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Evidence-based policy making

Does broadband infrastructure boost employment?

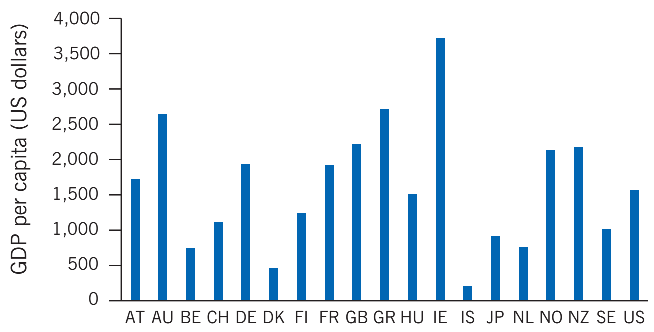
Broadband infrastructure has differing effects on workers of different skills

Keywords: internet, economic growth, employment, wages, skills

ELEVATOR PITCH

Broadband infrastructure enables fast access to the internet, which, evidence suggests, has significant effects on economic growth. However, labor market related issues have not received as much consideration. These include quantifying employment effects of broadband infrastructure roll-out and questions about who exactly are the winners and losers in the labor market, and whether skills in information and communication technologies (ICT) are reflected in labor market outcomes such as wages. Understanding these complementary issues allows for policy conclusions that go beyond simply encouraging the subsidization of broadband internet infrastructure.

Additional GDP in 2007 if country had same broadband diffusion rate as the leading country in 2003



Note: 2003 lead country = Canada, with a broadband diffusion rate of 15.1%.
Source: Author's own calculations based on [1].

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KEY FINDINGS

Pros	Cons
⊕ The roll-out of broadband internet infrastructure generates economic growth, partly through firm entry.	⊖ The positive employment and firm-entry effects of broadband internet infrastructure are limited to certain industries and/or locations.
⊕ The employment effects of broadband infrastructure are small, but positive.	⊖ Broadband infrastructure creates losers among low-skilled workers.
⊕ Broadband internet infrastructure complements skilled workers.	⊖ Adoption of high bandwidth internet connections is slow in many countries.
⊕ Access to broadband internet enables the accumulation of ICT skills, which are substantially rewarded in the labor market.	⊖ The share of workers without basic ICT skills is considerable in developed countries.
	⊖ Slow adoption of high bandwidth internet connections and lack of ICT skills might limit the growth effects of broadband internet infrastructure.

AUTHOR'S MAIN MESSAGE

Broadband infrastructure has positive economic growth effects, but only small employment effects; the latter is due to a mixture of positive effects among high-skilled workers and negative effects among low-skilled workers. Complementary ICT skills are highly rewarded in the labor market. Labor market institutions that support workers in adjusting to the rapidly changing work environment in a digital world, and measures designed to reduce the skill gap between "digital natives" and "digital illiterates," will reduce the inequality between the winners and losers of broadband infrastructure.

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MOTIVATION

The ongoing processes of digitalization in economies and societies have important implications, not only for economic growth, but also for the future of the labor market. The diffusion of broadband infrastructure, which enables firms and households to access high-speed internet, plays a crucial role in economic and labor market developments. But, what are the actual effects of broadband accessibility?

While growth effects will be substantial, labor market effects are likely to be ambivalent. On the one hand, positive employment effects might arise from innovative business models or new internet-based products and services. On the other hand, not everyone will profit from the “digital revolution” equally. The introduction of new technologies may make some, especially routine-task based jobs obsolete.

As public investments in ever-faster broadband infrastructure continue to increase, it is important to assess the labor market effects of broadband infrastructure that are already observable. This will help identify the political action needed to adjust to the rapidly changing work environments in a digital world.

DISCUSSION PROS AND CONS

It is widely assumed that broadband infrastructure will lead to economic growth because it fosters the diffusion of information and the development and adoption of innovation in society and the economy alike. Importantly, this effect goes beyond simply reducing transaction costs: the internet distributes ideas and information and fosters competition for and the development of new ideas, products, processes, and business models.

