Advances in Performance Measurement – A Mainland Labs Series

Economies of Scope

Cost Structures and Degree of Diversification

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Economies of Sope are cost-saving externalties between product lines.

Jean Tirole (1988)

I. Introduction

Economies of scope (as the closely related concept of economies of scale) are an important feature of modern industrial organization and can be analyzed using standard neoclassical cost theory. Still, the presence of scope economies cannot explain in full important phenomena such as vertical and horizontal integration, i.e. the multi-product firm. As TEECE (1980, p225) puts it, "conclusions about the appropriate boundaries of the firm cannot be drawn simple by examining the nature of the underlying cost function". Thus, in an effort to clarify the relevance of economies of scope in respect to market structure we will try to line out the factors which can guarantee for the joint production of multiple products within the boundaries of a single firm. Before dealing with organizational issues, however, we will give an overview over the key aspects of cost theory connected to the concept of scope economies.

II. Economies of scope and the Theory of Costs

Like its sister concept, economies of scale, scope economies can be the result of an extension of economic activity. Indeed, there are many similarities between the two[1] when it comes to their source which is declining average cost in production along the firm´s movement trough product space providing for the critical subadditivity of costs. Subadditivity and its dual concept superadditivity both rest on specific variants of concavity of the cost and production function of the firm. In the case of economies of scale and for the relevant sections of output rays where they prevail, costs (i.e. total, average and marginal cost) exhibit strict concavity (concave down). With ray average cost declining, it is economically advantageous to opt for production on a bigger scale instead of producing smaller batches of the product separately even if overall output is the same. First definitions in connection with the concept of economies of scale:

1. **(Strict) Ray Concavity (TC are output ray concave down)**
   Case: TC function, 2 product bundles, expansion in fixed proportions along the ray

$$C[ky^a + (1-k)y^b] > kCy^a + (1-k)Cy^b$$

$$0 < k < 1;\, y^a and\ y^b on\ same\ output\ ray$$

[1] If we consider the extreme case of the technical integration of two production lines assembling the same good we will see the two concepts merge. Furthermore, under certain circumstances (see e.g. BAUMOL 1977, 819) even scale economies can be the driver of integration. If we abandon the idea that the comparative advantage of a firm lies in its range of products and instead adapt the notion that it is capabilities what count in the end, the strict distinction between economies of scale (specialization) and economies of scope (diversification) will even loose some of its relevance (see e.g. TEECE 1980, p233). Indeed, the two concepts are intertwined which shows in breaking up scope effects in their various components, economies of scale being one crucial element (see e.g. CAVAS/KIM 2007).

This is the classic case of cost theory where there are increasing returns to scale (IRS) along the relevant output rays providing for economies in production. Resulting declining ray average cost (RAC) and declining ray marginal cost (RMC) play an important role in the analysis of market structures, e.g. (natural) monopolies.

2. (Strictly) Declining Ray Average Cost

$$C(vy_1, \dots, vy_n)/\, v < C(wy_1, \dots, wy_n)/w \qquad v > w$$

Strictly declining ray average cost imply strict ray subaddidivity. This holds especially true for homogeneous functions which we employ throughout this paper. Still, as BAUMOL (1977, 813) points out, declining RAC or strict output-ray concavity of the cost function are in general not a necessary condition for strict subadditivity.

3. (Strict) Ray Subadditivity

$$C\left(\sum v_j y\right) < \ \sum C(v_j y)$$

$$output\ vectors\ v_j\ (j = 1, \dots, n): v_1 y, v_2 y, \dots, v_n y; v_j > 0$$

Under the precondition of homogeneity or homotheticity, respectively, of the underlying functions (see above), we define economies of scale by output ray characteristics.

4. (Strict) Economies of Scale

Economies of scale in the production of outputs in an n-dimensional product space are present, if for any set of input and outputs ($x_1, \dots, x_n; y_1, \dots, y_n$) there is a different feasible set ($vx_1, \dots, vx_n; wy_1, \dots, wy_n$), with $v > 1$ and $w > v + \delta$ ($\delta > 0$).

