

INTERVIEW

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! I ran into similar problems with economic theory so I set out to try and imitate Adam Smith and observe something that would. I was in a perfect position. Innovation was happening all around me and I was personally involved in every aspect of it.

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 enumerate them and to discover and validate the underlying equations. A huge challenge was eliminating technical 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 'utils', which are undefined. 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:

Innovation professionals have used absolute utility to construct 'performance S-curves' for decades, and are still doing so! Cardinal utility

foundered in economics because humans are fickle and make buying choices for non-objective reasons. We avoided that 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. I adopted the util (anchored to the constant dollar) as a unit of this intermediate good (or service) performance.

Once established for intermediates the util can be extended to cover final products such as fountain, and other competing pens. This enumerates those fuzzy non-objective assessments of the final purchaser, absolutely.

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.

And because innovation is so dominant I call the resulting model Omnogenous Growth Theory.

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:

Real resources are obviously needed. But developmental knowledge, the D of R&D, is the primary input to innovation. I have also established a four-link mathematical chain

The richness of data on simple products makes innovation metrics possible. And when that richness extends over so many of them, connections to GDP become decipherable.

between it and economic growth. Then real resources are indeed included, as

the embodiments of that knowledge.

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 \mathbf{p} – the aggregated measure of innovation.

I have an extensive five-decade database which tracks 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. This is a small sample of the economy as a whole but possesses enough detail to validate and calibrate the equations and also, significantly, to make at least one testable prediction.

Peter Howells:

Where does the work go from here?

Chris Farrell:

That is the really exciting part because quantifying innovation is fundamental. It takes microeconomic growth, connects it to macroeconomic growth and links both back to development finance spent in support of entrepreneurs and innovators in firms of all sizes. Accounting for innovative potential in firms like this has never been done before.

The potential impact is enormous. Not only in government but also in the spheres of academia, finance, investment and consulting.

The apparent sudden appearance of such scholarship from practitioners will surprise many, though its long and hidden incubation is a natural consequence of its origin. One task for me - as its architect - is to match this unexpected emergence to advocates who come forward eager to apply it to advantage within their own sphere.

Peter Howells is Professor of Monetary Economics at the Bristol Business School and Chris Farrell is Founder of Technology Matters, Chicago. The Department of Commerce paper entitled *'How to Measure Innovation in the Products and Services of Firms and Use it to Explain GDP Growth for the Second Half of the 20th Century'* is one of several documents that can be downloaded from - www.techmatt.com - where more details can be found.

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