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31 July 2021

Online at <https://mpra.ub.uni-muenchen.de/110209/>
MPRA Paper No. 110209, posted 16 Oct 2021 05:19 UTC

Analyzing “Innovation” in economics

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Abstract

This article discusses existing theories on “Innovation” since the 1940s. It differentiates between “Innovation” and “Invention”, and presents examples of innovation that are modelled by theory.

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To understand the meaning of the term 'innovation,' one should review Malthusian ideas about economic growth. 'With the amount of land fixed, the population growing exponentially, and technology progressing linearly, there will come a time when food shortages will become acute' (Malthus, 1839) (Figure 1).

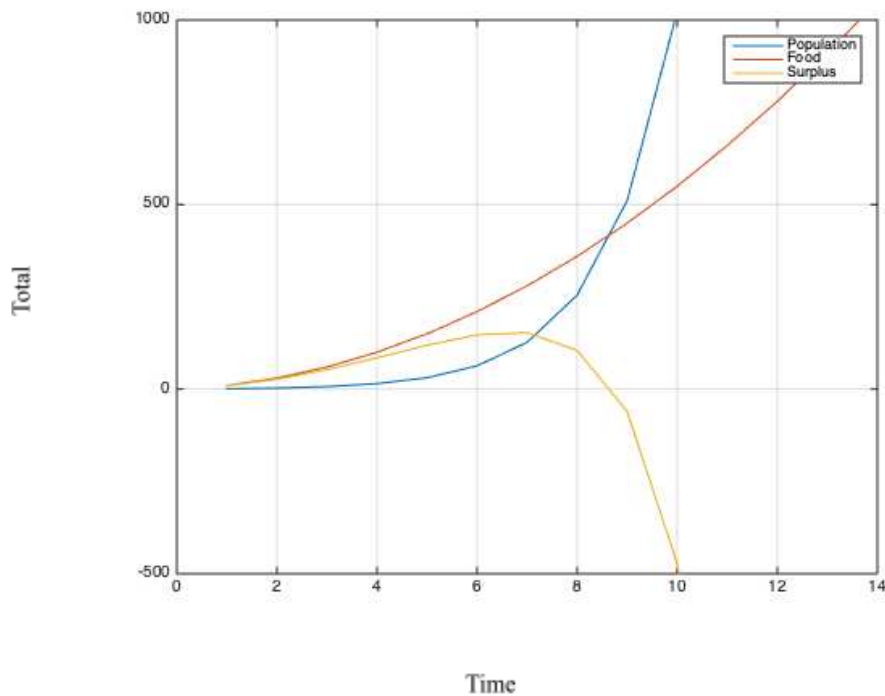


Figure 1: Simulated graph with population growing exponentially and food linearly.

Despite accounting for increasing factors of production, the prophecy never reached fruition, because Malthus overlooked the non-linear impact of innovation and resulting technological changes. Innovation explains Western economies' shift from nearly stagnant till early 1800s to that of sustained economic growth since. "Unless technology is changing, alternative sources of growth such as capital accumulation or improved allocation of resources will ineluctably run into diminishing returns" (Mokyr, 2010). The calorie consumption per person per day has been rising (Broadberry et al., 2014), sustained by innovative farming practices like genetic modification or vertical farming.

The classical "diminishing returns" idea makes innovation so paramount. Political stability, the efficiency of legal institutions, and globalization are important, which in turn impact the rate of innovation, but it is innovation that converts institutional qualities into production efficiency. Figure 2 plots output per worker as a function of capital per worker, showing diminishing marginal returns. As capital intensity increases, output intensity also increases but at a diminishing rate. Innovation rotates the curve upwards, enabling more output production with the same input, even though the factors of production still have diminishing returns.