5. Transray Concavity (TC are transray concave down)[2]

Case: TC function, product bundles, expansion in varying proportions between rays

A cost function C(y) is called transray convave (down) through $y^* = (y_1^*, \dots, y_n^*)$ if there exists any set of positive constants $w_1, \dots, w_n$, such that for every two output vectors, $y^a = (y_1^a, \dots, y_n^a)$ and $y^b = (y_1^b, \dots, y_n^b)$, lying in the same hyperplane $\sum w_i\, y_1$ through y^*, that is, for which $\sum_i w_i\, y_i^a = \sum_i w_i\, y_i^b = \sum_i w_i\, y_i^*$, we have

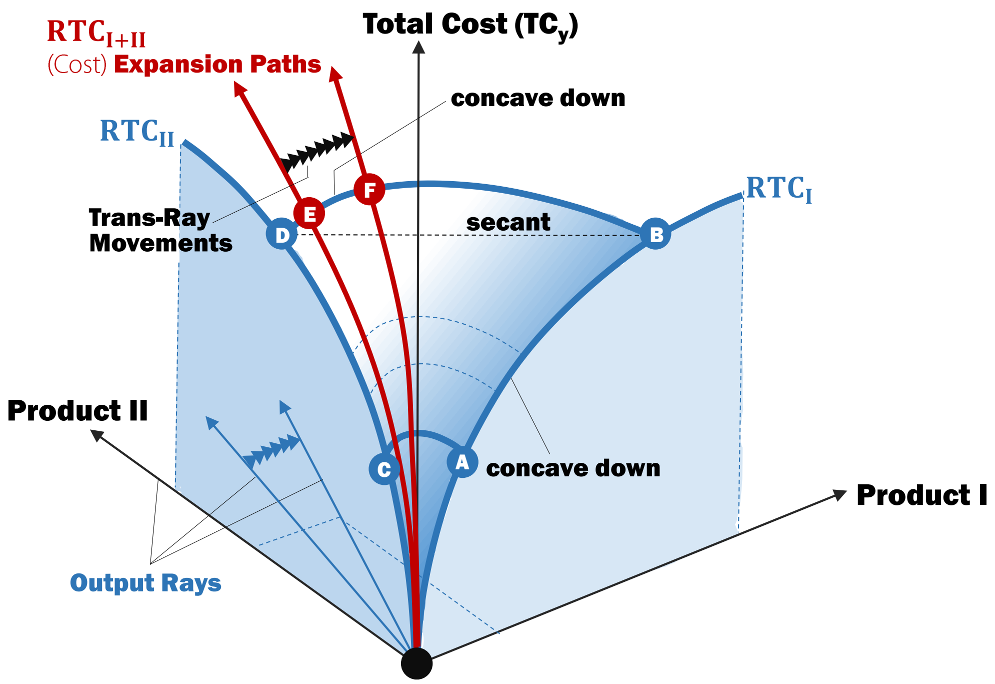
$$C[ky^a + (1-k)y^b] \geq kCy^a + (1-k)Cy^b \qquad 0 < k < 1$$

Here, product bundles make up the output of a firm. Changing the proportions within its current output set (keeping overall output constant) it moves between neighboring output rays (along one hyperplane) with average costs increasing (up to a point).

[2] BAUMOL (1977, p811)

Figure 1 brings together concepts 1 to 5 in order to discuss possible options of the firm in the presence of economies of scale. For that, we turn to the traditional presentation of this phenomenon in neoclassical cost theory.

Figure 1: Standard Case of Economies of Scale



The graph depicts various output ray-connected cost expansion paths, the two extreme cases being the expansion along single product dimensions ($C(y_I, 0)$ or $C(0, y_{II})$) or, for the sake of the argument, the movement from point A to point B in the graph. TC for all combinations of the two products is a concave shaped function exercising economies of scale and decreasing average cost in production along the respective output rays. For transray movements in product space (e.g. between points E and F), however, the classical case also assumes concavity making joint production (prices constant) economically inefficient. Firms therefore will opt for specialization rather than diversification (for large scale joint productions there can be exceptions from this rule; see footnote 1). For the latter to happen, cost behavior across product space has to change – an assumption made in the context of economies of scope.

