Finding the balance in Innovation and Commercialization

A. Cornford[1]

"*Innovation*" is defined by the US Council on Competitiveness as – *the transformation of knowledge into new products, processes and services* [2]. "Innovative capacity" is the *ability to create a continuous stream of commercially relevant innovations* leading to new, high impact ("disruptive") product and process opportunities that contribute to local, regional and national wealth creation. This capacity concerns the efficiency and effectiveness of the innovation and commercialization system within the overall economy.

The innovation *supply chain* may be viewed in two consecutive stages: (1) the R&D stage, which encompasses early invention up to prototype development and yields *interim* commercialization outcomes in the form of patents, product licenses or university spin-off companies – what we call "*product opportunities*"[3]; and (2) the commercialization stage in which firms, along with Highly Qualified Personnel (HQP) acting as management mature some of these product opportunities to final outcomes in the form of new companies, revenues, jobs and profits that produce wealth. Through each of the stages of the innovation supply chain there is a significant attrition in the generation of potential opportunities and the production of commercially viable products.

Research shows that there are four main drivers (key input factors) of a country's innovative capacity: *public R&D*, *private R&D*, *highly qualified personnel* or *HQP,* (research scientists, engineers and technicians), and *risk capital*. These drivers interact with each other, making the balance among them at least as important as their individual amounts. To study these balances, we may consider the following ratios: (1) *public R&D investment/ investment in developing HQP,* the latter taking place at such institutions as universities, polytechnics and colleges; (2) *private R&D investment/investment in developing HQP*; (3) number of *HQP/the total work force* and, (4) *private R&D investment/public R&D investment.* We may also consider (5) an overall relationship among private R&D, public R&D and HQP.

Almost all HQP that conduct private R&D are created by the educational system and public R&D, underlining the importance of investing in public R&D and HQP development. Not unexpectedly, however, the private R&D conducted by firms creates a large proportion (about 93 percent) of all new product/investment opportunities.[4] This can be attributed to the

---

[1] Edited by Richard G. Lipsey

[2] US Council on Competitiveness, Porter, M. and Stern S, The New Challenge to America's Prosperity: Findings From the Innovation Index 1999 p

[3] A "product opportunity" of public R&D equate to a (knowledge/technology) relationship with a private firm that may then proceed to commercialize the results of the public R&D. A private R&D product opportunity will usually equate to R&D related to developing or improving a product or process.

[4]Note: In general in North America, based upon data from the Association of University Technology Managers (AUTM) for public (university) research institutions, one invention is produced for each $2.25M and one commercial product opportunity for each $22.5M of public R&D. Using this data in association with the model of the US Council on Competitiveness, one may then calculate one product opportunity for each $1.5M of private R&D. Therefore private R&D produces 15 times the number of commercial product opportunities of an equivalent amount of public R&D. One may then calculate the approximate level of total product opportunities for any jurisdiction (at North American levels) by knowing levels of both public R&D and private R&D as follows: Total product opportunities = $M Public R&D/22.5 + $M Private R&D/1.5

"applied" nature of much of this research, which is directed toward meeting specific commercial needs. In contrast, public R&D produces only about 7 percent, since it tends to be more fundamental in nature, is policy-driven, and/or has non-commercial purposes. This gives a ratio of about 15/1 for the amount of new product/investment opportunities created by the private sector compared to the public sector.

Research has found that the resource allocation among the key drivers that optimizes the new product/process opportunities for each new dollar of R&D is given by the ratios: private R&D/HQP (researchers) = 3/2, and private R&D/public R&D = 3/1.[5] Jurisdictions that come closest to achieving these balances enjoy more interim commercialization outcomes (i.e., new product/investment opportunities) for each new dollar in R&D spending than those who are further away from it. When the value of 3/1 for the ratio private R&D/public R&D exists, 75 percent of each R&D dollar is creating product opportunities at the high rate applicable to private R&D, whereas 25 percent of each R&D dollar is only producing outputs at the lower rates applicable to public R&D—1/15 of the private rate (but also contributing to the development of HQP and pure knowledge that may be subsequently have applied uses, as well as other societal benefits). Another important influential benchmark value is that the ratio HQP (researchers)/total workforce should be at least 10/1000. We refer to the desirable values of the critical ratios as *benchmark values*.