The exchange of information as enabled by broadband infrastructure not only contributes to better usage of the existing knowledge stock but also increases knowledge. In particular, modern economic growth theory considers the creation of knowledge and technological progress as the key drivers of economic growth. Consequently, internet via broadband infrastructure may lead to growth through the following three main channels: first, it may increase the economy’s overall innovative capacity and, as a result, newly developed products and processes will promote growth. Second, easier transmission of information may facilitate the adoption of new technologies as well as the development of follow-up innovations. Finally, broadband in combination with other technologies, for example, information technologies, may lead to the creation of new products and increase firm productivity.

On the surface, the positive effects of broadband infrastructure on economic growth seem obvious, but convincing empirical assessments of these effects are in fact rare. A noteworthy exception is a study that investigates the early phase of broadband diffusion in OECD countries [1]. The authors find that a 10-percentage-point increase in the broadband penetration rate increases annual growth of GDP per capita by at least 0.9 percentage points. A 10-percentage-point increase in the broadband penetration rate is approximately the difference in broadband penetration rates between Germany and the leading OECD countries in 2003. The illustration on page 1 shows the increase in per capita GDP that 19 OECD countries would have achieved if, in 2003, they had had the same broadband penetration rate as the leading country in that indicator (Canada).

Empirical identification of broadband infrastructure effects: Maryland Scientific Methods Scale (SMS)

In order to design effective broadband infrastructure policies, their causal impact on economic outcomes first needs to be thoroughly isolated and empirically assessed. Even though the methodological literature on policy evaluation has made substantial progress in recent years, its application to the identification of causal broadband infrastructure effects is still in its infancy.

The basic problem in accurately estimating the effect of broadband infrastructure investments is the impossibility of observing how affected firms or households would have developed without the infrastructure project. A standard solution to this problem is to compare affected regions (the "treatment group") to similar places in which there has been no broadband infrastructure investment (the "control group"). When creating a valid control group, researchers need to pay attention to the "selection into treatment" problem: if, for example, certain firms or households deliberately move to places with a well-developed broadband infrastructure, the two regions are rendered incomparable.

The SMS provides a five-point scale for judging the methodological quality of causal policy evaluations. Higher scores thereby correspond to higher levels of causal validity.

Level 1: Plain one-dimensional analysis. Either as one-time comparison of treatment and control or as a simple before−after comparison of the treatment group over time. No adjustment for inherent differences between treatment and control group or periods.

Level 2: One-dimensional analysis after adjusting for inherent differences. Comparison along either time or space (like Level 1), but with an additional incorporation of control variables to account for regional idiosyncrasies or broad macro-level trends.

Level 3: Two-dimensional analysis along time and space. Comparison of the respective difference between treatment and control group before and after the policy (i.e. difference-in-differences). Initial differences between the groups are thus accounted for. Time-varying inherent differences, however, still may potentially threaten causal inference.

Level 4: Circumventing unobservable differences through quasi-randomness in treatment. Exploit quasi-randomness in the treatment so that it can credibly be held that treatment and control groups differ only in their exposure to the policy. This often entails the use of an instrument or a discontinuity in treatment, the suitability of which should be adequately demonstrated and defended.

Level 5: Circumventing any inherent differences through complete randomness in treatment. Reserved for policies that are applied based on explicit randomization. In this case treatment and control groups are solely distinguishable by their respective exposure to the policy. Evidence for actual randomness needs to be provided and extensively discussed.

Source: Madaleno, M., and S. Waights. *Guide to Scoring Methods Using the Maryland Scientific Methods Scale*. London: What Works Centre for Local Economic Growth, 2015; p. 4.

According to the available empirical evidence, the growth effects of broadband infrastructure are substantial. But, what are the labor market effects of this technology? What can be learned from existing research about the employment and wage impacts of broadband internet infrastructure?

Due to the variance in quality among existing studies, it is important to ensure that analysis is based on sound evidence. Toward this end, the Maryland Scientific Methods

Scale (SMS) can be applied to rate the quality of the empirical evidence on this topic; the scale ranges from 1 (lowest) to 5 (highest). The evidence presented in this article is based exclusively on studies that score at least Level 3 on the SMS.

