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METCALFE'S LAW IN THE DIGITAL MEDIA MARKET

The article describes network effects as one of the features of digital media markets. It reviews prior research in this area, demonstrating that a few concepts are supported by empirical evidence. One of the most accurate concepts, Metcalfe's law, which was developed in the early 1980s, states that the value of a network is proportional to its squared size. The present research validates the accuracy of this law using Meta and Netflix data from 2011 to 2020. Both companies have differences in revenue, user acquisition, business model and technology. However, both of their data fit Metcalfe's law well.

***Key words**: digital media, digital media market, network effects, Metcalfe's law, Meta, Netflix.*

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Introduction. Network effects, which take place when the value of a product or service increases with the number of people who use it, have been among the most influential ideas in industrial organization during the past years (Birke, 2009).

Due to the significant network effects that characterize digital markets, concentration and monopolization are likely to occur. There are two types of network effects: direct and indirect. In a market with direct network effects, the greater the number of users of a product or service, the greater its value to other consumers. On the other hand, indirect network effects arise when the growing use of a product or service creates a new standard, boosting the incentive for third parties to develop compatible technology, which boosts the popularity of the original product or service among customers.

Online platforms show tremendous network effects, because they connect multiple commercial sectors. Amazon and other online commerce platforms connect buyers and sellers. Similar to social networks, Amazon Marketplace grows value as more merchants and consumers connect with the site. Similarly, the value of internet advertising platforms such as Google increases with the number of users, as advertisers gain access to a larger client base and, as a result, a larger trove of consumer data. Similarly, social networks like Facebook display substantial direct network effects because they become more useful as more individuals engage with the network: no one wants to be on a social network without other users. Meanwhile, once a company has captured a network, it can be incredibly difficult to dislodge or replace.

Strong network effects display a significant entry barrier for new businesses seeking to enter a market and displace the incumbent. When combined with additional entry barriers, such as limits on consumers or corporations simply switching services, network effects ensure market concentration and long-term market strength (Shy, 2011).

Both same-side and cross-side impacts may occur on a platform. In general, a same-side network effect exists when an increase in the number of users on one side of a platform increases the value of the service for a given user on that side. The traditional telephone network is an illustration of a same-side network effect. If there are only a handful of users on a telephone network, it will be of relatively low value to each individual user and may have difficulty attracting new members. A network with a big number of users, on the other hand, will be of relatively high value to a user, making it attractive to potential new users. Consequently, a tiny new entrant may have difficulty gaining new clients compared to a large incumbent, thereby creating barriers to entry and expansion (United States Congress, 2020).

A cross-side network effect happens when a rise in the number of users on one side of the platform decreases the service's value for a given user on the other side. Cross-side effects act in both directions on a credit card platform: an increase in the number of customers using the card increases the card's value to merchants, and an increase in the number of stores accepting the card increases the card's value to consumers. Consequently, a positive feedback loop is created. Consequently, both merchants and consumers will find large-scale credit card systems more desirable than small-scale credit card platforms, which may pose an entry or growth hurdle.

2. Theoretical Framework. Although the concept was popularized in the early 20th century, real academic research on the phenomenon did not begin until 1974, when Jeffrey Rohlfs published his key paper (Rohlfs ,1974). Starting mid-1980s, robust theoretical literature on how network effects influence competition evolved. Consequently, economic theory on this topic has become profound and complex.

Four rules have been proposed to provide more precise definitions and descriptions of network effects. They are as follows:

• Sarnoff's law: $V \propto n$,
• Metcalfe's law: $V \propto n^2$,
• Odlyzko's law: $V \propto n \log(n)$, and
• Reed's law :$V \propto 2$

Metcalfe's law, introduced in the early 1980s, states that a network's value is proportional to its size squared. Recent publications have presented arguments for and against Metcalfe's law. Odlyzko et al. referred to Metcalfe's law as «wrong» and «dangerous» (Briscoe, Odlyzko and Tilly, 2006). They argued that if Metcalfe's law is accurate, two networks of any size should be interconnected regardless of their relative sizes. They developed the Odlyzko's law that states that the value of a network increases in proportion to n log(n). According to Van Hove, Odlyzko's inference is incorrect. He argued that Metcalfe's law was not wholly inaccurate (Van Hove, 2014).