6. Economies of Scope

Let $T = \{T_1, \dots, T_m\}$ represent a nontrivial partition of $S \subseteq N$ (N … product space) and $m > 1$,. with, $\cup T_i = S$ ($i=1, \dots, m$), $\cap T_i = \emptyset$ and $T_i = \emptyset$. There are economies of scope at y_S with respect to partition T, if

$$\sum_{i=1}^{m} C(y_{T_i}) > C(y_S) \qquad for\ p_s\ constant$$

If the inequality is not strict (weak) we talk of weak economies of scope; if the inequality is reversed diseconomies of scope are present across output rays in subset S of product space N (see PANZAR/WILLIG 1981, pp268). For economies of scope to be realized by any firm active in N, concavity of the total cost function has to exhibit certain characteristics. In contrast to the classic case (figure 1), for economies of scope, convexity of the relevant hyperplane (transray diversification trajectory at constant output) is needed.

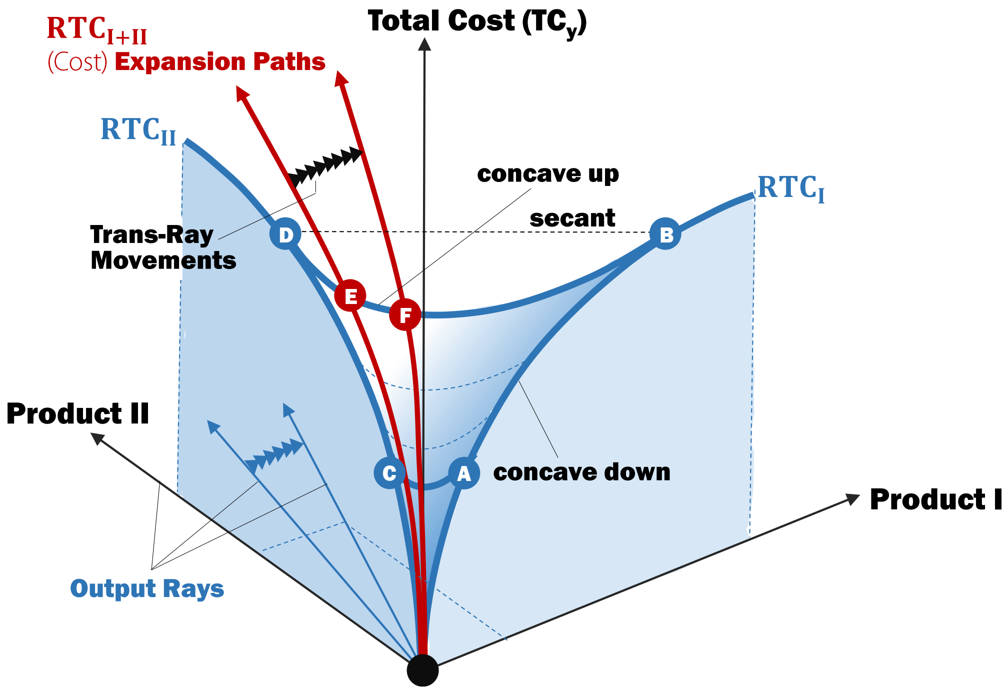
7. Transray Convexity (TC are transray concave up)[2]

A cost function C(y) is called transray convex through $y^* = (y_1^*, \ldots, y_n^*)$ if there exists any set of positive constants w_1, …, w_n, such that for every two output vectors, $y^a = (y_1^a, \ldots, y_n^a)$ and y^b= $(y_1^b, \ldots, y_n^b)$, lying in the same hyperplane $\sum w_i\, y_1$ through y^*, that is, for which $\sum_i w_i\, y_i^a = \sum_i w_i\, y_i^b = \sum_i w_i\, y_i^*$, we have

