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Nowcasting and forecasting aquaponics by Google Trends in European countries

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ABSTRACT

Aquaponics, an innovation in agricultural systems of production and food supply which combines aquaculture fish production with hydroponic production of vegetables, represents a valuable option to overcome the food needs of a constantly increasing world population, it can do so by improving production and supply with less inputs and in a sustainable way. Despite recent developments in this scientific area, there are still not enough commercial firms at a European level that allow for a consistent view of how this activity is evolving in society, as well as, to understand the impact of Aquaponics Hub in promoting the development of this activity in Europe - aquaponics is still at an early age and, despite innovative, it needs time to grow and evolve.

Thus, we used Google Trends data and a quantitative methodology, multivariate analysis and econometric models, in order to both nowcast and forecast insights about the importance, the role and the new trends in aquaponics. The results show an interesting trend of increasing popularity in aquaponics search terms as a *proxi* of aquaponics development in Europe, mainly in all the European countries belonging to the Aquaponics Hub. However, we conclude that there is still a long way to go for aquaponics before it becomes a commercial activity at economic level. Hence, European and public decision-makers are urged to be more concerned about legislation and the allocation of funds for research and for the commercial investment of companies and for their promotion and development in aquaponics.

1. Introduction

Aquaponics is nowadays the latest innovation in food production systems allowing reduced *inputs* use and short supply chains, with direct impacts on the sustainability of the entire sector. Due its great innovation your development at the commercial firms' level beginning now to take the first steps. But for research purpose this represents a constraint to obtain data for research at the microeconomic level, namely, at the firm level. Yet, innovation system on food production and short supply chain plays an important role to make agriculture and sector-wide changes more sustainable (Hoes et al., 2016) and cannot be neglected.

But nowadays the increasing volumes of 'big data' reflecting various aspects of our present scientific professional activities and represent a crucial new opportunity for scientists and experts to study the fundamental questions about the complex world we inhabit in different areas (Axtell and Zipf, 2001; Christakis and Fowler, 2009; Frizzo-Barker et al., 2016; King, 2011; Klievink et al., 2017; Perc, 2012; Petersen et al., 2012; Preis et al., 2013; Vespignani, 2009), namely, in management and business (Dittert et al., 2018; Frizzo-Barker et al., 2016) information and communication (Lu et al., 2018; Yu et al., 2018).

In today's world, information gathering often consists of searching online sources (Amankwah-Amoah, 2016; Blazquez, 2017; Preis et al., 2013). Recently, the search engine Google Trends (2017) has begun to provide access to aggregated information on the volume of queries for different search terms and how these volumes change over time, via the publicly available service Google Trends with historic searches available since January 2004. This recent non-traditional source of social and economic data GT provides up-to-date reports on the volume of search queries on a specific keyword or text, with historic searches from 2004 and was used to nowcast and to forecast social and economic variables with application in various empirical fields (Blazquez, 2017).

Despite GT captures how the demand of information under certain topics varies over time, providing useful data to detect emerging trends and underlying interests and concerns of society, namely, using GT data to nowcast social and economic variables (Blazquez, 2017), the use of GT in agricultural field still remain restricted in and with just only one contribution from Troumbis (2017) who analyzes the GT and cycles of public interest in biodiversity, and remains without any contribution in nowcast aquaponics what is recognized as a sustainable food production technology.

So, the present paper tries to fill this gap on the literature and

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examines the intriguing possibility of analyzing search query data from Google Trends to nowcast, forecast and provide new insights about the importance, the role and the new trends about aquaponics in general and about the role of European Aquaponics Hub from COST FA 1305 in this process, in particular in promoting the international scientific debate in this field in order to promote the sustainable development of aquaponics in Europe and in the world.

More specifically, this paper aims to:

a) To analyze the current development of aquaponics and aquaponics related activities, namely, the aquaculture, hydroponics and commercial aquaponics in Europe and if that development presents nowadays a trend of growth;
b) To confirm if that trend of development of aquaponics is similar in all the participants countries of COST Action FA 1305 and Aquaponics Hub and in all other the remaining European countries outside of this Hub in order to delineate aquaponics development to promote innovation and social change among all the European countries;
c) To analyze the contribution of that Hub and this COST Action to promote the development of Aquaponics and forecast new insights about the importance, the role and the new trends about aquaponics to be analyzed and developed;
d) To understand the actual commercial development of aquaponics in Europe in order to promote their sustainable development in order to contribute for technological and social change in food production systems and short supply chains.