None of these concepts, however, is backed by empirical evidence. Using Eurostat data to support Metcalfe's rule, Madureira et al. determined that the value of a network might be either quadratic or linearly proportional to its size (Madureira, den Hartog, Bouwman and Baken, 2013). Late in 2013, Metcalfe analyzed Facebook data from the previous 10 years to determine that his law was a good fit.

Zhang et al. used Facebook and Tencent data to support Metcalfe's law, which states that the value of a communications network is proportional to the number of users squared (Zhang, Liu and Xu, 2015). This comment indicates that the worth of a social network may be determined not only by its size, but also by the expansion of its service offerings and their quality. Their results showed that for both Tencent and Facebook data, Metcalfe's function fits the real data model well and is far more accurate than the other three laws.

3. Methodology and research results. The purpose of this research is to validate Metcalfe's law using Meta and Netflix data of years 2011-2020 (Appendix 1). Formulating the value function for the Metcalfe's law is straightforward:

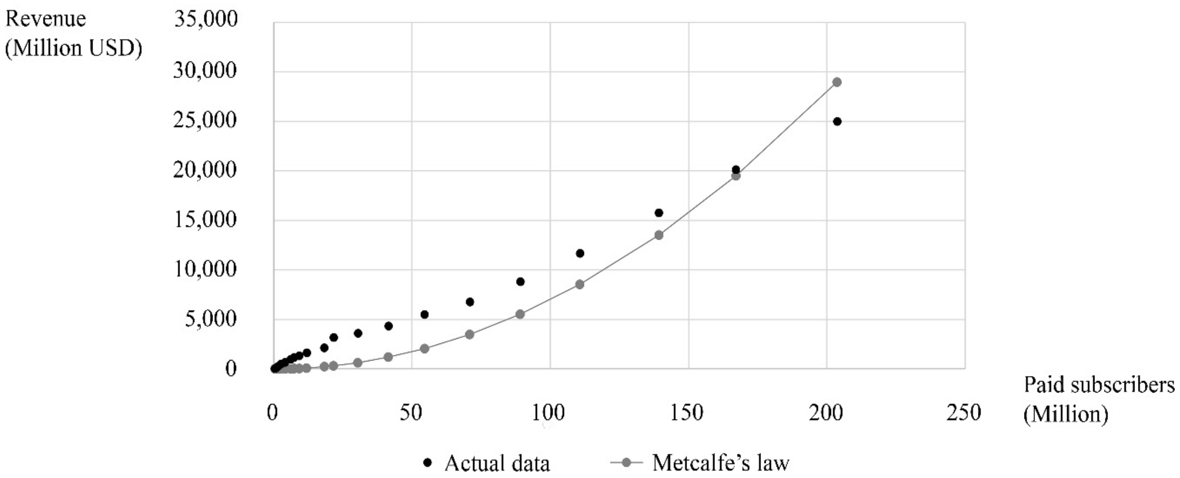
Table 1.

