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Resources as asset stocks

Most resources are the cumulative result of a series of investments over a period of time. For example, a firm’s reputation for quality is the result of a consistent set of policies on production and quality control, a consistent investment in communication with customers, etc. Similarly, a business school’s key resource, its reputation for excellence in teaching and research, reflects its past investments in faculty, the faculty’s investment in research and teaching, “word of mouth” advertising of its alumni base, etc. Likewise, the cost per unit of making a product is related to the cumulative experience in making this product (i.e. the experience curve). More generally, we can state that resources are stocks, which are accumulated over time by a stream of investments or flows.

It may be useful to provide an intuitive anchor for the view of resources as asset stocks. A resource may be pictured as the amount of water in a “bathtub.” This is the cumulative result of flows of water into the tub through the tap and out of it through a hole. Similarly, the “level” of an asset stock is the cumulative result of investment flows, which build the asset, and outflows that erode the asset over time. In the example of R&D, the amount of water in the tub represents the stock of know-how at a particular moment in time. The fact that know-how depreciates or that private knowledge becomes common knowledge is represented by the flow of water leaking through the hole in the tub.

The fact that stocks do not adjust as quickly as flows lies at the heart of the sustainability of competitive advantage. If competitors have different asset stock levels, the stock-flow dynamics imply that it will take time for them to catch up with the firm that has a higher asset stock level. The time it will take to catch up and the cost of this effort depends on the difference in the asset stock levels and the difference in the net investments (inflows) among competitors. Moreover, not all stocks are built in exactly the same way. Several characteristics of stock accumulation processes influence the time and cost of imitation. Some relate to economies of resource accumulation where “(initial) success breeds (further) success,” helping first movers to sustain their lead. A second set of processes relate to diseconomies of time compression, i.e. the time-cost
trade offs in the accumulation and imitation of resources. This is the focus of the present paper.

This paper first describes the concept and its importance to the sustainability of competitive advantage. It then focuses on a key driver of time compression costs, the time-dependency of resource accumulation, and thereafter explores the effect of three characteristics of this accumulation process (productivity, cycle time and absorption constraints). The effects are illustrated using a stylized stocks-flows simulation with the iThink software.

Time compression costs

In the absence of accumulation economies, latecomers may be able to build resources at the same cost as the firms that were among the first to build high resource levels. Yet, since stocks do not adjust as fast as flows, catch-up efforts typically take time. Latecomers who wish to shorten the time needed to build the resources may have to accept diseconomies of time compression (even if there are no economies of resource accumulation). This will be the case when maintaining a given rate of investments produces a larger increase in the resource level than maintaining twice the investment rate over half the interval. For example, crash R&D programs typically are less effective than R&D programs where annual outlays are lower but spread out over a proportionally longer period of time. Similarly, MBA students may not accumulate the same stock of knowledge in a one-year program as in a two-year program even if all inputs, except time, are doubled. Also, firms do not achieve the same learning from consultants if these double their efforts in half the period compared to an effort of lower but sustained intensity. And of course, time compression diseconomies affect learning: Freek Vermeulen, in a telling example, points out that as a child he found out that practicing the cello one day for three hours doesn’t produce the same result as practicing half an hour each day for six days!!

The importance of diseconomies of time compression is intuitively clear: if diseconomies are large, they provide extra protection to the firms that were the first to build resources; their resources stay unique for a longer time. Vice versa, with low diseconomies, latecomers can catch up quickly to first movers and incur few cost penalties (if there are no economies of resource accumulation).

What are the sources of these diseconomies? When do they occur? Can the diseconomies of time compression be reduced? Below, we discuss one major driver of diseconomies of time compression: the time-dependency of resource accumulation.
Time-dependency of resource accumulation

The time dependency of resource accumulation refers to the sequencing of tasks that needs to occur in order to obtain an end-result. In new product development, for example, there typically is an initial period during which research needs to be conducted before new ideas and projects may be formulated. This is followed by a product development period where ideas are further developed, tested and where the decision is made to launch or terminate the effort. Close coordination among research, product development and marketing may reduce the time required to move a product through the development cycle. However, some time lags are inevitable since products may need to be tested in the lab before they are tested in the market. Sometimes, the sequencing is regulated as in the case of products where consumer safety is at stake (foods, drugs, chemicals, engines, planes, cars, etc.). What is the consequence of this time dependency of resource accumulation for efforts to catch up to first movers?

A simple numerical example helps to illustrate some of the key effects. Let us consider the competition between an early mover, firm A, and a latecomer, firm B (see Figure 1). A enters a market five years before B and spends $100m a year on research to generate new products. Firm B waits five years but then commits $200m a year to catch up with firm A:

![Figure 1: R&D spending program of firms A and B](image)

For simplicity, let us assume that the new product output from the research is proportional to current research spending and that this relation is the same for both firms. That is, both have the same R&D productivity rate, say 0.20, which multiplied times the annual research spending gives the number of products that are generated. Further, A and B face the same time dependency constraint: after the research stage of one year, it takes another three years to move a project through feasibility studies, testing, obtaining regulatory approval, etc. before a new product is actually launched. Given the
time dependency as specified in our example, when can B hope to have caught up with A if both maintain their R&D spending levels?

Figure 2 shows the simulated ratio of the stock (cumulative number) of products that are launched by B and A at the end of each year (from year 6 onwards’). If the ratio is below one, this indicates that firm B has not caught up to A since, cumulatively, A has launched more products. Vice versa, when the curve shows a value of 1 or more, it indicates that B has caught up to A.