Employment effects

Convincing evidence on the employment effects of broadband infrastructure is available for only a few countries. One study on the US finds that broadband infrastructure expansion does not affect the employment rate, nor does it affect the average wage in ZIP code areas between 1999 and 2006 [2]. Similarly, another paper on the US finds that advanced internet technology in firms and wage growth were, in general, unrelated in the period 1995–2000 [3]. A precondition for the use of advanced internet technology in firms is access to broadband infrastructure. Advanced internet technology was associated with substantial wage growth, but only in densely populated US counties that had a wealthy and well-educated population and with IT-intensive industries.

In a paper on broadband expansion across German municipalities between 2005 and 2009, an overall positive but economically rather limited relationship between local employment and local broadband infrastructure is found [4]. The employment effect seems to be larger in rural municipalities and is likely to stem from the service sector. One potential reason for this finding is that the internet enlarges the market for firms in rural areas with a limited number of potential local customers. This may be especially true for some service industries, such as accounting. For the same time period, another paper on Germany finds positive effects of broadband infrastructure on the number of start-ups in the service sector and especially the knowledge-intensive service industries in more rural areas [5]. Thus, it appears that the employment effects of broadband introduction likely arise from job creation in newly founded establishments. This may explain why a study that investigates broadband internet introduction in rural areas in the UK from 2000 to 2004 does not show employment effects for incumbent firms [6].

Another study explores the effects of government subsidized broadband infrastructure installation in the province of Trento (Italy) between 2011 and 2014 [7]. The public authority subsidized the telecom provider to install broadband access points in predominantly remote and rural areas that were not privately supplied. The authors find that broadband availability is associated with a significant increase in annual sales turnover and an increase in value-added, but not with an increase in employment. Notably, this is the first study evaluating broadband infrastructure effects beyond the introduction phase of broadband internet. The estimated effects hence represent the impact of broadband internet in the Web 2.0 era, which entails more advanced and interactive applications than in its rather basic early years.

Despite the only small overall employment effects, fast internet access might increase the quality of job matching. In a newspaper article from 2000, it was already noted that by reducing the cost of information, the internet would allow workers and employers to learn more about each other and thereby improve the quality of job matches. However, most previous empirical studies have found no labor market friction-reducing effects (and, consequently, little effects on wages) of online job seeking [8].

Polarization in the labor market

The overall small employment and wage effects of broadband infrastructure may be due to underlying countervailing effects. On the one hand, positive employment effects might arise from new internet-based business models or new products and services that build on the internet (e.g. e-health applications). On the other hand, internet technology may make some jobs obsolete (e.g. in retail, through remote maintenance of machines, etc.), leading to negative employment and wage effects for parts of the labor market. Thus, the estimated average employment and wage effects of broadband internet infrastructure are likely to mask important differences in how worker subgroups are affected by this technology in the labor market and within firms.

This is not, however, an internet-specific phenomenon: a similar "winners and losers" pattern occurred when computers became prevalent in the workplace. In particular, evidence on this is provided by an influential study that investigates how the US labor structure has been affected by the emergence of workplace computers [9]. A major innovation of this work has been to classify labor into subgroups of workers according to the complementarity of their tasks with the tasks a computer can execute. Until then, conventional labor group distinctions were defined along skill levels (low-skilled, medium-skilled, high-skilled) and the type of jobs (production and non-production; blue collar and white collar). The basic idea behind this new approach is that computers substitute for routine tasks (those that can be accomplished by following explicit rules) and are complementary to non-routine abstract tasks (such as problem solving and coordination). The reason for that is related to the varying complexity involved in programming specific tasks. Routine tasks, for example, are relatively easy to program, as the knowledge required to perform these tasks is explicit and codifiable. This is not true for non-routine tasks. Therefore, workers performing routine tasks may be replaced by computers, while those performing non-routine tasks profit from the emergence of computers.

Employing this so-called "task-based approach" to the context of digital technological change, a recent paper utilizes the expansion of broadband infrastructure in Norway in the 2000s as a natural experiment to study the skill complementarity of broadband internet [10]. Interestingly, the study confirms that the findings on computer introduction also hold with respect to the labor market effects of the emergence of internet technology. In particular, the authors find that employment of unskilled workers decreases, whereas employment chances increase for skilled workers. Moreover, broadband internet availability appears to raise wages for skilled workers and to lower wages for unskilled workers. The authors provide evidence that these effects can, to a large part, be explained by the fact that broadband adoption in firms complements skilled workers in executing non-routine abstract tasks, and substitutes for unskilled workers in performing routine tasks.