Variable definitions

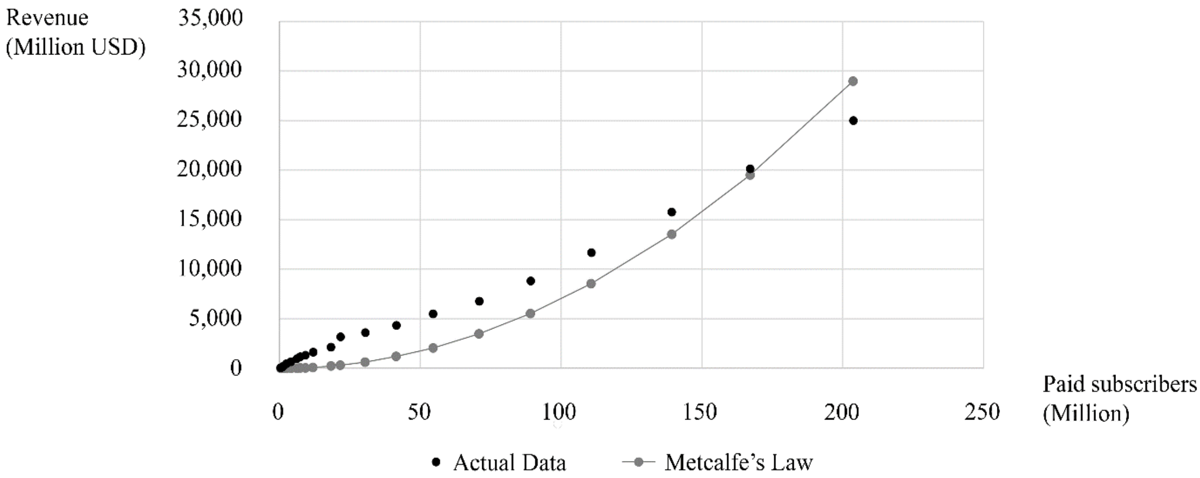
Symbol	Unit	Definition	Data source
V	USD	Value of a network	Revenue
n	MAU	Number of nodes of a network	MAU

Metcalfe's function $V = a \times n^2$; unit of parameters is as follows: $a = USD/MAU^2$.

In curve fitting, the least squares method is utilized to fit Tencent and Facebook data to the value function. The Metcalfe's functions of them are as follows: VMeta = $10.131 \times 10^{-9} \times n^2$ and VNetflix = $698.09 \times 10^{-9} \times n^2$ respectively. The corresponding fitting curves graphics are shown in Fig.1 and Fig.2 respectively.



Pic. 1. Value curves of Meta



Pic. 2. Value curves of Netflix

Appendix 1.

Actual data of Meta and Netflix

Year	Meta		Netflix	
	MAU (in millions)	Revenues (in millions U.S. dollars)	Paid subscribers (in millions)	Revenues (in millions U.S. dollars)
2001			0	74
2002			1	151
2003			1	270
2004	1	0.38	2	501
2005	6	9	4	682
2006	12	48	6	997
2007	58	153	7	1,205
2008	145	272	9	1,365
2009	360	777	12	1,670
2010	608	1,974	18	2,163
2011	845	3,711	22	3,205
2012	1,060	5,089	30	3,609
2013	1,230	7,872	41	4,375
2014	1,390	12,466	54	5,505
2015	1,590	17,928	71	6,780
2016	1,860	27,638	89	8,831
2017	2,130	40,653	111	11,693
2018	2,320	55,838	139	15,794
2019	2,500	70,697	167	20,156
2020	2,800	85,965	204	24,996

Sources: Meta (2022), Netflix (2022)

Conclusions. Network effects arise when the value of a product or service increases proportionally to the number of users. Metcalfe's law, developed in the early 1980s, states that a network's value is proportional to its squared size. Meta and Netflix have differences in revenue, user acquisition, business model and technology. Both of their actual data fit Metcalfe's law well. The Metcalfe's functions of them are $VMeta = 10.131 \times 10^{-9} \times n^2$ and $VNetflix = 698.09 \times 10^{-9} \times n^2$ respectively. As potentially future research, other networks could be used to validate Metcalfe's law, including Spotify, Google, Sony PlayStation networks etc.

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А. Бех

ЗАКОН МЕТКАЛФА НА РИНКУ ЦИФРОВИХ МЕДІА

У статті описані мережеві ефекти, які властиві ринку цифрових медіа. Аналіз попередніх досліджень по цій темі виявили ряд концепцій, достовірність яких підтверджуються емпіричними даними. Одна з найточніших концепцій — закон Меткалфа — розроблений на початку 1980-х років, стверджує, що цінність мережі пропорційна квадрату кількості підключених до неї користувачів. Дане дослідження підтверджує точність цього закону, на основі даних "Meta" та "Netflix" за 2011-2020 роки. Незважаючи на те, що ці компанії мають відмінності в доходах, моделі залучення користувачів, бізнес-моделі та технологіях, дані обох компаній підтверджують закон Меткалфа.

Ключові слова: цифрові медіа, ринок цифрових медіа, мережеві ефекти, закон Меткалфа, "Meta", "Netflix".