Line 1 shows what happens when both firms have the same research productivity, 0.20. It is not until year 14 that B matches the total number of product launches of A. By the end of the tenth year, when both firms have made the same cumulative investment ($1b), B is still lagging significantly, launching only one third as many new products as A. This is the case even though A only adds 20 projects to the R&D pipe-line (100 times 0.20) a year while B feeds its pipe-line at a rate of 40 per year (200 time 0.20). It takes nine years (years 6 to 14) and an extra $400m for B to pull even with firm A. Clearly, when the accumulation of resources is subject to time-dependency, latecomers pay a penalty to catch up.

![Figure 2: Time to catch up to the first mover with different rates of productivity](image)

Productivity. What would be the effect if B were able to achieve higher research productivity than A? Would this significantly reduce the time needed to pull even? In line 2 in Figure 2, we assumed that B has a productivity that is 50% higher than A. The result can be read from the graph: B would be able to catch up to A by year 12 rather
than year 14. Even with a research productivity that is *double* the rate of its rival, B still faces diseconomies -- it does not pull even with A in the first 10 years.

**Cycle time.** Rather than compressing the time needed to match the output of A by increasing research productivity, B may attempt to reduce cycle time, *i.e.* the time period spanning research, development and market launch. How does this impact overall time compression? Figure 3 maps the ratio of cumulative product launches of B and A. Line 3 shows the baseline case with a cycle time of four years (one year of research and three years of testing). This is the same curve as line 1 in Figure 2 above. When B reduces its cycle time to two years (Line 1), we see that A and B achieve the same cumulative number of product launches by year 10, i.e. after five years for B. This is because B moves twice the number of products (double R&D spending) at twice the speed (half the cycle time) through the pipeline. In all intermediate cases, B needs to wait beyond year 10 to match A’s cumulative output. Only if the reduction of cycle time comes at no extra cost to B would it eliminate the diseconomies of time compression (as shown in Line 1). In the other cases, B still has to accept extra costs to compress time.

![Figure 3: Time to catch up to the first mover and cycle time](image)

**Absorption constraints.** The reduction of cycle time has the advantage that, at any given point, fewer products are in the pipeline. This stands in contrast to higher investment in research productivity, which increases the number of products that are under development and launched in a given period. If firms have unlimited processing capacity, then this does not matter. However, what is the effect when – more realistically - late entrants face constraints on the number of projects they can handle? In Figure 4,
we have simulated the effects of such constraints. Both A and B face a limit on how many projects they can develop at any time: 100. As before, B spends twice as much and thus moves projects into the development pipeline at twice the rate than A. In addition, we factor in the possibility that B may be able to improve its research productivity. How fast does B catch up to A?

![Figure 4: Time to catch up and limits to learning](image)

Figure 4 shows that massive investments to increase research productivity do not make sense when there is a limit to the number of projects that can be handled. Even dramatic improvements in research productivity are of little help. Line 3 shows a “go-stop” cycle: with a productivity of 0.40, B hits the learning limit every two years and needs to wait for products to be fully developed and launched to take on new projects. Comparing Figures 2 and 4, we see that, on average, the time for B to match the cumulative output of A has increased by about two years. Though such a result is to be expected, many corporations appear to be overconfident in their learning capacity and assume they can handle a very large number of projects. Many “re-engineering” efforts suffer from congestion: too many teams work on too many projects and do not produce an output in proportion to the efforts.

**Stocks rather than flows drive research output.** In Figures 2-4, we assumed that the development of new products was driven by annual R&D spending. The assumption that current R&D spending drives research output was made to illustrate the essence of time compression costs. However, stocks drive competitive advantage, not flows. If
proprietary know how becomes available to the competition within one year, research output indeed is driven by current spending. However, when private knowledge leaks into the industry at a slower pace, R&D spending develops into a stock of private know-how. How does the accumulation of R&D spending into stocks of private know how affect time compression costs?

Let’s say that the decay rate of the R&D stock is 0.33, i.e. one third of a firm’s private knowledge becomes public after 1 year. Figure 5 shows the ratio of the stock of product launches of B to A. This may be compared to Figure 2. As in Figure 2, B catches up to A at a faster pace if its research productivity increases from 0.20 to 0.40. However, since stocks adjust slower than flows, it takes longer for B to catch up in Figure 5. On average, it takes an extra two years for B to match the cumulative output of A. Thus, when R&D output is driven by stocks rather than flows, time compression diseconomies loom even larger.

In sum, the accumulation of many resources is characterized by lags that are due to the fact that at least some tasks need to be sequenced. This need to carry out activities in a particular order gives rise to time compression diseconomies: doubling the efforts over a particular period of time does not yield the same level of resources as maintaining an effort of half the intensity over a period which is twice as long. This was illustrated in the context of new product development. With a simple numerical example, we illustrated that an increase in research productivity, a reduction of cycle time and an increase in the capacity to absorb new projects will reduce the cost to compress time (if
these efforts do not demand extra investments). Conversely, if lags cannot be shortened or if the cost of these catch-up efforts is very high, firms that were first to accumulate high resource levels are well protected. Time compression diseconomies support the sustainability of an early mover’s competitive advantage.

Relevant literature


The reader may recognize the familiar framework from Optimal Control Theory. See also Winter (1987) who similarly conceptualizes assets as state variables. His discussion but does not analyze the resource accumulation process, however.

Vermeulen, Freek, *Slow and Steady Wins the Growth Race*, HBR blogs.hbr.org, February 20, 2009


This is similar to assuming that proprietary research know how becomes public knowledge after one year. Till the fifth year, the ratio is not defined since the launches of A do not start until that year. Simulations are carried out with the iThink systems dynamics software.