$$C[ky^a + (1-k)y^b] \leq kCy^a + (1-k)Cy^b \qquad 0 < k < 1$$

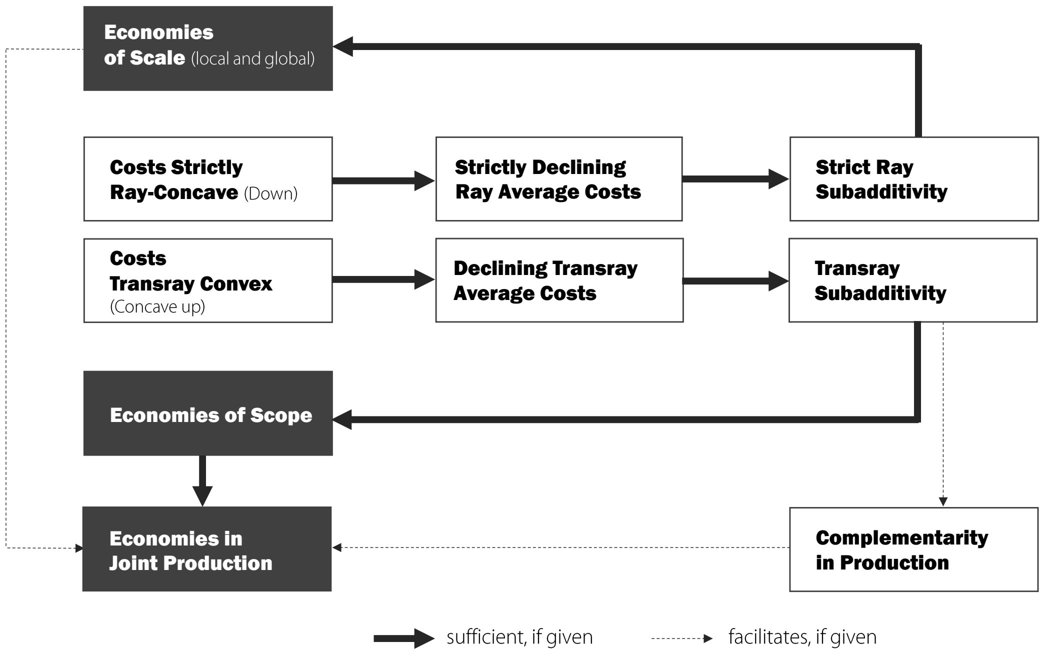
Figure 2 presents the setting favorable for diversification and joint production. Again we have various ray dependent concave cost expansion paths. For transray movements, i.e. diversification (for example movements between points E and F, representing different composite output), convexity of the trajectory and decreasing transray average cost lay the foundation for the multi-product firm.

Figure 2: The Case of Economies of Scope and Diversification



To give an overview over the relationship between cost curve characteristics and phenomena such as economies of scale or scope, figure 3 connects the various concepts discussed above.

Graph 3: Cost Structures and Economies in Production



One cannot postulate decreasing average costs in production or subadditivity of costs in transray movements without identifying the factors driving this specific cost behavior. In the case of economies of scope the main source is the sharing of resources of a firm between different uses (i.e. products), may they be physical assets or intangible ones like knowledge or experience. It is important to note at this point that availability and access to these resources or so called sharable inputs do not predetermine the organization of production of the goods in question. We will deal with this important aspect of economies of scope in the following section, starting with the concept of the sharable inputs.

III. Economies of Scope, Sharable Inputs and Organization

Sharable inputs are inputs, which "[…] once procured for the production of one output, would be also available (either wholly or in part) to aid in the production of other outputs" (PANZAR/WILLIG 1981, p269). There are basically two sources of this special property of inputs, (a) indivisibilities in production, and (b) public good characteristics of the respective input. As for (a), there is the fact that input or resources, respectively, are on a regular basis under-utilized in production processes because they cannot be scaled to perfection. Unexploited capacity can then be put to different uses, within the company, leading to a multi-product firm (diversification), or outside the boundaries of the firm, via market solutions. Resources of that kind might be particularly physical (tangible) assets, such as machinery, research labs or parts of a logistics system (e.g. trucks or warehouses), and to a certain degree intangible ones, such as knowledge and experience embedded in a firm´s employees or (at a more general level) in the organization per se[3]. For a detailed categorization of sharable (common) inputs in production see TEECE (1981).

No matter what kind of sharable inputs they all potentially contribute to cost savings (economies of scope) if (and only if) put to use in joint production. The organizational decision taken by a firm owning and controlling sharable inputs will depend heavily on the efficiency of product and assets markets[4]. Excess capacity of some of these inputs is a private good, so it can be potentially reallocated through the market. For a general (multi-purpose) piece of machinery, for example, we can imagine a lease out of capacity to a third party, and chances for diversification not being very high; with more specialized machines and a significantly smaller range of applications, however, the firm faces a much thinner market. High transaction cost in the search for potential leases and additional strategic considerations (securing competitive advantages) will have the firm opt for in-house solutions, i.e. diversification into a related application or product.