Returns to information and communication technology skills

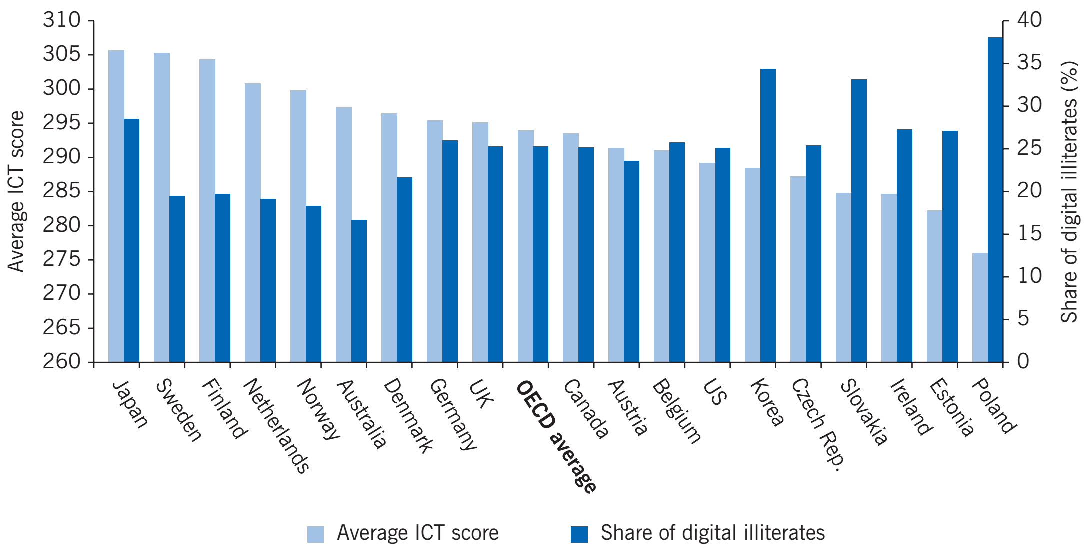
A very recent paper highlights another channel through which broadband infrastructure affects wages: Broadband infrastructure enables the accumulation of skills in mastering ICT which are, in turn, well rewarded in the labor market [11]. More precisely, ICT skills are accumulated by regularly using email programs, search engines, and so on, at home or at work; that is, through learning-by-doing, for which internet availability is a precondition.

There is a widespread belief that ICT skills are rewarded in modern labor markets, which increasingly require the ability to operate effectively in the digital world, that is, to access, locate, extract, evaluate, organize, and present digital information. Accordingly, Neelie Kroes, former Vice President of the European Commission, even describes ICT skills as “the new literacy” and goes on to explain that “the online world is becoming a bigger part of everything we do. No wonder these [ICT] skills are becoming central in the job market” (http://www.getonlineweek.eu/vice-president-neelie-kroes-says-digital-literacy-and-e-skills-are-the-new-literacy/; accessed July 22, 2016).

Notably, this study is the first to provide an empirical assessment of the role of ICT skills in modern labor markets [12]. Using new OECD data from the Programme for the International Assessment of Adult Competencies (PIAAC) that contain internationally comparable information on individuals’ ICT skills in 19 countries, the authors find that ICT skills are highly valued in the labor market. They show that a one standard deviation increase in ICT skills leads to about a 25% increase in wages. The estimated returns to ICT skills can be interpreted as follows: if an average worker in the US increased their ICT skills to the level of an average worker in Japan, their wages would increase by about 8%; this is close to the well-identified estimates on the returns to one additional year of schooling in developed countries.

The continued evolution toward a digital economy makes it likely that ICT skills will continue to increase in importance. Figure 1 shows average ICT skills among the prime-age population (aged 20–49) in OECD countries in 2012. The US and many EU countries perform close to the average of the OECD participants (294 PIAAC points of a maximum 500 points). The international top performer is Japan (306); top performers in Europe are Sweden (305), Finland (304), and the Netherlands (301). At worryingly low levels, Poland (276), Estonia (282), Ireland (285), and Slovakia (285) constitute the bottom of the international league tables. Moreover, the countries that performed most poorly in the PIAAC assessment of numeracy and literacy (i.e. France, Italy, and Spain) did not even participate in the ICT skills assessment.

