ Determination of the estimated demand:

$$\hat{D}_{i,r,t} = \begin{cases} S_{i,r,t} & \text{if } SL_{i,r,t} > 0 \\ S_{i,r,t} \cdot (1 + \nu) & \text{if } SL_{i,r,t} = 0, \end{cases}$$

where $0 < \nu < 1$.

Production planning

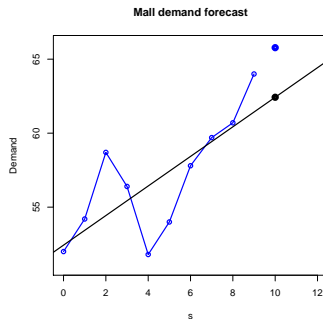
- ▶ $Y_{i,r,t}$ is chosen such that the firm expects to be able to satisfy the market demand with probability $1 - \chi$ (χ , stock-out probability).
- ▶ Linear regression model based on previous demands:

$$Y_{i,r,t} = \hat{a}_{i,r,t} + \tau \cdot \hat{b}_{i,r,t} + \bar{q}_{1-\chi} \cdot \sqrt{\hat{\delta}_{i,r,t}}.$$

- ▶ \hat{a} , \hat{b} linear regression coefficients, $\hat{\delta}$ estimated variance, and $\bar{q}_{1-\chi}$ the $1 - \chi$ -quantile of the standard normal distribution.

Production planning

- ▶ Illustration: Linear regression of $\hat{D}_{i,r,t-\tau+s}$ with regressor s , and $\tau = 10$ past observations.
- ▶ Estimation of demand for $s = 10$: $\hat{D}_{i,r,t} = Y_{i,r,t}$



Production planning

- ▶ Desired replenishment quantity:

$$\tilde{D}_{i,r,t} = \begin{cases} 0 & SL_{i,r,t} \geq Y_{i,r,t}, \\ Y_{i,r,t} - SL_{i,r,t} & \text{else.} \end{cases}$$

- ▶ Sum of all replenishment quantities is $\tilde{D}_{i,t} = \sum_{r=1}^R \tilde{D}_{i,r,t}$.
- ▶ Smoothing of (planned) production quantity:

$$\tilde{Q}_{i,t} = \xi \tilde{D}_{i,t} + (1 - \xi) \frac{1}{T} \sum_{k=t-T}^{t-1} Q_{i,k}.$$

- ▶ Proportional adjustment of delivery volumes: $D_{i,r,t} = \frac{\tilde{D}_{i,r,t}}{\tilde{D}_{i,t}} \tilde{Q}_{i,t}$.

Input factor planning

- ▶ The firm aims to realize a capital to labor ratio according to the standard rule for CES production functions:

$$\frac{\tilde{K}_{i,t}}{p^{inv}} / \frac{\tilde{L}_{i,t}}{w_t^e} = \frac{\beta}{\alpha}.$$

- ▶ w_t^e expected mean wage, and p^{inv} a calculatory capital goods price.

Input factor planning: Labor

- After determining the desired capital stock $\tilde{K}_{i,t}$, the firm computes the required labor input:

$$\tilde{L}_{i,t} = \left(\frac{\tilde{Q}_{i,t}}{(\tilde{K}_{i,t}^\beta \min[A_{i,t-1}, B_{i,t-1}])} \right)^{1/\alpha}.$$

Financial planning

- ▶ Financial needs of a firm :
 - ▶ Expected expenditures for the production:

$$\hat{Exp}_{i,t}^{Prod} = w_t^e \tilde{L}_{i,t} + (\tilde{K}_{i,t} - K_{i,t-1}) \bar{p}_t^{Inv}.$$

- ▶ Financial obligations: $\hat{Exp}_{i,t}^{Fin}$ (Dividends, taxes, interest payments, debt installment payments).
- ▶ Total financial needs:

$$\hat{Exp}_{i,t}^{Tot} = \hat{Exp}_{i,t}^{Prod} + \hat{Exp}_{i,t}^{Fin}.$$

- ▶ The firm checks how much can be financed internally.
 - ▶ The amount that cannot be financed by internal resources has to be obtained on the Credit or Financial Market.

Financial planning

- ▶ If the firm has to raise external liquidity:
 - ▶ Firm checks if it obtains the complete external financial needs.
 - ▶ If this is not the case: The firm has to adapt its expenditures.
 - ▶ Priority to serve the financial obligations.
 - ▶ Firm reduces the output quantity as long as the recalculated expected expenditures are covered by the resources.
 - ▶ If the firm is still not able to serve its financial obligations: Bankruptcy.