1.1. Significance of the paper for the literature, limitations and suggestions

This paper making a threefold contribution in the literature:

1) Although there are many studies in the scientific field of aquaponics none of them so far analyzes your situation in the European countries nor brings to the scientific debate and forecast new insights about the importance, the role and the new trends about aquaponics;
2) For the first time, this paper uses Google Trends information due the shortage of data available in aquaponics in Europe. This could bring a new way to get information not only in aquaponics but also to study innovation systems in agriculture;
3) This paper gives insights to stakeholders and to public decision-makers about the way forward in the promotion and development of aquaponics as well as the importance of HUB in this process, in order to foster research in innovative areas.

Despite the fact of GT are in constant improvement as a consequence of the development of artificial intelligence there are, however, some limitations in general, and, on this paper in particular. The first one can occur because we do not know which agents conduct the research (searching in GT). We don't know if the search on google trends it done by the general public, or consumers, or producers or even researchers. On the other hand, we also don't have any information about the purpose/motivation, and therefore, the present results obtained should be analyzed carefully.

Another limitation is related about geographical and linguistic restrictions, because when the search on GT involve a continent (for example Europe), or even the world, these have various different languages. Therefore, research in only in English language can be a limitation, because the majority of the research is still done in English by researchers, not invalidating that other agents do as well. Therefore, we recommended in future works in this field the use of GT research combining different languages from different countries among Europe or even in the world. That allows at the same time more degrees of freedom and consequently, more accurate models and adjusted results.

1.2. The contribution of aquaponics as a sustainable food production system for innovation, technological and social change

Aquaponics is very recent and innovative agricultural practice of production vegetable and fish recognized as sustainable by the Food and Agriculture Organization (FAO) of the United Nations (Somerville et al., 2014; Dos-Santos, 2016and Miličić et al., 2017). Aquaponics integrating aquaculture with hydroponic crops production wherein the water from the fish tanks that is enriched in nutrients is used for plant growth in a closed and environmental system. Which implies that a large volume of production of fish and vegetables can be produced locally in a sustainable food production way (Bosma et al., 2017; Van Ginkel et al., 2017) including in urban agriculture (Dos-Santos, 2016; Lal, 2016) with smaller quantities of use inputs such as soil (Betz, 2018), nutrients and water and with low carbon charges to the atmosphere, allowing the production of fresh and healthy food in short supply chains from producers to consumers (Dos-Santos, 2016; Goddek et al., 2015; Miličić et al., 2017). Aquaponics, as both an innovative agricultural practice and business, is experiencing a period of rapid growth, being practiced nowadays in at least 43 countries around the world and on every continent (Love et al., 2014). Besides that, the development at European level of aquaponics commercial production is taking the first steps with the new startups (Miličić et al., 2017).

According to the sectorial trends, aquaponic technology might evolve in at least two directions (Junge et al., 2017): the first relates to low-tech solutions, probably mostly in developing countries and for hobbyists, and the second, highly efficient hi-tech installations, predominantly in developed countries and with professional/commercial partners (Junge et al., 2017). However, in both situations aquaponics will be always a technology for sustainable food production that will contribute to a more sustainable world.

Technological change in agriculture plays a decisive role for meeting future demands for agricultural goods (Dietrich et al., 2014) and currently, green growth is the only strategy of mainstream economists and policy makers to address climate change (Antal and Van Den Bergh, 2016). On the other hand, research on innovative and topics, whose technology is still in constant progress, development and improvement of efficiency on the use of inputs and the production of outputs as occurs in aquaponics in Europe, sometimes results in difficulties in obtaining data. These difficulties arise, or because there is no data available from private companies or formal institutions, or because either there are data from other continents, or countries whose production systems do not allow comparability, or because the soil-climatic conditions, or technical-institutional-economic conditions (Dos-Santos, 2016; Goddek et al., 2015). This occurs because they use different production techniques due to the difference in quality and quantity of inputs available in loco (Dalsgaard et al., 2013; Goddek et al., 2015).

In order to promote innovation and capacity building by a network of researchers and commercial aquaponics companies was formed EU Aquaponics HUB from the COST Action 1305 (EU Aquaponics Hub, 2017).

1.3. COST action and the EU Aquaponics Hub

The COST FA1305 (2014) - *The EU Aquaponics Hub - Realising Sustainable Integrated Fish and Vegetable Production for the EU* is supported for Horizon 2020 (The EU Framework Programme for Research and Innovation, 2017). This Action is aimed at studying aquaponics in an integrated way and promoting its development in all European countries, and commercial aquaponics companies (EU being nowadays a reference in the promotion and development of aquaponics and aggregates presently twenty-eight countries in Europe), including all the researchers and professionals of the agricultural/fisheries and aquaponics and aquaponics related sciences in that strategic sector, and, as well as, other related sciences (e.g., fisheries, aquaculture, hydroponic, etc.), such as, economists, communication and marketing specialists,