Figure 1. Information and communication technologies (ICT) skills across OECD countries



Notes: Average ICT skills of employees aged 20–49 (no first-generation migrants); share of digital illiterates among PIAAC participants. Digital illiterates either scored below 175 points (out of 500), reported no computer experience, or failed ICT core test.

Source: Author’s own calculation based on PIAAC 2012.

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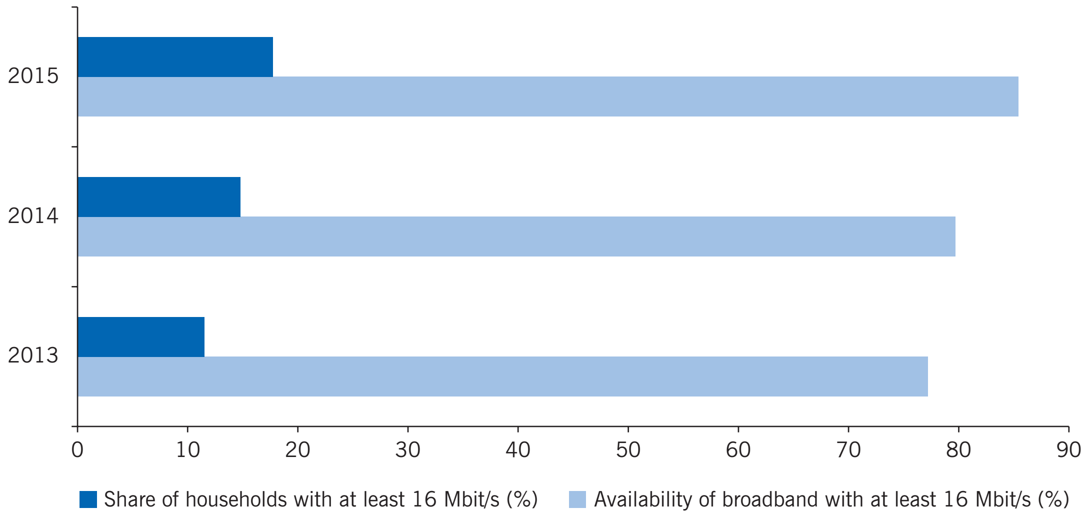
Figure 1 also shows the share of "digital illiterates" by country. This share includes PIAAC participants who either performed poorly in the ICT skills test, failed an initial core ICT test, or did not participate at all due to lacking computer experience. The average share of digital illiterates across OECD countries is about 25%, with Poland (38%) having the highest and Australia (17%) the smallest share of illiterates. Thus, no country fully succeeded in equipping its population with basic ICT skills.

Adoption of broadband internet

The internet, as a general-purpose technology, enables follow-up innovation in many industries. In order for a general-purpose technology to reach its full potential for growth it requires fast adoption.

Especially in its early years, the extensive diffusion of the internet (i.e. the take-up rate by users) was very rapid. For example, 50% of US households were using the internet only ten years after it was introduced to the public. In comparison, for television it took 25 years to reach the same market penetration. In the early years of broadband diffusion, adoption was chiefly limited by the availability of appropriate infrastructure; however, this does not seem to be an obstacle to the adoption of higher bandwidths (which serves as a proxy for use intensity). Taking Germany as an example, internet subscriptions at a bandwidth of minimum 16 Mbit/s (megabits per second) were technically available to more than 80% of households in 2015, but less than 20% of households were actually using these bandwidths (Figure 2). Slow intensive diffusion of the internet may in fact create a vicious circle because it hinders follow-up innovation which, in turn, slows down intensive diffusion even further. Eventually, the slow intensive diffusion of broadband usage in many countries could delay growth effects of broadband infrastructure or lead to substantially smaller effects than those that materialized in the past.

Figure 2. Broadband subscriptions and technical availability in Germany



Source: Author's own calculations based on German Broadband Atlas (http://www.bmvi.de/DE/Themen/Digitales/Breitbandausbau/Breitbandatlas-Karte/start.html); and Dialog Consult/VATM Market Analysis (http://www.vatm.de/vatm-marktstudien.html).