Production

- ▶ Firm enters the Capital Market and the Labor Market.
- ▶ The capital stock after realized investments is $K_{i,t}$ with a technical productivity of $A_{i,t}$.
- ▶ The number of workers is $L_{i,t}$ with a mean specific skill level of $B_{i,t}$.
- ▶ The realized production quantity $Q_{i,t}$ is then:

$$Q_{i,t} = \min [A_{i,t}, B_{i,t}] L_{i,t}^{\alpha} K_{i,t}^{\beta}.$$

- ▶ Delivery volumes to malls: $D_{i,r,t} = \tilde{D}_{i,r,t} \frac{Q_{i,t}}{Q_{i,t}}$

Cost accounting

- ▶ The production expenditures are:

$$Exp_{i,t}^{Prod} = w_{i,t} \cdot L_{i,t} + I_{i,t} \cdot \bar{p}_t^{Inv}.$$

- ▶ $w_{i,t}$ is the mean wage firm i pays in period t .
- ▶ The production costs are:

$$Cost_{i,t}^{Prod} = w_{i,t} \cdot L_{i,t} + Cost_{i,t}^{Cap} + Int_{i,t}.$$

- ▶ $Cost_{i,t}^{Cap}$ calculatory capital costs, $Int_{i,t}$ interest payments.

Cost accounting

- ▶ Unit costs:

$$Cost_{i,t}^{Unit} = \frac{Cost_{i,t}^{Prod}}{Q_{i,t}}.$$

- ▶ Mark up pricing:

$$p_{i,t} = Cost_{i,t}^{Unit} \cdot \frac{1}{1 + 1/\epsilon_i^e}.$$

- ▶ ϵ_i^e expected demand elasticity.

Earnings statement

- ▶ At the end of the selling period the mall informs the firm about the sold items $S_{i,r,t}$ and the current mall stock $SL_{i,r,t+1}$.
- ▶ The firm computes the EBIT:

$$EBIT_{i,t} = \sum_R S_{i,r,t} p_{i,t} - Cost_{i,t}^{Prod}.$$

- ▶ Determination of taxes, dividends, interests and debt installment payments to be paid in the next production cycle.

General features

- ▶ The IG sector is in the current model version simplified.
- ▶ One IG firm offers its capital good on a global market.
- ▶ Consumption goods producers order the capital good and get the required amount without rationing.
- ▶ The IG firm produces without input factors.
- ▶ Net earnings (revenues minus taxes) are paid out as dividends.

Technological progress

- ▶ The IG firm carries out R&D activities to improve the technology.
- ▶ R&D is successful with a probability $prob^{Inno}$.
 - ▶ The productivity increases: $q_t^{Inv} = (1 + \theta)q_{t-1}^{Inv}$.
 - ▶ The price of the investment good increases at the same rate:
 $p_t^{Inv} = (1 + \theta)p_{t-1}^{Inv}$.
- ▶ Technological progress is driven by innovations in the investment goods sector, diffusion of the technology is induced by consumption good firms' investments in their capital stocks.

Malls

- ▶ The malls are local market platforms where consumption goods producer offer their goods and households purchase consumption goods.
- ▶ One mall per region.
- ▶ The mall informs the consumers about the range of provided goods and the corresponding prices.
- ▶ It receives orders from the household, if the sum of order quantities for a particular good exceeds the local inventory, consumers of that good are rationed.
- ▶ Sales are collected at the mall and transferred to firms.

Households purchasing decision

- ▶ Once a week a household goes to the mall located in their home region.
- ▶ $CB_{k, week_t}$ is the weekly consumption budget which a household can spend.
- ▶ $G_{k, week_t}$ is the set of goods, which is available at that day.

Households purchasing decision

- ▶ The household decides about one good to purchase using a standard discrete choice model.
- ▶ Logit model based on price differences.
- ▶ The value of consumption good i is given by $v_k(p_{i,t}) = -\ln(p_{i,t})$.
- ▶ Consumer k selects one good where the probability for good i to be selected is

$$Prob_{k,i,t} = \frac{\text{Exp}[\lambda^{\text{cons}} v_k(p_{i,t})]}{\sum_{i' \in G_{k, \text{week}_t}} \text{Exp}[\lambda^{\text{cons}} v_k(p_{i',t})]}$$

- ▶ The intensity of (price) competition is λ^{cons}

Households purchasing decision

- ▶ The household orders $\frac{CB_{k,week_t}}{p_{i,t}}$ units of the selected good i .
- ▶ If the household cannot spend the complete budget $CB_{k,week_t}$ due to rationing, the household enters a second loop in order to spend the remaining budget for another good.
- ▶ If the household is rationed once again, the remaining budget is rolled over to the following week.

- ▶ In this lecture presented:
 - ▶ Producer role of consumption goods producers.
 - ▶ IG firm.
 - ▶ Malls.
 - ▶ Consumer role of Households.
- ▶ Interactions with other EURACE components:
 - ▶ Labor Market.
 - ▶ Credit and Financial market.
 - ▶ Public sector.