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MEASURING INNOVATION

Global competition has raised government interest in the economic impact of innovation – with several national plans afoot to measure it. Here Royal Economic Society newsletter editor Peter Howells talks to Chris Farrell, who is working to provide a rigorous foundation with practical value for innovation metrics.

Peter Howells:

Chris, You've been doing observational work on innovation for the last twenty years or so and recently you've been in discussion with the U.S. Department of Commerce and the U.K. Department of Innovation, Universities and Skills about a new way of measuring innovation and its contribution to economic growth. Can you explain the basic principles?

Chris Farrell:

I became motivated to discover how innovative new technologies displace old ones when my own inventions started to do just that. Two engineers from the General Electric Company had come up with a model that had pretty good mathematics. I used an improved version to predict the demise of the incandescent light bulb! Although starting to be true today this seemed so fantastical at the time that even I doubted it - so I turned to Economics to get some guidance from price.

Marty Feldstein, of the National Bureau of Economic Research, once observed after touring plants of the defense contractor TRW that nothing in his years of studying productivity was helpful to him in understanding what was going on there. After reading George Stigler's *Theory of Price* I could understand why, so I set out to try the Adam Smith approach and observe something. But I wasn't just a visitor. Innovation was happening all around me and I was personally involved in its every aspect. I watched and I learned.

The basic principle I adopted is that price increases when products are improved by innovation, and when other factors – principally competition and the value of money – are constant. It took many years to observe how to enumerate that and to discover and validate the underlying equations. A huge challenge was eliminating quality change bias from inflation indices.

Now global competition has raised government interest in measuring innovation. And these equations can do it. Government already collects most of the data. But they must collate and analyze it differently than they do now.

Peter Howells:

In the paper for the Department of Commerce you give the example of measuring innovation in the tyre industry by measuring 'tyre cord performance' - something that has an objective reality, but when it comes to pens your innovation variable becomes undefinable. This will strike most economists as a return to rather discredited attempts to measure cardinal utility a century or so ago. Isn't it a problem for your approach that you cannot get objective performance measures for a whole range of goods and services?

Chris Farrell:

But innovation professionals don't rely on what economists call 'utility' to construct 'S-curves'. We have found a way to calculate what economists call 'quality' and what we call 'performance'. It's cardinal. But humans are fickle and make buying choices for non-objective reasons. We avoid the ordinal trap by focusing on business – to – business. A good choice, not only because most of us work in this part of the economy, but also because intermediate products like tyre-cords are bought and sold on performance describable in pure engineering terms. The methods and equations for calculating performance from price were therefore validated and calibrated on them.

Once established for intermediates the same method can be extended to cover final products such as fountain, and other competing pens. This captures and enumerates those

fuzzy non-objective assessments of the final purchaser; and it does so cardinally.

Peter Howells:

Just suppose that we take your measurements at face value, what are we told about the contribution of innovation to economic growth?

Chris Farrell:

Once I got going I started calculating the innovation capacity of industries, then segments and finally the whole economy. Of course I started to try and fit it into a Cobb-Douglas type of equation – substituting the residual or making it a factor in multi-factor productivity. It took me many frustrating months to realize that the innovation component is so large that it must be close to the only factor!

My equations are determinative (I haven't used statistical regression methods at all) so I was able to prove that innovation is the primary input, though it took several pages of advanced algebra to do so. It turns out that the aggregated effect in terms other than innovation is significant, but small.

Peter Howells:

That sounds as though innovation explains the whole of economic growth and maybe more. But that's going to be a serious problem for economists who will point to the fact that growth has self-evidently required additional inputs. If innovation explains it all, why have industries felt obliged to use more real resources?

Chris Farrell:

Dependent resources are obviously needed. But developmental knowledge, the D of R&D, is the primary input to innovation. The exact mathematical link between it and economic growth is a new discovery. The diffusion of this knowledge into real resources for everyday use is also included.

Peter Howells:

Can you tell us more about the equations?

Chris Farrell:

The detailed equations await publication in due course but in the meantime I can say this. A higher performing good or service will have a higher price, P, unless competitive forces change. So the basic equation can be written p = G (P, C, I), where p is the 'cardinal' performance of that good or service and C is a function of other variables that capture the inter-firm competition in the supply of demand - and I corrects for inflation. This basic equation is also implicit because, as we know, inflation indices are biased by 'quality change' - in other words I also contains some p. Fortunately, it turns out that G can be transformed to F in such a way that P = F (p, C, I') – an explicit equation where I' is corrected for bias, the extracted 'quality change' being incorporated into p.

And because GDP is the sum of the prices of all final units, GDP can then be expressed in terms of **p** – the aggregated component measure of innovation.

To discover and then validate this I had to assemble a five-decade DINTEC™ database of mainly commercial numbers to track the annual economic fate of about a *hundred and fifty products of firms, many of which* did not exist in 1951 and many others of which became insignificant by 2001. Although a small sample of the economy as a whole it was enough to calibrate the equations and also, significantly, to make at least one testable prediction.

Peter Howells:

Where does the work go from here?

Chris Farrell:

If economists are going to avoid facing Marty Feldstein's dilemma when they visit an actual commercial facility they may need to think differently about how innovation affects, or even effects, price. Such thinking is easier for innovation practitioners. Their domains already include the factory floor, the corporate office and the R&D facility, all of which can provide the necessary data to feed scholarship that is much harder to conduct from campuses.

One task for me - as architect - is to match the unexpected emergence of fundamental advances to the demand from those who must apply Economics in the real world but lack the necessary tools to do so effectively. Almost everything associated with innovation falls into that category, including how we might quantify our quality of life and our national well-being. Not to mention the stimulating impact that the open use of the right innovation metric[†] could have on economic growth.

(Note: This interview describes the situation as it was in 2008. Advances continued to emerge from DINTEC™ and were published as 'Innovation in Economics: Missing Pieces' in 2018. Download the latest 2022 web edition www.techmatt.com/techmatt/Innovation-in-Economics-Missing-Pieces.pdf

[†] the right innovation metric (**p** – **p′**)/**c** operates at firm level and provides an otherwise absent means for CEOs to guide innovation upwards within their organizations. The slope of its plot against R&D is Feldstein's missing productivity.