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LIMITATIONS AND GAPS

Although there is increasing interest among researchers to study the economic and social impact of broadband infrastructure, convincing and rigorous evidence via empirical studies at the micro-level is still relatively rare. Moreover, the studies discussed in this article generally only identify the effects of the extensive diffusion of the internet. However, it remains an open question whether these findings are transferable to the intensive diffusion of broadband internet. Intensive diffusion reflects not only the intensity of overall usage, but also the provision and usage of increased bandwidths via next-generation technologies. Clearly, extensive diffusion, which has comprised the main topic of study so far, may not tell the whole story, as a new technology may be used more or less intensively by its users. However, as growth effects might arise from a wide range of opportunities made possible by increasing broadband deployment, extensive diffusion is still an informative measure.

It is important to understand that the internet has changed dramatically over the last 25 years. In its early years, the internet was mainly used for email communication and for locating and accessing digital information (Web 1.0); nowadays, the rise of user-driven content and interactive applications (Web 2.0) is well underway. Its future has been described as the "internet of things," where physical objects embedded with electronics, software, sensors, and network connectivity collect and exchange data. Yet, so far, empirical research has mainly examined the impact of the introduction of broadband internet technology during the late 1990s and early 2000s. Not much is known about how these findings might vary in the Web 2.0 era and beyond.

SUMMARY AND POLICY ADVICE

Given its impact on the economy, investment in broadband infrastructure is of great political interest. In the past, many OECD countries expanded ICT infrastructure to their so-called white spots, which are predominantly rural municipalities that would have remained underprovided if left to market forces. To date, a broadband speed of 1 Mbit/s has been achieved for almost all households in most OECD countries. Governments are now pursuing digital agendas with the intention of ensuring speeds of up to 100 Mbit/s, even though there are as yet few applications requiring a bandwidth of this magnitude.

The changing nature of the internet toward the "internet of things" makes it likely that even more tasks that are currently carried out by humans will be done by machines in the near future. Such developments may mainly affect low-skilled workers executing tasks that are easily automatable, but even high-skilled workers may not be safe. Imagine medical diagnoses performed by medical equipment with access to huge medical databases instead of doctors, or e-learning that could make teachers or professors obsolete. Internet-related developments such as these will have important consequences for individual labor market outcomes; future labor market institutions should be designed in a way that ensures they support workers in adjusting to the rapidly changing work environment in an increasingly digital world.

ICT skills will become increasingly important in this technology-rich digitalized world, and their acquisition (or absence) has serious implications for individual labor market success and overall inequality. Indeed, one could imagine a world inhabited not by the haves and have-nots, but by the "know-hows" and the "don't-know-hows." Ensuring access to the internet in order to regularly practice internet-related tasks such as writing emails or searching for information has shown to be an effective way of accumulating ICT skills and of reducing the wage gap between "digital natives"—those who are capable of using modern information and communication tools—and "digital illiterates".

In the foreseeable future, society will be facing a fast-changing digital environment. It is impossible to predict specific developments and their impacts, even in the short to medium term. In such an environment, specific (ICT) skills, e.g. focusing on a given software or methodology, are always in danger of becoming obsolete "overnight." Adaptability and resilience of workers to such change should be emphasized; general ICT training may be a better way to prepare workers for future developments, providing them with a general toolbox that can be adjusted and honed to suit different situations. Typically, one size is not going to fit all: Digital illiterates will have to attain basic digital literacy (independent of their age), and adequate levels of basic skills for the majority of the workforce must be determined. With respect to digital education, it is already apparent that some “push” will be required, perhaps in the form of (potentially mandatory) courses and activities. As seen in the low adoption rates of high-bandwidth connections throughout much of the world—despite the technological availability—simple provision of access to content is no longer enough. Each of these steps is required to achieve the essential task of fostering the accumulation and further development of ICT skills as a life-long endeavor.

Acknowledgments

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Competing Interests

The IZA World of Labor project is committed to the *IZA Guiding Principles of Research Integrity*. The author declares to have observed these principles.

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Further readings

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