Overview

The structure of costs in firms depend on the many choices management takes and on the effectiveness of internal procedures and external bargain. Liebenstein underlined that firms differ in efficiency even when operates on the same market and it is now widely accepted that what he called X-inefficiency can be tracked down to firm-level history and capabilities.

What happens when firms that have different mixes of fixed and variable costs compete on the same market? What happens when their break-even point is different and they compete on both price and quality?

In this easy evolutionary model we introduce a market with a large number of firms, each characterised by a different cost structure, and you'll be able to study the evolution of profits over time, according to changes in demand and endogenous technology.

A key statement will relate the way demand interacts with technological innovation. In particular, we shall demonstrate that, given the same system of technological opportunity and generation process:

- with long-term decline in demand, firms will prevalently cut fixed costs;
- with long-term rise in demand, firms will prevalently choose innovations that allow them to reduce variable costs.

The implication for labour market and the tax revenue are not explored, however there is room for expecting far-reaching consequences for the kind of dynamics you are going to experiment with it [1].

1. Description of the model

The present model comprehend only artificial firms, not human players, as in this other. Thus, it is an agent-based model of industrial dynamics. You can however change a lot of parameters and choose from a wide set of options, so that many experiments can be done, whose results can be analysed through the free econometric software we distribute or through this easy Excel file.

1.1. The context: firm cost structure

In this model, each firm has a certain level of fixed costs (FC) per period, irrespective of production level (Q), and a constant average variable cost (AVC), so that total costs (TC) are expressed by this formula:

\[ TC = FC + AVC \times Q \]

Marginal costs (MC) are equal to variable costs. Indeed, if in parenthesis we explicit the level of production at which the cost is computed we can write:

\[ MC = TC(Q+1) - TC(Q) = FC - FC + AVC \times (Q + 1 - 1) = AVC \]
Total variable costs will simply be proportional to production level $Q$. Marginal costs are not rising.

Each firm has its own level of fixed and variable costs. For instance a firm might have the following cost structure

$$TC = 1027 + 37 \times Q$$

whereas another could have

$$TC = 1138 + 41 \times Q$$

The first firm is more efficient than the second at every level of production.

The kind of costs is not specified. In particular, some fixed costs could be due to advertising, whereas employment and wages surely enter into the picture. However, there is no explicit modelling of cost split. Also sunk costs are not included in the model.

### 1.2. The context: the good, price and demand

The good is similar but not identical across firms, to the effect that each firm sets his own price and it is possible that high price goods are sold in larger quantities than low price good because they are regarded by at least a part of consumer as superior in quality (vertical differentiation) or simply more in line with capricious will (horizontal differentiation).

This is fairly realistic and correspond to empirical results of markets. However, if you stick to the neoclassical hypothesis of perfectly homogeneous product and identical market shares, you can choose this option as well.

Demanded quantity on the whole market can be the same over time or have changes, according to the option the user chooses. In particular, there can be a trend (positive or negative) and a business cycle fluctuation.

In general, consumers are not individually modelled, nor quality is explicited. For a model in which you have individual consumer choices see our *Race to market*.

### 1.3. The context: production and sales

Firms announce their price and show the product to the potential customers, who, in turn, express the total quantity the want to buy in the aggregate. They order the goods, possibly through a (un-modelled) distribution channel, so that production is exactly equal to sales, in physical quantities.

There are no unsold inventories. For a model with inventories and stochastic demand see "*You are a monopolist*".

### 2. Key decisions

#### 2.1. Technical change

In the basic level of the model, there is no technical change: fixed and variable costs do not evolve over time. However, you can check an option so that, each period, internal formal and informal R&D suggests to the top management a change in procedures of production affecting the structure of costs.

The proposal have pros and cons: every cut in fixed costs leads to an increase in variable costs, and the reverse. In other words, the top management should make a real choice. Were the proposal involving an increase in both fixed and variable costs, the management would simply reject it, because it generates more costs for every level of production.

To make a choice, the top management can follow different rules of thumb. In the basic case, it takes the current level of production and look whether the new structure of costs would reduce total costs at that level. If so, it accept the change and in the next period, the firms is able to use the new structure.

Firms are able to protect themselves from imitation, so there are no spillovers and appropriability of innovation is complete. In terms of the other parameters defining the so-called "technological regimes", the technical progress is highly cumulative and local, because the changes are centred on current technologies. Technological opportunities involve frequent small potential improvements.

#### 2.2. Pricing

Demand is responsive to price, in the sense that if the price of the same good changes, the demand reacts with a certain own-price elasticity. The matrix of crossed-price elasticity is empty in the basic version of the model but in principle could be...
In the basic option, price is kept constant over time. But a rule of price change depending on market condition can be imposed as well. In particular, price will be raised by firms that have seen an increase of their sale. On the contrary, firms facing a falling demand will reduce the price.

This simple rule mimics what most human players do when taking part into this model.

### 2.3. Exit

In the basic option, firms do not exit the market even if they have negative economic profits, possibly because of stubborn optimistic expectations that they will be able to overcome current difficulties.

However, you can impose (by checking the relative options) that firms making losses for one or more periods do exit the market.

### 2.4. Entry

In the basic option, new firms do not enter into the market. However, you can impose (by checking the relative options) that a certain number of firms enter into the market over time, depending on the **average profits of incumbents** and on their own entrepreneurial will.

Because of a lack of technological spillovers and the non-cumulability of technological progress in this industry, the entrant has a cost structure derived from a stochastic extraction from the initial distribution, not from the possibly much more advanced current distribution of skills.

### 3. Relevant results

The most striking result of the model relates **demand** and the **kind of innovation** adopted by firms.

If demand is fixed over time, the number of innovations cutting fixed costs is erratically larger or lower than the number of innovations resulting in lower variable costs.

But if there is a trend of decline in demand, firms will massively prefer cutting fixed costs, whereas a long-term rise in demand is conducive to the kind of innovation that reduces variable costs.

This happens leaving the mechanism that generates innovation exactly the same, with the same level of technological opportunities.

The long debate about the relative importance of "technology push" and "demand pull" in fostering innovation is thus given a new dimension, by relating the kind of innovation to the market trends.

As many intriguing results systematically confirmed by experimentation, it turns out to be to some extent obvious. A decline in demand tends to bring the sold quantity below the break-even point of many firms. Since quantities will be "low", the share of fixed costs in total costs will be high. Thus, a fall in variable costs compensated by an increase in fixed costs will rather be rejected by profit-oriented bounded-rational top managers. The same "people" will instead enthusiastically embrace the same proposal when a rising demand makes the quantities sold "high", so that variable costs represent the major components of total costs.

Other results connect the business cycle with the cost structures, underlining that a recession particularly hits firms with high fixed costs, exactly as the empirical evidence shown in the Thai currency crisis in 1997.

However, the opportunity our model gives you to experiment goes well beyond one or few stylized facts: you can make a lot of changes and try to understand why certain results are so robust!

If you "discover" something, please send us a feedback.

### NOTES

[1] Just imagine that all fixed costs are the costs of capital and all variable costs are the cost of labour. The technological change would thus influence in a predictable way the relative strength between labour and capital.

On the other hand, property tax is typically a fixed cost, whereas VAT is a variable cost.
cost; the model would under this perspective offer a hint about the firms' preferences for certain kind of taxation.