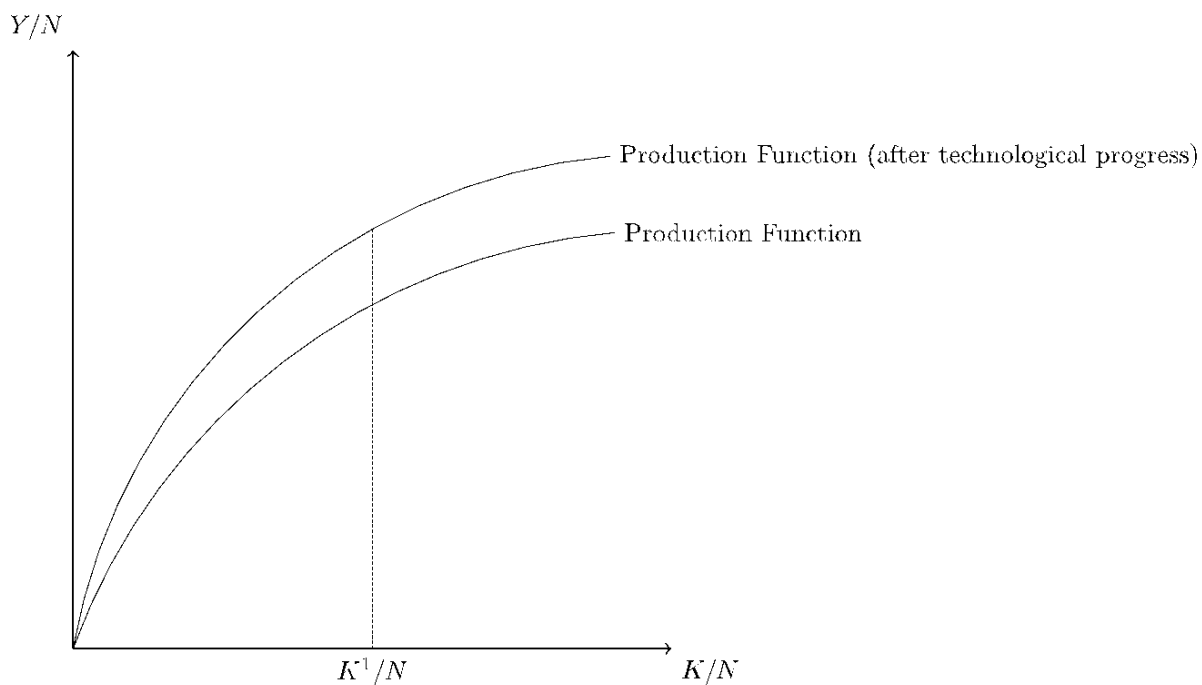


Figure 2: Technology innovation shifts production function upwards. K/N capital intensity, Y/N output intensity.

Joseph Schumpeter (1942), who put ‘Innovation’ at the centre of economic growth debates, defined innovation simply as the setting up of a new production function. Schumpeter argued that the accumulation of factors of production was not enough in explaining the sustained growth in output. Rather, it was the changing ways of combining these factors. If the innovation enables more output with the same input, Production Possibility Frontier (PPF) (Figure 3) shifts outwards.

Entrepreneur’s role is crucial as the human agency for economic development through innovation (Schumpeter, 1942). Economists further defined entrepreneur’s role as short term innovation and on the demand side to enable easier investment decisions (Kalecki, 1954). An entrepreneur has been the economic agent who introduces innovation under uncertainty operating under an adaptive system.

The use of the word ‘Innovation’ has been increasing since the 1940s, accelerating since the 1970s – and must be distinguished from ‘Invention’. Invention is defined as creating new products or processes, while Innovation is a significant improvement in an already existing creation, not necessarily making something new. However, sometimes these two words are used interchangeably in daily lives.

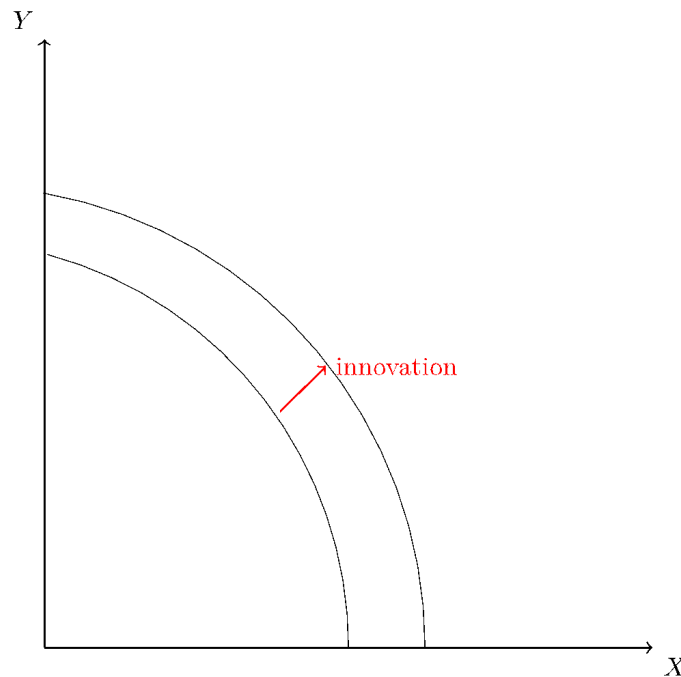


Figure 3: PPF outward shift with innovation.