As for the other category of sharable inputs (b), they show characteristics of public goods, e.g. in the case of positive external effects, or of impure public goods (club goods), as with some aspects of human capital. Pure public inputs can be localized external effects of a firm´s production which can be utilized across various products in a region or in an even more narrowly-zoned area (e.g. heat). These inputs are not tradable because of their specific properties (non-rivalry and non-excludability in employment of these resources). On grounds of costs only (not considering e.g. strategic issues or demand side aspects) we will see the firm diversifying into productions sharing this very public input.

With impure public inputs, however, one has to consider the aspect of congestion. So called club goods share their principal properties with public goods up to the point where the capacity of the underlying asset (classic examples include golf clubs or public swimming pools) is technically fully utilized (congestion point). Before that point it is economically efficient to introduce more users to the service, passed that point Pareto-principle kicks in. An important example in the context of industrial activities is human capital, or aspects related to it, such as (tacit) knowledge and experience. For instance, it might be the case that engineers contracted in for the production of any product A will be ready and capable to contribute to the production of any product B, with no or moderate extra cost for the respective firm, creating an incentive for the firm to diversify[5]. Transfer of expertise and capabilities between different uses will meet its limitations with the exhaustion of the capacity of the engineering team (U-shaped transray average cost curve). "Congestion associated with accessing common inputs

[3] Learning effects are contributing significantly to the growth of (excess) capacity (PENROSE-effect)

[4] Neoclassical Theory knows the market as efficient allocator of resources; in competitive equilibrium, with perfect information and no transaction costs, specialization of firms would be the rule and the multi-product firm can only emerge be accident, with internal organization and market arrangements as perfect substitutes (TEECE 1980, p41).

[5] Of course, even capacity of a highly qualified labor force can be traded; still, this is not very likely from a strategic standpoint considering the danger of transfer of knowledge and a potential loss of competitive advantage.

will thus clearly limit the amount of diversification which can be proftitably engaged" (TEECE 1982, p53).

WILLIG (1979, pp346) models the public input case. $V^i(q_i, K)$ are the costs of producing quantity q_i, with K units of a public input available and $p_K = r$.

The multi-product cost function, based on a public input, yielding economies of scope:

$$C(q_1, q_2) = \min_K [V^1(q_1, K) + V^2(q_2, K) + rK]$$

Case: if $V^i(q_i, K) \equiv f^i(q_i) g(K),\ with\ g' < 0,$

then $C(q_1, q_2) = rT[\frac{f^1(q_1) + f^2(q_2)}{r}] \quad T' > 0;\ \ T'' < 0$

IV. Excess Capacity, Organizational Slack and Efficiency

In our concluding section we want to discuss in short the potential value of excess capacity if not utilized through diversification. One has to note that standard economic theory treats under-utilized resources as a temporary phenomenon, or, in principle, (organizational) slack is to be zero. For the general practice of the modern enterprise, however, this does not hold true. Slack exists despite the real potential of economics in diversified production. Even more so, slack acts as an important instrument of performance smoothing. "Organizational slack is that cushion of actual and potential resources which allow an organization to adapt successfully to internal pressures to adjustment or to external pressures for change in policy, as well as to initiate changes in strategy with respect to the external environment" (BOURGEOIS 1981, p30). Also, slack can function as a crucial facilitator of strategic behavior providing resources for innovation and experimental approaches to the market.

In the light of organizational slack there is the question if the merits of strategies to capture economies in production through (vertical and/or horizontal) integration can be offset by those of an alternative long term expansion of the firm only made possible by excess resources spared and geared up for the decisive moment. Considering this, one can also assume an optimal non-zero level of slack, different between firms, changing over time and depending on the level of competition and demand behavior, among other things. If this is so, the measurement of the efficiency of a firm might become even trickier, especially when economies of scope or diversification, respectively, play a key role.

V. Literature

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