The fourth key driver is risk capital. When married with the yield of product opportunities stemming from the first three input factors (public R&D, private R&D and HQP), plus good management (another important form of HQP[6]), it provides the mechanism through which new wealth is generated through the second (commercialization) phase of the innovation supply chain. The research suggests that up to approximately one-quarter of the product opportunities available at any given time are successful in acquiring venture investment, which is an observation rather than a benchmark.[7] But the figure is a good indicator of the proportion of product opportunities that actually moves on towards commercialization and hence wealth creation.

New product opportunities determine risk capital activity, not the other way around. The implication is that, other influences held equal, risk capital will tend to migrate toward those jurisdictions possessing the best balance among the first three drivers, since these jurisdictions will have the most product opportunities.

Determination of the total level of product opportunities per new dollar of R&D spending is of key importance. Research also shows that when the benchmark value of at least 3/1 holds for the ratio of private R&D/public R&D, there will be about one new product opportunity created for each $2 million of total R&D investment[8]. For any given amount of

[5](a) US Council on Competitiveness, Porter, M. and Stern, S.: The Innovative Capacity Index, 1999, p 33, 39 and (b) G.P.T Management Ltd. Innovation and Commercialization in British Columbia, Jan 2004

[6] Note that venture capital managers typically weight their investment criteria as follows: approximately 70% on the quality/capacity of the management team, 25% on the market opportunity and 5% on the technology.

[7] Of opportunities not financed, some are abandoned, some are amalgamated with other opportunities and then may or may not proceed and some are taken up by larger firms who do not need external venture capital.

[8] The general calculation is as follows: Product opportunities/$M R&D = [$M Public R&D/22.5 + $M Private R&D/1.5]/$M Total R&D. Therefore for $3M of private R&D and $1M of Public R&D we get [1/22.5 + 3/1.5]/4

total R&D spending, a lower ratio will generate a lower yield of product opportunities and reduced competitiveness per R&D dollar.

The following table summarizes some key relationships:

BENCHMARK OPTIMAL RATIOS	
Private R&D/Public R&D Ratio	>3/1
HQP(researchers)/Total workforce	> 10/1000
Private R&D/investment in HQP	>3/2
EMPIRICAL RELATIONS	
Product Opportunities per $Million R&D Spending	0.51
Venture Investments/Product Opportunity	1/4

As already noted, interdependence among these drivers implies that it is not sufficient to achieve just one benchmark. The best results require the right proportion of all individual drivers. Thus while investment in private R&D, public R&D, HQP and risk capital can all be increasing, if they are not in the optimal proportions, the overall result will be less product development than could have occurred. This may result in a country losing competitiveness compared to its international rivals.

This problem of balance lies at the heart of the current competitiveness problem for Canada and for all of the provinces, except Ontario. To illustrate this, consider Canadian R&D during the period 1997/98 – 2002/03. Annual increases in both public and private R&D investment were quite large, in the order of 10% and 5% respectively, but not in optimal proportions as defined by the benchmark value of 3/1 for the private/public R&D ratio. At the beginning of the period, the ratio was only 1.48/1 and by the end it had declined to 1.18/1. So, in spite of absolute increases in public R&D, private R&D and product opportunities, the private/public R&D ratio in Canada is low and declining. While the Canadian ratio HQP(researchers)/total workforce rose modestly, from 5.4/1000 to 6.4/1000, it is still far below the benchmark value of 10/1000.

In contrast, the private/public R&D ratios of many of our key international rivals are higher and rising. This implies an inefficient use of our scarce R&D resources that is allowing us to fall behind in international competitiveness. Furthermore, my calculations show that Canada's productivity in terms of the level of product opportunities generated for each new R&D dollar invested started the period low at 0.42 (compared to the typical value of 0.51) and declined to 0.38 by the end of the period. This is 25 percent lower than more innovative economies such as the US, Finland and Sweden. Hence, the innovative capacity of Canada per $million in incremental R&D actually dropped over the period, placing Canada at a competitive disadvantage against countries possessing a superior quantitative "mix" of the key input factors. Simply increasing investment in GERD (gross expenditures on R&D), as currently advocated by many Canadian innovation policy pundits, will worsen the situation. To remain competitive, success will depend on rebalancing our investments in the key drivers.

* * * * *

= 0.51. This means that there will be about one (actually 1.02) new product opportunity created for each $2 million of total R&D.