Solow (1956) 's growth model separated the determinants of growth between factors of production and technical progress – creating a portion of economic growth, that the accumulation of the factors could not explain, Solow residual. Economists credited technological progress for this growth and later terming it - total factor productivity. Data from the USA suggested residual accounted for almost 85% of the output growth (Abramovitz, 1956).

Economists doing development accounting, were again left with a large fraction of different countries income variation, which the factors of production could not explain (Islam, 1995). Now, Economists widely recognize that innovation crucially accounts for the differences in income-per-capita and growth dynamics of different countries (Hall, 1999).

Kenneth Arrow (1962) introduced technology as an endogenous variable as human capital in his model of learning by doing. Innovation was no longer "manna from heaven"- now an integral part of the models. Romer's (1990) seminal work depicted knowledge as a long-term driver of growth, and how economic forces govern the willingness to innovate. Romer explained that innovation results from a combination of 'growth-fostering institutions' and 'dissemination of new ideas'.

Demand-side mechanism, tangible and intangible investments, and institutional fostering (through infrastructure and policies) are critical for innovation systems. Innovation usually starts on a small scale, but the true impact lies in its diffusion. Innovation can be discontinuous and disruptive, resulting in dynamic business cycles. Innovation is an outcome of interlinked

processes of learning and knowledge creation in a manner where agents adapt to the changing environment. While countries are converging in the adoption, they are diverging in the intensity of use of these new technologies (Comin, Mestieri, 2018). So the explanation for income divergence between countries is shifting from 'innovation' in the eighteenth century to 'adoption' in the nineteenth century to 'usage intensity' today.

"Innovation offers the carrot of spectacular reward or the stick of destitution", Schumpeter said about entrepreneurs. IP protection protects entrepreneurs, but simultaneously hampers dissemination of knowledge. The government's role in the "systems of innovation" approach is shifting from R&D in basic sciences to focus on the whole process of innovation - including public incentivization to take risks. Innovation depends on the interactions and sharing of knowledge between different actors - which come from taking risks. Modern thinking hypothesizes that economic development is the result of innovation, knowledge and entrepreneurship within a dynamic system.

Empirical studies in the past showed that innovation has led to higher wages and prosperity all around. However, in the last three decades, the worries of impact of innovation on inequality have risen again (Giles Saint-Paul, 2008). The full picture would be slow to emerge, but this phase is going to have an impact on all dimensions of development. Rapid technological change can disrupt but also open up a window for developing economies' governments to adapt, harness frontier technologies, and bridge the gap (UNCTAD,2021). Through innovation, technology is creating new sectors and jobs (WDR, 2019). This requires strengthening and aligning innovation policies, bridging the digital divide and enhancing social protection for the vulnerable amidst the transition.

Economists' efforts are also directed towards understanding the 'black-box' of technology (Rosenberg, Nathan, 1982). Research output is itself facing diminishing returns – more researchers are needed today for the same amount of productivity gains (Bloom et 2020). Innovation in the global production chain makes innovation of a new complete product redundant (Breznitz,2021). For example, parts producing Samsung and Intel are able to enjoy better profit margins than HP or Dell (Dedrick et al., 2009). Chinese economic growth is continuing despite diminishing returns on wages, demography and reforms, because of the innovation potential laid bare by the global fragmentation of the supply chain. The study of innovation has also led to a revision in understanding the role of manufacturing in economic growth. It is no longer possible for just one firm to continuously develop frontier technologies. Thus, economists are focusing on the fragmentation of the innovation process (Tassey, 2014).

It is only through innovation that we can overcome the apparent "limits to growth". Rising populations desire greater economic growth, only possible through innovation despite the fixity of earth's various resources. Innovation may not always be about growth-inducing phenomena but also about increasing sustainability of existing methods of production. While we are more confident about the role of innovation, we must further research its determinants- helping avoid unwanted consequences of unrestrained innovation like rising inequality and climate change.

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